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Martin Kowarsch

A Pragmatist Orientation for the Social Sciences in Climate Policy

How to Make Integrated Economic Assessments Serve Society

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How to Make Integrated Economic Assessments Serve Society

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This work was accepted by the Munich School of Philosophy as doctoral dissertation. The changes made compared with the original version of the dissertation (submitted in 2012) were approved by the PhD reviewers. Any opinions expressed in this book are solely mine and do not necessarily represent those of MCC Berlin, my PhD supervisors, or the reviewers of this work.

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Preface

The black and glutinous oil slicks swimming on the surface of the sea after a crash of an oil tanker and the image of thick dispersed oil around a drilling site have become common global scenes symbolising humankind's destruction of its own basis of life through environmental pollution. Consider, for example, the case of Nigeria where the oil industry is still contributing to extensive environmental pollution which began there in the late 1950s. Much damage has already been done to the mangroves and fish populations; the wetlands have been severely degraded, and in some places, people drink from water wells highly contaminated with benzene. These never-ending disasters, affecting human and non-human life, as well as many other cases of severe environmental degradation (such as large-scale deforestation or the explosion and core meltdown in Fukushima in 2011), are undoubtedly caused by human beings. Why do we jeopardise our very existence and that of future generations with these activities? Why do we destroy the life-sustaining richness and beauty of nature, with its wonderful life forms and recreational and spiritual value?

One could say it's the economy; economic interest and material well-being are the main reasons why oil is produced, rain forests are cleared and nuclear power plants are built. Environmentalists often criticise the economic rationales that lead to such environmental and social problems. However, to return to the Nigerian example, the oil industry provides jobs for thousands of people and meets the ever-increasing demand for worldwide affordable and reliable energy. In almost all modern economies in the world, fossil fuels are as important for creating wealth as blood is for the human body. This wealth has helped to overcome (and avoid) social crises and famines as well as stabilise democracies. Even if the social benefits were not so considerable, some still argue, in the libertarian tradition, that the individual liberty of a person, especially in terms of their economic activities, is ethically sacrosanct.

In political processes, such disputed points of view – presented above in an admittedly oversimplified manner – often function as arguments for or against particular public policy options. Yet, it is not so clear which arguments to accept or to reject and how an appropriate political regulation of economic activities should look considering their environmental and social consequences. There are complex trade-offs which are frequently neglected. To better understand the policy issue at stake and its potential solutions, the political processes should be informed by the available expertise, including that from social sciences. For example, due to the complexity of the multidimensional field of climate change policy, the debate surrounding appropriate policy arguments is often partially transferred to the scientific arena – and sometimes even fully held in terms of scientific facts. When scientific expertise dominates the issue, the struggle between economic, social and environmental arguments is often continued in expert policy advice in a disguised manner, ignoring, for example, the value dimension of these arguments.

My motivation for writing this book was to contribute on a metalevel to the resolution of stubborn, often heated, yet essential political controversies on how to interpret, and react to, the grand challenges that societies are currently facing. This volume will not discuss how a reasonable policy, e.g. an appropriate climate change mitigation policy, should look in terms of economic, ethical or other arguments. Instead, it will develop a philosophical framework for an appropriate contribution of the indispensable social-science expertise, particularly economics, to the public evaluation of and reasoning about climate policy options. Roughly speaking, the idea will be to adequately and openly consider, evaluate and compare the variety of the pros and cons of different policy pathways in light of their practical consequences.

The philosophical underpinnings and resulting recommendations presented in this book may help the Intergovernmental Panel on Climate Change (IPCC) and other assessment bodies to present highly policy-relevant and scientifically sound insights, particularly regarding disputed, value-laden and highly complex socio-economic issues, without being policy prescriptive. The book aims to provide better orientation for both assessment practitioners and their critical observers. As an alternative to value dogmatism or technocracy in the sciences on the one hand of the spectrum and procedural liberalism regarding policy decisions on the other, this book will offer an assessment rationality that could indirectly promote true deliberative democracy. The framework may help to improve policy decisions and could enable the IPCC to regain legitimacy as well as trust after much criticism in recent years. Looking at it another way, it could help the democratic public regain sovereignty. This is at least what is hoped for in this work.

Producing this book was an audacious, though exciting, project. Writing about such a complex, broad and interdisciplinary topic has been a huge endeavour and challenge; it was not always possible to do full justice to every single philosophical aspect or other aspects of this topic. The issues addressed by the economics of climate change, however, are of the utmost relevance to all current and future societies, since they are about the material and physical basis of each society. Therefore, we should be determined to tackle the huge challenges of scientifically assessing the related, often disputed arguments.

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I am grateful to Johannes Wallacher for all the academic and institutional opportunities he gave me, for all I have learned from him (particularly about the ethics of economics, with which he inspired me greatly) and for the very friendly and helpful supervision and support.

I also wish to express my sincere thanks to Ottmar Edenhofer to whom I owe, inter alia, so many invaluable lessons about (climate) policy and politics, society and the economics of climate change and particularly about scientific assessments. Edenhofer is a pioneer in the field of policy-relevant, integrated economic assessment-making. Many of the ideas on the science-policy interface presented in this volume are inspired by him and his practical experience with scientific assessment-making through the IPCC; he greatly encouraged me to address these swampy issues of the science-policy interface.

I also thank my colleagues in Munich (IGP), Potsdam (PIK) and Berlin (MCC), inter alia, for many helpful and clarifying discussions about the topics addressed in this volume. Last but by no means least, thanks go to my dear parents, my own family and my friends; they hopefully know how deeply grateful I am for all their kind support and patience.

Berlin, Germany Martin Kowarsch

Contents

List of Acronyms

AR	IPCC Assessment Report (AR4 = the Fourth AR, 2007; AR5 = the Fifth AR, 2014)
CBA	Cost-benefit analysis
CCS	Carbon capture and storage/sequestration
CO_2	Carbon dioxide (an important GHG)
COP	Conference of the Parties (UNFCCC, since 1995)
DICE	Dynamic Integrated Climate and Economy model (an IAM)
EMF	Energy Modeling Forum (of the IAM community)
EU	European Union
FAR	First IPCC Assessment Report (1990)
FCCC	*See UNFCCC; FCCC refers to the convention itself*
GDP	Gross domestic product (measuring a nation's economic output)
GHG	Greenhouse gas (such as CO_2 or methane)
IA	Integrated Assessment
IAC	InterAcademy Council (independent IPCC review in 2010)
IAM	Integrated assessment model
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
MCC	Mercator Research Inst. on Global Commons and Climate Change
NGO	Non-governmental organisation
NRC	National Research Council (USA)
PAGE	Policy analysis of the greenhouse effect (an IAM)
PBL	Planbureau voor de Leefomgeving (Netherlands Environmental Assessment Agency)
R&D	Research and development (mostly referring to investments in technology)
(Re)MIND	(Refined) Model of Investments and Technological Development (an IAM)
RICE	*See DICE; RICE is the regionalised variant of DICE*
SAR	Second IPCC Assessment Report (1995)

SBSTA	Subsidiary Body for Scientific and Technological Advice (for the UNFCCC)
SPM	Summary for Policymakers
SRREN	IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation
TAR	Third IPCC Assessment Report (2001)
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WG	IPCC Working Group (WG III = working group on mitigation of climate change)
WMO	World Meteorological Organization

List of Figures

Chapter 1
Introduction

Abstract This chapter provides an overview of the book, with its essential relevance and approach (Sect. 1.1). The novelty and timeliness of this study are also highlighted (Sect. 1.2). Scientific assessments are valuable as tools to inform the public on complex policy issues such as climate change where so much is at stake for so many people. However, guidance is still lacking at the science-policy interface where there are perils lurking. These include the treatment of disputed normative implications in much of the social-science evaluation of policy options. Currently, taking account of this and other challenges, a central open question for many large-scale scientific assessments is whether and how to strengthen and extend social-science policy evaluation to appropriately inform public policy. This book develops a novel philosophical framework for the appropriate role of social-science expertise, particularly economics, in climate policy. The focus is on the integrated economic assessments of the Intergovernmental Panel on Climate Change. The work mainly adds to the existing body of literature by refining John Dewey's pragmatist philosophy of scientific expertise in public policy, and systematically applying this philosophy to integrated economic assessments.

In the first weeks of 2010, there were some feelings of depression and disappointment among many people concerned about the impacts of climate change. This was particularly felt by those climate scientists who had thought that their scientific studies (e.g., Richardson et al. 2009) were now compelling enough to, at last, trigger political climate action. What had happened? So many people had placed their hope in the famous climate policy conference COP-15 (i.e., the 15th Conference of the Parties, December 2009, Copenhagen) that the gathering was sometimes referred to as "Hopenhagen." However, Hopenhagen, as well as the following COPs to date, failed to achieve a substantial global agreement on future climate policy. During COP-15, policymakers merely agreed on the relatively weak "Copenhagen Accord" (UNFCCC 2009). The question arose as to whether scientific policy advice – which can in principle contribute much to the understanding of the pros and cons as well as requirements of such climate policy goals – had been truly adequate and whether it had satisfactorily considered the legitimate economic, financial and other concerns of many governments.

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One could also attack policymakers who sometimes attempted to shift the responsibility for their political objectives and decisions onto the shoulders of scientists. The Copenhagen Accord itself is a good example of this. Among other things, it alleges that scientific evidence determined the so-called 2 °C goal to be the global temperature goal for climate policy in its statement "recognizing the *scientific view* that the increase in global temperature should be below 2 degrees Celsius" (UNFCCC 2009). Some media also adopted the view that scientific evidence determined the 2 °C goal (e.g., Harvey 2011). In contrast, many natural and social scientists have pointed out – both before and after Copenhagen – that the 2 °C goal is a political rather than a scientific goal.[1] Moreover, the influential Assessment Reports (ARs) of the Intergovernmental Panel on Climate Change (IPCC) never really determined such a global temperature goal.

A number of scientific reports and verbal assertions by climate scientists, however, have suggested – at least indirectly – that scientific experts can and should define "dangerous anthropogenic interference" (UN 1992) with the climate system, determine related climate policy goals and identify the most appropriate policy instruments. In addition, experts certainly did not and do not always fully point out the normative (partly policy-prescriptive) assumptions[2] – as well as the uncertainty – implied in such far-reaching statements.

The Copenhagen example thus reveals some of the core pitfalls and challenges at the science-policy interface in general and of climate policy advice and the IPCC in particular. Consequently, the (misguided) use of the climate-related sciences[3] in

[1] Examples include Schellnhuber (2008), Ramanathan and Feng (2008), Smith et al. (2009), Bernauer and Schaffer (2010).

[2] In line with much of the science-policy literature, I use the attribute 'normative' in a rather broad and inclusive sense: providing guidance for our choices (e.g., in public policy or in scientific knowledge production) in terms of what we should do or want to do – in contrast to a descriptive approach to what is actually the case. In this sense, 'normative assumption' is used synonymously with 'value judgement', a widespread but often misleading notion; normative assumptions are necessarily (yet sometimes only indirectly) related to 'values', i.e. to those aspects that we find particularly important and that we appreciate as guidance (in various fields of human life). Besides directly occurring as values, however, normative assumptions can be based on, or be identical with, for instance, virtues, principles, criteria, societal norms and (individual or group) interests (Biewald et al. 2015). More specifically, normative-*ethical* assumptions as the most discussed value judgements claim to provide *well-reflected* action guidance in terms of the good or the right that can be *generalised* (in contrast to, e.g., particular sectional interests in politics); as a discipline, philosophical ethics is identical with moral philosophy. 'Epistemic' or 'cognitive value judgements' (see Chap. 5) provide guidance for the particular field of knowledge production. Moreover, expertise is 'policy-prescriptive' if it, roughly spoken, provides or implies normative guidance (i.e., a preference) on disputable policy choices (see also Sect. 2.1.3). Chapter 5 provides a more detailed explanation and discussion of normative concepts; it also discusses the epistemological entanglement of normative and descriptive aspects.

[3] In this work, I will usually use the plural form, i.e. "sciences" instead of "science," to emphasise the existing variety and diversity of scientific questions, paradigms and methods. For the sake of simplicity, I mostly use the terms "sciences," "scientific," etc. as *pars pro toto* abbreviations for the entirety of the natural sciences, the social sciences, the humanities, philosophy and technology, such as, for instance, the term "scientific assessment" (which can include, e.g., contributions from

public policy processes was the subject of much academic and public debate after Copenhagen. With this, the discussion on the appropriate role of expertise and particularly the IPCC concerning the public evaluation of climate policy options was effectively and fruitfully revived.

Six years after Copenhagen, the Paris Agreement on international climate policy, adopted in December 2015, was a milestone in multilateralism and environmental governance. This agreement still does not ensure the achievement of low-stabilisation goals for climate change mitigation, nor does it imply a fair international burden sharing for mitigation and adaptation. Nonetheless, it was a surprisingly ambitious compromise reached by the international community. Some argue that the latest IPCC assessment (e.g. IPCC 2014) considerably contributed to this success (see Sect. 3.1.3). At the same time, the Paris Agreement involves changes in public debates about environmental governance. Policy implementation and barriers, along with potential trade-offs and synergies between policies, are now particularly relevant. In general, there is a shift of the focus of climate policy debates away from primarily discussing the problem of climate change towards identifying potential policy solutions (Lee 2015). This is reinforced by the adoption of the complex global Sustainable Development Goals in 2015 – as another huge milestone in multilateralism and environmental governance. Having agreed on all these ambitious environment-related policy goals, the challenge for the international community now is to find and mobilize the appropriate policy means for achieving these goals. This has considerable implications also for future IPCC assessments. In light of these developments, this volume aims to contribute to the ongoing debate into the appropriate role of the IPCC at the interface between scientific expertise and climate policy.

1.1 The Topic, Its Relevance, and Major Steps

The general purpose of this volume is to provide orientation for contemporary scientific assessments of policy options in order to support public policy-making in complex and disputed cases. More specifically, the book develops a novel philosophical framework for the appropriate role of the social sciences, particularly economics, in climate policy, assuming that social-science expertise is indispensable for successful climate policy-making. The focus is on the integrated economic assessments by the IPCC, with an emphasis on global climate change mitigation as key example. The development of the framework builds on pragmatist philosophy in the tradition of John Dewey, particularly the assumed ends-means

the humanities). Moreover, in this work, the singular term "science" is usually used synonymously with "scientific knowledge," for instance when I employ the terms "science-policy interface," "sound science" or "value-laden science." This terminology may sometimes cause problems, but so does the English language with its unwieldy distinction of the most respected (natural) science from other (social) sciences and the humanities, including philosophy.

interdependency. Technically speaking, the guiding question of this book is: *what is an appropriate normative as well as theoretical, philosophical framework for critically evaluating and improving the essential integrated economic assessments by the IPCC and similar institutions?*

The framework is envisaged as a new fundamental and normative idea of integrated economic assessment-making for public policy, including key elements of an associated guideline for the IPCC. Such a framework can serve both as orientation for a critical reflection on the past or present work of the IPCC, and as orientation for the design of future integrated economic assessments by the IPCC. This could be of interest not only to scientific experts involved in assessment-making, but also to officials of the IPCC and the United Nations (UN), as well as decision-makers and stakeholders in climate policy, including non-governmental organisations (NGOs). This work may enable the IPCC – from a societal perspective – to better and more legitimately contribute to a rational public deliberation of disputed climate policy options.

The book is divided into four parts. Part I begins by explaining why an integrated economic assessment of climate policy options is desperately needed. It also discusses basic perils and the resulting key challenge at the science-policy interface, showing the need for an appropriate framework for assessments. Part II provides first but still relatively abstract elements of the philosophical framework envisaged in order to respond to the key challenge at the science-policy interface. This part evaluates the prevalent normative models of the science-policy interface in general, and develops a refined model to better guide the role of scientific expertise in public policy. Then, in Part III, the specific challenges, strengths and weaknesses of current integrated economic assessment-making are identified in light of this refined normative science-policy model, both in terms of the underlying scientific literature and the assessment thereof. This paves the way for transforming the rather abstract ideas from Part II into more specific and concrete ideas for how future integrated economic assessments by the IPCC could be improved. Thus, based on the analyses in the previous parts, Part IV presents key elements of a more specific guideline for improving the integrated economic assessments by the IPCC, including an outlook on the potential implications of implementing these recommendations. The following sections will explain the main steps of the book in more detail. Section 12.5 will summarise the major results.

Why this topic is highly relevant to both public policy-making and philosophy

Why should we bother with the science-policy interface and, particularly, the integrated economic assessments by the IPCC (Part I)? Dewey's conception of a scientifically well-informed, collective regulation of indirect consequences of human actions explicitly provides the – indispensable – normative point of departure, from which also some (widely accepted) general norms for scientific expertise in policy are derived (Sect. 2.1): sound science, policy-relevance, good communication and political legitimacy. Employing Dewey's political philosophy, it is argued that integrated economic expertise, if it complies with the general norms for scientific expertise in policy, is urgently required to adequately understand and design complex climate policy where so much is at stake for so many (present and future) people (Sect. 2.2). Yet, it is very difficult for scientific assessments, such as those by the highly influential IPCC (Sect. 2.3), to realise the general norms for scientific expertise in policy (Sects. 3.1 and 3.2). To illustrate this point, the recent criticism of the IPCC is presented (Sect. 3.3). A particular difficulty is the treatment of disputed normative implications in the social-science evaluation of policy options. For many people, this is a core reason not to support social-science policy evaluation in IPCC assessments. Mitigating the trade-offs between the general norms is finally identified as the *key* challenge for scientific assessments. Hence, the assessments require orientation in terms of an appropriate framework, and this is what is currently lacking (Sect. 3.4).

The focus on assessments in this book may require some explanation. Large-scale scientific assessments, although being laborious processes, are particularly useful when it comes to highly complex and disputed, uncertain and longer-term policy issues, such as climate policy (Kowarsch 2016). Assessments are a highly elaborate science-policy interface to inform public policy. They are formalised social *processes* spanning several years; a number of experts and stakeholders assemble, evaluate and synthesise the available scientific literature in a particular field in order to inform public policy in a relatively comprehensive manner. Large-scale assessments often have a mandate from governing bodies, and formalised procedures (e.g., for scoping, author selection and stakeholder engagement), to ensure legitimacy and impact, as well as a strict review process.[4] Hence, in this work, the focus is on such large-scale scientific assessments.

"Integrated economic assessments" mainly focus on economic knowledge, but are *integrated* with other types of scientific knowledge from various disciplines. Climate policy affects multiple policy fields, dimensions and scales. Different disciplinary perspectives need to be integrated into assessments for public policy processes, so it does not make much sense to have a mere economic assessment of policy options (Sect. 2.2). The climate policy pathway exploration proposed in Chap. 11 necessarily requires, but clearly transcends the economics of climate change. Therefore, integrated economic assessments of potential policy solutions should be essentially social-science assessments, i.e. they should include all of the social sciences, as well as furthermore the natural sciences and the humanities.

The IPCC has been chosen as an object of scrutiny because it is currently the biggest, most important, and influential science-policy body providing integrated economic assessments for climate policy. Section 2.3 briefly introduces the IPCC's mandate, structure and processes. At the end of this book, it is suggested that, to some extent, the results of this study can also be applied to science-policy institutions other than the IPCC (if they take into account social sciences), and to complex public policy issues other than climate policy (Sect. 12.4.2).

There is a need for a critical reflection on the integrated economic assessments by the IPCC. Why would a philosopher, however, with basic economic training,

[4] See Kowarsch (2014) and Mitchell et al. (2006) for a more detailed explanation of scientific assessments.

write a book about this interdisciplinary quest for an assessment framework? This topic has deep roots in unresolved philosophical issues (see also Douglas 2009; Kitcher 2011). These fundamental philosophical issues are often neglected in discussions involving the science-policy interface, which often concentrate on procedural issues and thus cannot provide sufficient orientation for these assessments.

Reflecting on the role of economics and other sciences in public policy-making touches on several important philosophical problems. These include those concerning truth, objectivity and the limits of scientific knowledge (philosophy of (social) science, epistemology, metaphysics, etc.); the nature and peril of value judgements (ethics and meta-ethics, epistemology, philosophy of science); as well as conceptions of democracy and public policy processes (political philosophy). The latter is necessary because the determination of an "appropriate" framework for strategic policy advice needs to reflect on the normative ideals for public policy-making, which is primarily a philosophical task. Philosophising about the science-policy interface thus requires a blend of the philosophy of (social) science, ethics and political philosophy.[5]

It seems particularly difficult to argue for the possibility of objectivity of economic results given the unavoidable entanglement of facts and values in integrated economic policy analysis, for instance regarding the climate change mitigation goals. Hence, this book also discusses the nature and treatment of the – often implicit – value judgements (i.e. normative assumptions) in economic assessments. They are typically regarded as dangerous and undesirable; it is often assumed, not just in democracies, that making value judgements in policy advice should be left to the public or its representatives, rather than to researchers.

Rather than being just a matter of luxury and a playground for intellectuals, philosophical issues have considerable implications for practice at the science-policy interface – and consequently also for public policy, as will become clearer in Part II. However, the focus on philosophical aspects in this book does not mean that the factual views held by diverse players in the science-policy interaction can be ignored for the purposes of this book (see Chaps. 3 and 4).

Seeking a refined science-policy model as a first, more abstract response

Part II discusses models of the legitimate role, competence and responsibility of scientific expertise in policy-making processes. This is due to the assumption that, on a general and rather abstract level, these models are potential means of tackling the key challenge for scientific assessments from Chap. 3. The predominant science-policy models are analysed (Chap. 4) and critically evaluated (Chaps. 5 and 6). According to empirical findings, the prevalent traditional models, i.e. the technocratic and decisionist models, are inappropriate in terms of their practical implications (Chap. 5). This is because they have fallen prey to philosophically misconceived notions of the fact/value relationship and scientific objectivity. The pragmatic model cluster that incorporates many of the more recent concepts of scientific expertise in

[5] For an overview of interesting philosophical questions regarding social sciences and climate change, see also Parker (2014).

policy in the literature is more promising (Sect. 6.1). This pragmatic model cluster, however, largely lacks a fully satisfactory methodology for how to make inevitably value-laden scientific policy assessments simultaneously reliable, legitimate and highly policy-relevant. Therefore, as an amendment to Dewey's political philosophy from Chap. 2, Sect. 6.2 introduces a pragmatist philosophy of enquiry in the tradition of Dewey and Hilary Putnam, with the emphasis on the assumed interdependency of ends and means in their evaluation. The resulting refined pragmatic model allows for a highly policy-relevant scientific assessment of policy options, while disclosing core value judgements and uncertainties, without being policy-prescriptive (Sect. 6.4). Part II not only provides first elements of the envisaged framework, but also an evaluative viewpoint for Part III.

Developing a more specific guideline for economics in the IPCC assessments

With the science-policy model from Part II, we are prepared to have a closer, more specific look at the current challenges, strengths and weaknesses of integrated economic assessment-making by the IPCC (Chap. 10) – going beyond the key challenge of scientific assessments identified in Sect. 3.4. Before that however, Part III also has to critically analyse the potential, problems and limitations of the economic literature underlying the IPCC assessment in order to better understand these current specific challenges of IPCC assessments. The performance of the cook (i.e., the IPCC) is dependent on the quality of the ingredients (i.e., the publications of the scientific community). Therefore, Chaps. 7, 8 and 9 critically evaluate some of the studies on the economics of climate change underlying the IPCC assessments with regard to: (1) whether they truly help explore climate policy pathways (i.e., different sets of policy objectives and means) and their relevant implications (Chap. 7); (2) whether they consider and explore alternative normative assumptions in a transparent manner (Chap. 8); and (3) whether their results are reliable and sound, including from an epistemological perspective (Chap. 9). The focus is on the most important economic tools for the most important economic issues of climate change, namely integrated assessment models (IAMs), to calculate the economic costs of climate change mitigation options under different assumptions. Although the IAM-based studies provide very useful insights, challenges remain in terms of all three of the evaluation criteria that also need to be adequately dealt with in the IPCC assessments.

Finally, Part IV presents key elements of a guideline for the IPCC's integrated economic assessments (Chap. 11), based on the preparatory work of Parts I–III. This guideline consists of ideas that may help to overcome the current challenges faced by the IPCC (see overview in Sect. 11.1). It also includes recommendations for the economics community (beyond the IPCC) so that, in the future, they will deliver the material needed for a more comprehensive integrated economic assessment-making (Sect. 11.5). Part IV also concludes by discussing potential positive and negative implications of an implementation of the recommendations (Chap. 12).

Specifying the scope of the book

It is not just climate change and climate policy that are highly complex; the science-policy interface is also complicated. To be successful with scientific assessments in public policy, all the experts, policymakers, stakeholders, NGOs, media and other players at the science-policy interface (see Sect. 3.1.2) have to share the public responsibility. To keep things manageable in this book, it is not discussed how policymakers, media or other stakeholders and citizens should ideally act (or build up capacities). Instead, my focus is on the analysis and evaluation of the IPCC assessments and the underlying economic studies. This covers a large part of the problem and means that I act, loosely spoken, as an *advocate of "the public"* in this book. For the sake of the argument, it is assumed that the public would expect the IPCC to provide an assessment that truly supports rational, well-informed and integrated climate policy-making from a societal perspective (as outlined in Sect. 2.1). In Chap. 12 it is briefly discussed how realistic this ideal is.

This study certainly does not consider all the details of the institutional and procedural structure of the IPCC, or the communication of results. It also does not take full account of the economics of climate change, the specific contents of assessments,[6] or the general ethos for individual IPCC economists. It can serve, however, as a valuable basis for responding to such issues. It does not, by any means, come to an all-embracing or final conclusion about how to reform the IPCC assessments, but it aims to shed a bit more light on a vast, complex and difficult issue.

Until now, the IPCC has primarily provided its integrated economic assessments through its Working Group III (WG III) reports on options to mitigate climate change. To simplify matters, the evaluations of existing assessments in this volume focus solely on the WG III mitigation issues although the framework developed does not only apply to WG III; a more serious integration of the WGs in future assessments is suggested (Chap. 11). IPCC WG II also addresses some crucial economic aspects regarding climate change impacts (as "problem analysis") and adaptation options (as potential solutions, in combination with mitigation efforts). Moreover, although economics is the major focus of this volume, Chap. 11 argues for highly interdisciplinary and integrated assessments where economics plays a major, though not an exclusive role. Furthermore, the focus is on the voluminous ARs of the IPCC WG III, although the IPCC WGs also produce Special Reports, oral policy advice, etc. This is because the ARs are currently the most comprehensive, detailed and influential product of the IPCC. One should, however, bear in mind that IPCC assessment-making is primarily to be understood as a social learning process that cannot be reduced to the ARs.

[6] This book does not investigate whether the WG III ARs sufficiently assessed all the available relevant literature and in an unbiased manner, nor whether there are errors in the economic details of the ARs. Instead, it focuses on some key philosophical aspects of the economics of climate change and how they were dealt with by the WG III.

1.2 What Does This Book Add to Current Debates?

In what sense does the present book actually add to the existing literature and current debates in terms of novelty and timeliness? The book combines, and adds to, three major strands of the literature: (1) philosophy of the role of scientific expertise in policy, including philosophy of (social) science and the role of values therein – mainly in Parts I and II; (2) philosophy of economics – mainly in Part III; and (3) specific analyses of and recommendations for scientific assessments, including the IPCC reform debate – mainly in Part IV.

Contribution to the philosophy of the science-policy interface

The fundamental issues related to science-policy interactions have already been thoroughly discussed over decades and even centuries (Brown 2009).[7] Chapter 6 introduces and discusses some of the most compelling, and promising proposals for general, normative science-policy models. Notwithstanding, much of the literature still points to the need for an appropriate orientation of the science-policy interface, particularly in terms of a normative and hermeneutic model of the role of scientists in scientific policy advice.[8] Daniel Sarewitz, a scholar working on science-policy issues, clearly states:

> Almost three centuries into *the Enlightenment* […] and sixty years into an era of modernity where scientists are recognised as crucial contributors to policy processes at national and international levels, it is perhaps an embarrassment, yet nonetheless no surprise, that we are still trying to figure out how to ensure *quality*, and even what *quality* actually means, at the intersection of science and policy advice (Sarewitz 2011, p. 54).

This might also be due to the difficult philosophical issues at the science-policy interface (see Sect. 1.1). Consequently, although often insightful, some of the science-policy models suggested in the literature do not satisfactorily tackle the trade-offs between policy-relevance, sound science and legitimacy – which is amongst the oldest and most crucial challenges at the science-policy interface. Sometimes the issue of policy-relevance is neglected in the philosophical literature, while other sources do not sufficiently consider legitimacy or the reliability of

[7] According to Maasen and Weingart (2005), there were two waves of interdisciplinary publications on scientific policy advice. After the first wave in the 1960s, which focused on technocracy and the critique of it, there has been a second wave in recent years with a focus on democratic participation in scientific policy advice. Examples of seminal philosophical works on the role of science in policy include Habermas (1968), Brown (2009), Douglas (2009) and Kitcher (2001, 2011). Although there is a lot of literature on science-policy interactions, there is not much reflecting on scientific assessment-making in particular. Exceptions include, inter alia, Boehmer-Christiansen (1994a, b), Pinter (2002), Cash et al. (2003), Rayner (2003), Watson (2005), Mitchell et al. (2006), Farrell and Jäger (2006), NRC (2007), PBL (2008), UNEP and UNESCO (2009), Beck (2009), Rothman et al. (2009).

[8] The high impact of such models and especially the need for a new model are explained, for example, by Beck (2009, p. 19; 2011), Pielke (2007), Brown (2009), Hulme (2009, pp. 102–10), Kitcher (2011, pp. 25f), Grunwald (2008, p. 285) and Jasanoff (e.g., 1990), but also by some bureaucrats and stakeholders.

scientific knowledge. Sometimes, however, it is just hard to see the practical relevance of the abstract proposal described. The specific focus on the economics of climate change in this book helps to more profoundly address this challenge. Moreover, compared with natural sciences, there are still not many works on the role of the social sciences in policy.[9] More publications in this area would be valuable both because of the ethical need for integrated economic policy advice (Chap. 2), and because the challenges for science-policy models are slightly different for social sciences (Sect. 6.4). This is evident, for instance, in the more prominent role of normative-ethical assumptions in social-science findings.

The main novel contribution of this study to the existing literature is that it *refines* and further develops Dewey's pragmatist philosophy concerning scientific expertise in policy, particularly with regard to the exploration of alternative policy pathways and their practical consequences in assessments (Sect. 2.1 and particularly Chap. 6). It also systematically applies this philosophy to integrated economic assessments by developing a framework to evaluate and appropriately design such assessments (Parts III and IV). Interestingly, despite the far-reaching implications revealed in the book, the central Deweyan claim of the interdependency of ends and means is rarely elaborated on in the science-policy literature, and even in appraisals of Dewey's work (see Chap. 6 for a discussion). Maybe it is too straightforward to be taken seriously?[10]

Furthermore, this book adds to the literature through a systematic, coherent description of the *predominant* general models of scientific expertise in policy (Chap. 4) as well as a thorough philosophical evaluation of these models. This includes an overview and evaluation of compelling arguments from the literature against a supposed fact/value dichotomy in scientific knowledge. It also analyses the tremendous implications of a fact/value entanglement for how to conceptualise the science-policy interface in an appropriate manner (Chaps. 5 and 6).

Finally, this book helps to clarify the crucial philosophical questions and challenges arising at the science-policy interface (Parts I and II), showing that a philosophical reflection on assessment-making is indispensable for successful public policy processes.[11]

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[9] There are a few works on the philosophy of the social sciences that also address some of the major aspects of social-science expertise in policy. See, e.g., Cartwright and Montuschi (2014) as well as Risjord (2014).

[10] Among the exceptions is Brown (2012) who brings together Dewey's philosophy of enquiry and current debates in philosophy of science. See also Chap. 6 for more discussion of the available literature.

[11] The existing literature on the science-policy interface lacks a compelling justification and explanation of why and how alternative policy pathways can be explored. Most of the science-policy literature in the last two decades is about the sociology and history of scientific expertise in policy. These are undoubtedly valuable studies, but cannot replace the critical reflection on the philosophical issues.

Contribution to the philosophy of economics

In the last two decades or so, a large number of philosophical reflections on methodological and ethical issues of economic theory and modelling have been undertaken.[12] This book focuses on the rather under-researched application of a pragmatist view of these issues to the economics of climate change. It mainly contributes to this body of literature by: (1) developing evaluation criteria for the economics underlying integrated assessments, including a conceptual framework to make normative assumptions in economic modelling more transparent (Sect. 7.3.2); (2) providing several examples of different kinds of implied value judgements in climate-related economic models (Chap. 8); and (3) providing a literature-based overview of different types of uncertainty in economic studies (Chap. 9).

Contribution to the discussion about assessment-making and IPCC reform

A refined general model is needed, along with a new *specific* guideline for the social-science assessments of the IPCC. The IPCC has faced much criticism in the media, particularly after the COP in Copenhagen (i.e., in 2010 and beyond). This has led to the InterAcademy Council review (IAC 2010) of the IPCC, focussing on its procedures and processes.[13] The international community, de facto, considered a critical evaluation of the IPCC's work to be important. As a result of this review, the IAC concluded "that the IPCC assessment process has been successful overall and has served society well" (IAC 2010, p. 51). Nevertheless, the IAC strongly recommended a reform of the IPCC's governance, management and communication, along with the review process (e.g., stricter rules and more transparency), the treatment of uncertainties, and transparency (IAC 2010). In May 2011, the IPCC Plenary Meeting decided to reform the IPCC processes in several ways based on these recommendations. This confirmed the IAC's previous statement:

> In fact IPCC has shown itself to be an adaptive organization in the past in the sense that it has adjusted the processes and procedures surrounding its assessments both in response to scientific developments and as a result of lessons learned over the years (2010, p. vi).

In principle, I agree with the IAC's conclusion that the IPCC has done good work to date. The IAC proposals already provide a comprehensive and satisfactory guideline for the specific institutional and procedural aspects of the IPCC in light of its recent public criticism. Beyond the mandate of the IAC review, however, was the examination of the IPCC for fundamental flaws and dangers regarding its role in the political arena. In this respect there is a need for a more far-reaching reform beyond the aspects analysed by the IAC.

An interesting discussion about more fundamental IPCC reform took place principally in the first few months of 2010,[14] and popped up again in 2015 after the fifth

[12] See the literature discussed in Chaps. 7, 8 and 9.

[13] "In response to some sustained criticism and a heightened level of public scrutiny of the Fourth Assessment Report, the United Nations and IPCC asked the InterAcademy Council (IAC) to assemble a committee to review the processes and procedures of the IPCC and make recommendations for change that would enhance the authoritative nature of the IPCC reports" (IAC 2010, p. v).

[14] See particularly the different discussions in Nature 463 (Opinion, February 2010), pp. 730–32, and a couple of other articles in Nature 463 and 464. See also publications such as Skodvin (2000),

IPCC assessment cycle (e.g. Lee 2015; Victor 2015; Carraro et al. 2015). Many proposals for reforming the IPCC were put forward, and most of them are worthwhile. However, this debate still left many important questions unanswered. For instance, neither the IAC nor the other academic debates – apart from a few exceptions[15] – specifically scrutinised the IPCC's integrated economic assessment, let alone its relationship with economic literature.

This book contributes key elements of a novel guideline for the IPCC's integrated economic assessments (Part IV), taking these research gaps into account. Additionally, it provides a rationale for the serious inclusion of social sciences in scientific assessments; integrated economic expertise is urgently needed for successful climate policy-making.

Why this topic is timely

As said, recently, the focus of academic and political discussions and quarrels regarding climate change seems to have slightly shifted from the physical aspects of global warming to policy solutions, and their potential implications particularly in economic terms. In the aftermath of what was probably the most important climate policy event of the entire decade – the COP 21 in Paris in December 2015 with the resulting Paris Agreement – particularly the IPCC's statements on socio-economic issues of climate policy are widely and critically discussed. A key example is the debate into the feasibility of, and requirements for, ambitious climate change mitigation pathways. Reflecting upon the IPCC's *integrated economic* assessment-making is thus necessary and timely.

Additionally, the next scientific assessment cycle of the IPCC (AR6) has just begun and requires critical reflection and orientation, particularly in light of the IPCC reform debate since Copenhagen. Unfortunately, the IPCC plenary in Nairobi (February 2015) did not achieve substantial agreement on a far-reaching IPCC reform for the sixth assessment cycle. However, many questions still require an answer and some problems remain unresolved. For example, should future IPCC assessments further develop the approach that was chosen by the IPCC WG III in its contribution to the most recent, fifth IPCC assessment cycle (AR5, 2014)? Based inter alia on some of the ideas that are presented in this book,[16] WG III had tried to explore alternative climate policy pathways, analysing their means, requirements and practical implications (see also Chap. 10 below). Critics inter alia claim, however, that sound scientific knowledge is very hard to achieve given the often disputed normative implications of policy evaluations. A central question for many

Beck (2009, 2011), Hulme and Mahony (2010), Tol (2011), Pielke (2010), Watson (2010), Grundmann and Stehr (2011, Chap. 4), and the discussions, for instance, on the blogs http://rogerpielkejr.blogspot.com/, http://wattsupwiththat.com and http://judithcurry.com/2011/10/06/ipcc-discussion-thread/. The governments' discussions about IPCC reform can be found here: http://www.ipcc.ch/apps/future/ (all accessed 7 Jan 2015).

[15] E.g., Victor (2015) mainly from the perspective of political sciences, and Carraro et al. (2015) mainly from an economics perspective.

[16] See IPCC (2014, Preface).

large-scale scientific assessments[17] currently is whether and how to strengthen and extend (or rather get rid of) their social-science policy evaluation. This book contributes to this debate.

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[17] Upcoming large-scale scientific assessment projects include, for instance, the envisaged assessments by the Intergovernmental Platform on Biodiversity and Ecosystem Services that explicitly follows the role model of the IPCC; the Sixth Global Environment Outlook by the United Nations Environment Programme; and the next UN Global Sustainable Development Report.

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Part I
The Key Challenge of Integrated Economic Advice for Climate Policy

Chapter 2
The Need for an Integrated Economic Assessment of Climate Policy Options

Abstract This chapter indicates the need for appropriate integrated economic assessments to support climate policy-making. A normative point of departure for this is John Dewey's concept of a scientifically well-informed, collective regulation of indirect consequences of human actions – as the essence of "the public" (Sect. 2.1). From this Deweyan philosophy of deliberative democracy, a few (widely accepted) general norms for the role of the desired scientific expertise in policy can also be derived: sound science, policy-relevance, good communication and political legitimacy. Employing Dewey's political philosophy, I argue that integrated economic expertise, if it complies with the general norms for expertise in policy, is urgently needed to adequately understand and design complex climate policy where so much is at stake for so many (present and future) people (Sect. 2.2). This is particularly, although not exclusively, true for climate change mitigation where many socially relevant aspects are still poorly understood. Section 2.3 introduces the highly influential Intergovernmental Panel on Climate Change (IPCC) and its integrated economic assessments, particularly those of IPCC Working Group III, on which this book will focus.

As the normative point of departure for the topic of this volume – the search for a new framework for integrated economic assessments on climate policy – this chapter highlights selected elements of John Dewey's philosophy of public policy and deliberative democracy (Sect. 2.1), and applies this philosophy to the economics of climate change (Sect. 2.2). This clarifies the more precise ideal purpose of scientific expertise in policy, and shows that integrated economic expertise is truly needed in climate policy. The need for natural sciences, on which most of the science-policy literature is still focussing, is widely accepted. However the need for, and potential of, social sciences in assessments of policy options is still frequently underestimated by many scholars, assessment practitioners and stakeholders. The most important and influential institution organising integrated economic assessments on climate policy is currently the IPCC (introduced in Sect. 2.3).

The basic normative perspective presented here will serve as the philosophical "anchor" for the rest of the volume. It is decisive for developing evaluation criteria

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for the critical analysis of the IPCC's assessments in the following chapters. A normative point of departure is in any case unavoidable.[1]

2.1 The Ideal Role of Scientific Expertise in Public Policy

What can benefit from scientific policy advice from the perspective of political philosophy and what are the necessary conditions? John Dewey's political philosophy provides some interesting general answers to these questions. I will, however, *only* discuss those handpicked, but core aspects of his political philosophy that are necessary to argue for the need of scientific expertise in public policy and its more precise ideal function.[2]

2.1.1 Dewey's Philosophy of Deliberative Democracy as Conceptual and Normative Point of Departure

John Dewey presented his influential idea of democracy in his book on *The Public and its Problems* (1927). In this, he identifies the organisation of public interest as the core function of democracy, and as the factual, generic reason for the emergence of democracies in history. More specifically, he refers to the regulation (in a very broad sense, including market-based instruments) of the indirect consequences of human actions for other people, who are not directly engaged in a free transaction. Such indirect consequences can result from very different kinds of human activities. This does not make all these activities "political" per se, but the regulation of these indirect consequences is or should be regarded as "political." For Dewey, the *common* awareness of such indirect consequences, which makes them no longer "private," is what constitutes "the public." The organisation of this public through representatives and a public discourse is the core of Dewey's concept of democracy, although a 'public' can exist on sub-national level, too.[3]

Thus, for Dewey, democracy is not simply an ethical ideal that is implemented in reality; neither can it be identified using a fixed idea of the common interest of a society. Instead, democracy is the regulation of the public interest arising from indirect consequences and related conflicting interests; it is combined with the idea that everyone should be involved and, in principle, regarded as a person capable of

[1] See also Kitcher (2001, Chap. 5). This will be discussed in Chaps. 5 and 6 of this book.

[2] Recommendable introductions to Dewey's political philosophy in general are offered by Brown (2009), Putnam (1992) and Posner (2003).

[3] Feenberg (1999) made one of the more recent attempts to describe the public as constituted by the experience of indirect consequences. This also shows that Dewey's thoughts on democracy, despite their age, are still highly interesting to contemporary scholars.

co-deciding about a regulation of such indirect consequences (Dewey 1927, p. 147).[4] Dewey's theory of democracy, including the role of the sciences within it, should be understood partly as a normative idea (rather than a pure description of a particular political system in reality). However, it is also strongly based on an analysis of the factual history of democracies.

Obviously, not every indirect consequence constitutes a public. Since every action has so many consequences, which cannot all be considered, Dewey argues that it is only the most important, most disputed consequences that can be classified as such. In addition, there are often substantial uncertainties regarding these important consequences. Examples of indirect consequences that clearly constitute a public are the (simplified) conflicting arguments from the Preface of this volume about economic, ecological and social aspects of the Nigerian oil industry.

The main function of a democratic state and of its regulation of indirect consequences is to make the formation of expectations of everyone more secure concerning these consequences and their regulation. In other words consequences should be made more predictable, *first* through a better understanding of the likely consequences arising and *second*, through effective regulation. Thus, the function of laws and other regulations is not to *ensure* an action is *avoided*, which is impossible, but to make the consequences – in this case punishments for causing severe indirect consequences for others – of individual actions more predictable. Although Dewey never explained precisely which consequences are "important" enough (Smiley 1992, pp. 293f), he at least listed three characteristics that often apply to consequences regarded as important by a democratic public (Dewey 1927, p. 64): (1) long lasting and enduring; (2) extensive, i.e., affecting many in a similar way, sometimes even repeatedly; and (3) serious and often irreparable.

For Dewey, the loss of the public's control over indirect consequences leads to the "eclipse" of the public and of democracy (Dewey 1927, pp. 126 and 165f), since it is exactly the public interest concerning indirect consequences that constitutes the public and democracy. A "public debate," i.e., an open and fruitful discourse about the public interest(s) and the regulation of indirect consequences is therefore very important for democracy in general.[5] Consequently, good communication and, with it, a common attempt to understand public affairs (see also Smiley 1992) is decisive for a Deweyan democracy. For Dewey, this is the reason why scientific expertise is also required for democracy. An intelligent public debate into indirect consequences – as public concerns – and their regulation is needed, which requires support from scientific experts as well as transparency in public affairs (Brown 2009, p. 138; Dewey 1927, p. 167). Scientific experts can help to identify and better understand problematic indirect consequences of human actions (such as, e.g.,

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[4] Dewey's theory of democracy is a liberal one, but should not be misinterpreted as libertarian. Instead, Dewey's approach seems to imply a welfare state.

[5] With this, Dewey's book (1927) was a reply to journalist Walter Lippmann who postulated that in modern, big and complex societies, direct participation of the people is no longer possible; this is usually called a "realist theory" of democracy (Brown 2009, pp. 138f). For Dewey, without such participation, democracy cannot be realised at all, and political power cannot be controlled.

identifying anthropogenic climate change) and the prospects of different options to regulate indirect consequences. This is even more important since – due to the continuous change of technological, socio-cultural, economic and other conditions – indirect consequences also continuously change. Therefore, regulations and, with it, political institutions have to be continuously adapted. According to Dewey (1927), this is the reason why democratic institutions should, and actually do, change all the time (see also Dahl 1989).

Although democracy for Dewey is not an ideal as such, in his view, it is the best available alternative we currently have for the organisation of community life (Dewey 1927, p. 149).[6]

2.1.2 Discussion

According to Posner (2004, p. 168), there are at least two concepts of democracy that are to be identified: epistemic and political democracy. Both have a normative and a heuristic-descriptive function. Posner defines "epistemic democracy" as "the idea that inquiry and decision making in general, not just political inquiry and decision making, are democratic in character"; and he defines "political democracy" as follows: "in its most common modern form, [it] is a system of political governance, the defining feature of which is that the principal officials are selected by popular vote." Dewey's theory of democracy can be regarded as an attempt to unite these two concepts (Posner 2004, p. 168).

I agree with Dewey and Posner that, besides political democracy, epistemic democracy is also necessary for policy-making, because otherwise, public interest(s) and public policies may be determined in a way that neglects the interests and experiences of many people affected. The political formation of an opinion should be collective action, both regarding its genesis and regarding validation (Posner 2004, p. 169). Epistemic democracy is more than mere political democracy as a "clash of wills and interests" (Jeremy Bentham) or "merely a check on the officials," (i.e. Schumpeter's concept of democracy) (Posner 2004, p. 171).

[6] Dahl (1989, p. 311) excellently summarises three core reasons why democracy in general is superior to all other possible alternatives: "First, it promotes freedom as no feasible alternative can: freedom in the form of individual and collective self-determination, in the degree of moral autonomy it encourages and allows, and in a broad range of other and more particular freedoms that are inherent in the democratic process, or are necessary prerequisites for its existence, or exist because people who support the idea and practice of the democratic process are, as a plain historical fact, also inclined to give generous support to other freedoms as well. Second, the democratic process promotes human development, not least in the capacity for exercising self-determination, moral autonomy, and responsibility for one's choices. Finally, it is the surest way (if by no means a perfect one) by which human beings can protect and advance the interests and goods they share with others." Dahl (1989, p. 312) adds that democracy is not only an important goal, but also an important means of achieving distributive justice.

This Deweyan combination of epistemic (or "cognitive") democracy and the – more popular – political democracy can be called, in more modern terms, "deliberative democracy" (see also Posner 2004, p. 171). Some people presumably understand democracy merely as an instrument to control power. The brilliance of Dewey's idea, however, was to show that this particular function of democracy is only subsidiary to the idea of democracy as the deliberative regulation of indirect consequences – including, for instance, disputed power accumulation with problematic indirect consequences for other people.

The literature does not criticise Dewey much for his combination of epistemic and political democracy. Rather, the main critique on Dewey's concept of democracy is that it is supposedly too naïve in proposing the overly optimistic view of the capacity of human beings to take part in a fair and rational, public political debate. Posner (2004, p. 171) calls such an optimism "unrealistic" and as aspirational as Plato's idea of the rule of philosophers. This is because in Posner's view, many people are not intelligent enough, the political problems at stake are very complex and many people are simply not interested in such public debates. Policy-making processes can hardly be regarded as primarily driven by "the truth" and the "common good" (see Sect. 3.1). Instead, selfish interests, power asymmetry and other issues play a decisive role. We are thus already in the middle of the discussion about the science-policy interface.

But Posner (2004, pp. 171f) rightly admits that Dewey himself was not too optimistic in this regard either. Dewey only asserted that *most* people have the basic intellectual capabilities required for participating in a public debate, but did not state that these people are actually interested in establishing a rational public debate. Dewey's well-known efforts to promote education are due to this concern.

A further critique of Dewey's theory of democracy concerns the role of law and institutions (as elements of "political democracy"), which he tends to neglect. Although Dewey discusses these issues in his book (Dewey 1927), he indeed somewhat neglects the issues of rule and power and its control. It is possible that democracies emerged more often as mere attempts to constrain the power of cruel rulers than from the direct urge to regulate indirect consequences in general (as assumed by Dewey). Posner (2003 and 2004) criticises Dewey harshly for underestimating institutional and legal aspects as well as for overestimating the importance of knowledge, the level of intelligence of the citizenry and the role of scientific experts in policy (see also Smiley 1992, p. 288).[7] Posner states that democracy works quite well without intelligent debates; in his view TV information is sufficient, assuming that in a democracy, not everyone has to understand every detail of a policy problem. Moreover, Posner argues that such a rational public debate, as required by Dewey, is counterproductive and dangerous, as it may incite political fundamentalism and radical ideas. It would be much better to simply follow one's self-interests

[7] Posner's line of critique is thus again related to the disputed optimism or pessimism regarding the human capability to participate in deliberative democracies; more pessimistic views of human nature in that regard – as Posner's – would put more emphasis on the need for the institutional and legal control of policymakers and political power in general.

and avoid the misuse of power by law and adequate institutions. Societies added *political* democracy, he continues, precisely because of the disadvantages and risks of epistemic democracy.

However, Posner underestimates both the weaknesses of his alternative view[8] and the need for a rational, well-informed public discussion in order to overcome the huge global challenges of the twenty-first century, such as climate change. This should become clear throughout this book. His argument that democracy works quite well without the Deweyan ambition seems to be based merely on the observation that we still *have* (some kind of) democracy in most Western and some other countries. This is certainly insufficient to argue against Dewey. Dewey's concept of democracy does not endanger liberty, as Posner mistakenly suggests, but instead clearly incorporates "political democracy." Dewey's concept is probably the only way to secure liberty in its fullest sense, which presupposes the opportunity to take a more active part in political processes in a well-informed and rational way.[9]

Moreover, although Dewey perhaps underestimated institutional issues, this does not constitute a fundamental objection against his concept of a deliberative democracy. These criticisms could, rather, help develop Dewey's quite abstract theory and put it into practice. Thus, by choosing Dewey's political theory as the normative anchor for this book, I do not want to argue that institutional issues should be neglected, or that there can be no substantial improvements to Dewey's theory. As already said, Dewey's philosophy is actually richer than that described above.[10] However, there are many aspects of democracy addressed in contemporary, differentiated, literature, which are not (extensively) discussed by Dewey.[11]

For the purpose of this study it is sufficient to learn that, despite existing criticism, the core ideal of public policy can be reasonably conceptualised as the *common, deliberative regulation of the more severe indirect consequences of human actions*.[12] Scientific expertise can support this by systematically analysing the consequences of human actions and of the options to regulate them. This is particularly true in complex and multi-dimensional policy cases with high uncertainty (such as, for instance, climate policy). Dewey states that

> genuinely public policy cannot be generated unless it be informed by knowledge, and this knowledge does not exist except when there is systematic, thorough, and well-equipped search and record (Dewey 1927, pp. 178f).

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[8] It is not "natural" in my view to simply and exclusively follow one's own interests, as Posner mistakenly suggests; see also Chap. 8 below.

[9] For such an ethical claim see, e.g., Kowarsch and Gösele (2012).

[10] E.g., Chap. 6 will introduce Dewey's philosophy of scientific enquiry underlying his philosophy of the public.

[11] Neglected aspects of current developments in existing democracies and in the political science literature include specific issues related to pluralism, representation, (global) governance, international co-operation, distributive justice, differentiated societies and (modern) technologies. These issues, however, are not particularly relevant to my argument in the present chapter.

[12] When I am talking about the Deweyan idea of democracy in the following sections and chapters, I am solely referring to this core part of his theory, unless stated otherwise. This core part seems compatible with several richer concepts of democracy.

2.1.3 Resulting General Norms for Expertise in Policy

From the core of Dewey's political theory, one can derive some general norms for the role of scientific expertise in public policy – as necessary conditions for the desirability of scientific policy advice.

First, the offered scientific knowledge should, as far as possible, be sound and reliable (based on scientific rigor). This is precisely what can make scientific input so valuable for policy processes when compared with other types of knowledge (see also Sect. 2.2.4).

Second, the Deweyan stance implies that scientific advice ought to be relevant to a better understanding of the indirect consequences of human actions or to their successful regulation.

Third, scientific policy advice would be ineffective if the reliable and policy-relevant scientific insights were not well communicated to policymakers and the public.[13] Good communication means, among other things, that scientific advice is comprehensible, clear and accessible for everyone involved in the decision-making process.

Fourth, since Dewey's concept also includes the idea of political democracy as defined above, the democratic legitimacy of the potential influence of scientific experts on public policy is crucial. This requires sovereignty of interpretation and decision-making on the policy side, and it means that scientific experts should not be policy-prescriptive[14] or politically biased, particularly if their views are opaque.[15] Scientific experts should, as far as possible, adhere to political impartiality. The democratic public also need to be able to somehow control the interactions between experts and politicians, which have to be transparent.

Does this mean, however, that the ideas for assessment-making developed in this book are only valid and reasonable when applied to countries that agree with the above concept of democracy? No, these thoughts can apply, for instance, to the IPCC, whose member nations are not all governed by democratic systems.

Such a normative approach as taken in this book will, of course, only be convincing for those who accept its (partly democratic) premises and arguments. However, many of the above aspects are presumably also important for those governments or actors who are not following the democratic ideas outlined above. Rulers in non-democratic countries are also interested in thorough scientific assessments of policy options in order to achieve "good" policy-making (howsoever defined); therefore, they also demand sound, policy-relevant, and well-communicated scientific results.

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13 See Sect. 3.1 for the need for a transformation and translation of scientific results for policymakers and the public; see also Habermas (1968) and Grundmann and Stehr (2011).

14 This can be understood in the broad sense of the preference of specific, disputable policies over others, either directly or indirectly.

15 In order to avoid one-sided presentations of scientific results, the scientific advice needs to be comprehensive with regard to the existing scientific assumptions and findings in the literature on a specific policy-related issue.

Additionally, although they do not demand “democratic” legitimacy, I assume they would be greatly interested in transparent scientific advice that is not prescribing them what to do. Furthermore, although there is no free, *democratic* public discourse in non-democratic countries like China, there are pressure groups and corresponding discourses.

We can, however, slightly modify the claim from “democratic legitimacy” to “non policy-prescriptive and politically legitimate knowledge, including transparency,” or in short, “political legitimacy.” In this way we can achieve a provisional set of four general norms for scientific expertise in public policy, in terms of necessary conditions for desirable scientific policy advice: (1) sound science, (2) policy-relevance, (3) good communication and (4) political legitimacy.

These general norms are very robust in the sense that they can – in different variations – frequently be found in the literature on science-policy interactions as well as in official IPCC documents[16]; the IPCC seems share to these generic norms. Mostly, the IPCC uses the term “policy-relevant but not prescriptive.” Most prominently, such norms have been defined, justified and well-explored in the series of studies provided by the Harvard “Global Environmental Assessment” project[17] – in terms of “credibility, salience and legitimacy” to ensure the effectiveness of scientific assessments. Some years ago, this project, mainly based on empirical case studies, produced the most comprehensive and authoritative research on scientific assessment-making to date. In contrast to these studies, by drawing on Dewey’s political philosophy, my approach to justifying the general norms for scientific expertise in policy is more normative as well as more material (i.e., less formal, less constructivist). My interpretation of the meaning of the general norms for scientific expertise in policy is, thus, slightly different from the suggested interpretation by the Harvard project.

2.2 Seeking an Integrated Climate Policy

Let us now have a brief look at some basic aspects of climate change and climate policy (Sects. 2.2.1, 2.2.2 and 2.2.3), and apply Dewey’s political philosophy to current climate policy-making. This will show the extent of the need for scientific expertise to better understand practical consequences of human actions and what their regulation options may mean in practice. More precisely, it will show why integrated economic expertise is so valuable in climate policy (Sect. 2.2.4).[18]

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[16] See, e.g., IPCC (2008), Cash et al. (2003), Creutzig et al. (2012, pp. 66–68).

[17] See http://www.hks.harvard.edu/gea/, accessed 31 Aug 2014, and the summary paper by Cash et al. (2003), including the definitions of their general norms.

[18] For an overview of the current knowledge on the physics, economic issues and policies of climate change, see IPCC (2014c), Edenhofer et al. (2013), Wagner and Weitzman (2015) and IPCC (2014b, Chaps. 1–4).

2.2.1 Climate Change: Why Worry?

As we can learn from the latest IPCC assessments (AR5, see particularly the synthesis in IPCC 2014c), the global average temperature rose about 0.85 °C since the beginning of the industrial revolution. Most of the warmest years on record (since 1880) have been in recent years. However, that there are considerable differences between regions. To summarise the strongest evidence for current climate change:

> Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased (IPCC 2013, SPM.B titled 'Observed Changes in the Climate System').[19]

There is much evidence and high agreement in the scientific community that this global warming (and the resulting climate change) is mainly anthropogenic (IPCC 2013). It is primarily caused by the anthropogenic emissions of CO_2, which is very long-lived in the atmosphere and the most important greenhouse gas (GHG), and of other GHGs that are primarily emitted through the combustion of fossil fuels (coal, oil and gas) in the energy sector (including energy supply, industry, transport, buildings, etc.). Additional causes include deforestation and agriculture.

Less certain are the future developments of climate change, not only due to soaring uncertainties about human behaviour (future emissions, etc.), but also due to uncertainties in the climate system, i.e., in the interplay of the atmosphere, hydrosphere, biosphere and geosphere (UN 1992). The best guesses of the AR5 scenarios concerning the rise in global average temperature by 2100 above pre-industrial levels range from roughly 2° to roughly 5° Celsius, depending on the respective scenario. There is some delay (inertia) in the reaction of the climate to GHG emissions, mainly due to CO_2 sinks such as oceans and forests.[20] This has two important implications: First, we are already committed to a further global warming of at least 0.6 °C even if we counterfactually imagine that humankind had already stopped its GHG emissions in 2000. Second, future people would particularly benefit from the reduction of GHG emissions. The long-term impact together with the partial irreversibility of the consequences of climate change makes climate change a paradigm for questions of intergenerational justice.

Many of the more specific, and regionally diverse, future impacts of climate change in biophysical and socio-economic terms are highly uncertain, but one can already observe some of these impacts today (IPCC 2014c). The main actual and potential consequences – with the negative ones outweighing the positive – of human interference with climate change include acidification of oceans, endangering

[19] I can recommend this section for an overview of the evidence for current climate change. See particularly Table SPM.1.

[20] "Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90 % of the energy accumulated between 1971 and 2010 (*high confidence*), with only about 1 % stored in the atmosphere. […] The ocean has absorbed about 30 % of the emitted anthropogenic CO_2" between 1750 and 2011 (IPCC 2014c, SPM).

maritime ecosystems; an increase in extreme weather events such as storms, droughts or floods; a change in precipitation patterns and winds also resulting in regional decrease of agricultural yield and water availability; a great loss of biodiversity; rising sea levels, particularly endangering archipelago states and residents at river mouths; as well as an increased risk of epidemics and other health issues (IPCC 2014c; Smith et al. 2009). People suffering from poverty will be particularly affected by climate change because (1) they live in geographically more vulnerable areas (such as the Sahel); (2) they have less technological, economic and infrastructural opportunities to adapt appropriately to climate impacts (e.g., building large dams); and (3) they are much more dependent on the agricultural sector, which is badly affected by the impacts of climate change (Edenhofer et al. 2012).

There could, however, also be non-linear and irreversible changes to the earth's system involving the so-called tipping points, such as the melting of Greenland's ice at about 2–4 °C above the pre-industrial level leading to an approximate 7 m rise in sea levels, on average, or the thawing of permafrost leading to the release of large amounts of methane, one of the strongest GHGs (Lenton et al. 2008). Although some tipping points are shaded with high uncertainty and the likelihood of occurrence is rather low for some of them, they still pose a huge problem for humanity (Weitzman 2009). They may potentially lead to a state that could undoubtedly be referred to as a "catastrophe" (e.g., the 7 m average sea-level rise, or the "vicious circle" effects of tipping points accelerating further global warming so that it becomes virtually unstoppable).

However, due to different ethical points of view, there are very different understandings and metrics of "risk," "costs," "catastrophe," "vulnerability," "dangerous climate impact," etc.

2.2.2 Basic Economic Aspects of Climate Change (Mitigation)

There are basically two strategies to tackle the challenge of climate change: mitigation of climate change and adaptation to the unabated climate change. As argued in Chap. 11, both strategies actually have to be combined. However, because mitigation is the more fundamental necessity – serious adaptation to a 4° or 5° warmer world and to the related risks of tipping points is hardly possible for humankind, let alone for other species –, and because mitigation is the key example used in Part III on the economics of climate change, I will mostly focus on mitigation here. Thus, what can be done in order to avoid the potentially catastrophic adverse consequences of climate change, particularly vicious circles resulting from the irreversible activation of tipping points, which can already happen at 2 or 3 °C above pre-industrial levels? Since GHG emissions are the main cause of current global climate change, it is only natural to start by thinking about reducing them in order to avoid dangerous climate change (howsoever defined). Ambitious climate change mitigation targets[21] would require drastic reductions of GHG emissions in the near future and possibly even a completely "decarbonised" energy sector of the world economy in the second half of this century (IPCC 2014b). It would also require that all big emitters reduce their GHG emissions, since it does not matter for global warming where on the planet or by whom GHGs are emitted. Although climate change is mainly caused by wealthy countries and mainly affects the poorest nations, it could, in principle, only be tackled through a more or less global effort (Edenhofer et al. 2012). The most recent IPCC assessment talks about a "global commons problem" (IPCC 2014b, SPM, footnote 4). For effective mitigation, it is thus crucial to limiting the overall, global budget of carbon emissions released into the atmosphere, for instance to achieve the popular target to limit global warming to 2 °C above pre-industrial levels, i.e., the "2 °C goal":

> limiting total human-induced warming to less than 2 °C relative to the period 1861–1880 with a probability of >66 % would require cumulative CO_2 emissions from all anthropogenic sources since 1870 to remain below about 2900 $GtCO_2$ […]. About 1900 $GtCO_2$ had already been emitted by 2011 (IPCC 2014c, SPM).

One of the most exciting insights from the recent IPCC WG III report (IPCC 2014b) is that achieving the 2 °C goal is still possible at moderate economic costs.[22] But the report also lists some major requirements, such as availability of a broad range of low-carbon energy technologies, peak and strong decline of emissions rather soon, all major emitters reduce their emissions, market-based policy instruments (carbon taxation or emission trading scheme), etc.

In terms of temperature targets, ambitious mitigation efforts (for instance, the 2 °C goal) do not mean that the aspired limit of the global mean temperature increase can be achieved with certainty if GHG emissions are reduced to a certain extent. Instead, these targets – due to the above-mentioned uncertainties – can only aspire to reduce the probability of exceeding the respective global average temperature. Additionally, even if global warming was limited to a certain temperature, this would once again only reduce the probability of causing further severe climate impacts (Knopf et al. 2012a), such as the activation of some tipping points. The climate system is complex; therefore, climate policy is essentially about dealing with substantial uncertainties and with the long-term and non-linear risks of

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[21] The IPCC (2007c, p. 818) defines "mitigation" as "implementing policies to reduce GHG emissions and enhance sinks" through "[t]echnological change and substitution that reduce resource inputs and emissions per unit of output." A "mitigation target" (in contrast to "adaptation"), thus, usually refers to the mitigation of anthropogenic GHG emissions and comprises targets concerning global temperature, radiative forcing, atmospheric concentration, emissions or fossil fuel budgets, relative emissions reduction, etc. I am not fully satisfied with this narrow, possibly biased definition of mitigation as it, inter alia, excludes many geo-engineering options that, theoretically, could also help mitigate climate change and its bio-physical impacts. Nonetheless, I will keep to this definition in this book in order to avoid confusion.

[22] Under ideal conditions, consumption in 2100 would only be reduced by 4.8 % compared with current levels for a very ambitious mitigation scenario, and the reduction of the annualised consumption growth rate for the same scenario would only be 0,06 % (IPCC 2014b, Table SPM.2). See Box TS.9 for an explanation of the meaning of 'mitigation costs.'

influencing the climate system. Nonetheless, the drastic reduction of GHG emissions would, as far as we know, reduce the main risks of climate impacts considerably, particularly regarding tipping points and poor countries (IPCC 2014a; Lenton et al. 2008; Smith et al. 2009; Weitzman 2009; Knopf et al. 2012a).

Yet in recent years, global CO_2 emissions reached levels never witnessed before (Olivier et al. 2011), approaching the "business-as-usual" scenario of previous IPCC assessments (e.g., 2007a). This means that we are currently heading towards a high probability for a global average temperature that is more than 4 °C above pre-industrial levels by 2100, which is far more than civilisation has ever experienced before. Such a temperature increase will surely have many negative effects on ecosystems and socio-economic systems all over the world, although they are uncertain in detail. In addition, there would be, as was said above, some risk of triggering certain tipping points with potentially catastrophic consequences.

One central reason why humankind is still on such a dangerous path is certainly because energy supply through the combustion of fossil fuels (as well as most other climate-damaging activities, such as deforestation and agriculture) is fundamental for most economies today. The historical development of wealth in the industrialised countries is largely based on the use of fossil fuels, since they were a relatively cheap and abundant source of energy to meet the extensive demand by industry (Edenhofer et al. 2012). Particularly in the aftermath of the global economic and financial crisis, many countries (e.g. India) point out the need for further economic growth and a sufficient and cheap energy supply in order to overcome the current crises experienced by many countries, or even to avoid a collapse of the whole national and international economic system, which could possibly lead to severe social conflicts. Hence, most nations are understandably hesitant to revolutionise their energy systems at potentially high costs (if they assume that the substitution of fossil fuels is expensive for them) in order to mitigate GHG emissions, from which mostly future persons would benefit.

Furthermore, some companies benefitting from fossil fuels (and partly from the still high subsidies for fossil fuels)[23] understandably dislike ambitious political mitigation actions. The essential meaning of a fossil fuel-based energy supply for the global economy is indirectly reflected by a ranking of the biggest companies in the world (in terms of annual turnover): the majority of the top ten companies are involved with fossil fuels.[24]

Moreover, the need for energy will probably increase dramatically in the twenty-first century, particularly due to massive economic growth in some emerging economies such as China (IPCC 2007c, Chap. 4; Edenhofer et al. 2010). In addition, the hope that fossil resources (coal, oil and gas) will run out and the climate problem

[23] The "IEA estimates that subsidies that artificially reduce the price of fossil-fuels amounted to USD 409 billion in 2010 – almost USD 110 billion higher than in 2009," see http://www.oecd.org/newsroom/oecdandiearecommendreformingfossil-fuelsubsidiestoimprovetheeconomyandtheenvironment.htm (accessed 14 Aug 2014).

[24] Source: The news on http://money.cnn.com/magazines/fortune/global500/2011/full_list/ (accessed 14 Aug 2014).

will thus be solved automatically is unjustified. There is still a large amount of coal and gas as well as a considerable amount of oil in the ground, much more than an ambitious climate policy target can cope with, if all these fossil fuels are extracted and combusted (Knopf et al. 2012b, p. 141; IPCC 2014b). Even worse, one can currently observe a renaissance of relatively cheap coal, particularly in China (Edenhofer et al. 2008; IPCC 2014b).

Thus, one major problem of climate change that is highly relevant for all economies seems to be balancing (1) the probable benefits of mitigation in the long-term and (2) the difficulties and potential costs of radically abandoning fossil fuels for mitigation, particularly in terms of economic growth and the need for an increasing yet affordable energy supply. In the case of lacking climate change mitigation efforts, however, adaptation to the likely climate impacts (tipping points, etc.) in the future would be almost impossible, as far as we can imagine today (Stern 2007; IPCC 2007b, 2014a; Edenhofer et al. 2012). The often costly adaptation to climate change impacts is, to some extent, necessary in any case, since we are already experiencing climate impacts today and, due to inertia, we are already committed to some further global warming as a result of previously emitted GHGs (see above, Sect. 2.2.1).

Because of the difficulties and dangers of mitigating GHG emissions, measures for large-scale engineering of the climate system – so called "geo-engineering" measures – are considered an alternative climate policy option (Royal Society 2009). They could help reduce global warming while still allowing for the combustion of fossil fuels. There are, however, plenty of big problems with geo-engineering, particularly with solar radiation management (Royal Society 2009; Knopf et al. 2012b): (1) many of the geo-engineering ideas are still immature or unrealistic, and costly; (2) they mostly have only limited potential to avoid further climate change and could at best serve as a supplement to mitigation technologies; (3) they possibly have many risks (even political ones) and side effects; and (4) very importantly, most geo-engineering measures do not address another adverse effect of CO_2 emissions: the acidification of the oceans.[25]

Consequently, drastically reducing GHG emissions ("mitigation") – tackling the climate problem at its source – is still indispensable for now (with or without additional geo-engineering), if the adverse impacts of human interference with the climate system are to be reduced. This implies that permissions to use the atmosphere as a dumpsite for GHG emissions have to be limited, which could also imply a massive redistribution of wealth (depending on political decisions, see Edenhofer et al. 2013) – especially if the transformation of the energy system towards a

[25] This implies that the "climate problem" is to be regarded as more than only "global warming," and that there are further adverse consequences of the human interference with the climate system particularly through anthropogenic GHG emissions and the change of GHG sinks. "Since the beginning of the industrial era, oceanic uptake of CO_2 has resulted in acidification of the ocean; the pH of ocean surface water has decreased by 0.1 (*high confidence*), corresponding to a 26 % increase in acidity, measured as hydrogen ion concentration" (IPCC 2014c, SPM).

carbon-free economy cannot be achieved at low costs. This distributional dimension is one of the most important economic implications of climate policy.

There are many other important economy-related aspects of climate change (see also Part III). For instance, climate change impacts affect economies, adaptation to climate change has its price as well, and the mitigation measures and technologies can have multiple effects on other policy fields which has high relevance from a welfare economic perspective (IPCC 2014b). This section merely points out that climate change is essentially an economic problem. For now, three interim conclusions can be drawn for the overall project of this book: (1) Obviously, related to virtually all the mitigation, adaptation and geo-engineering options of climate change and to climate impacts themselves are globally and inter-temporally aggregated economy-related risks, costs and benefits, but also – from a disaggregated perspective – economic winners and losers (for instance, particular households, companies, national economies or entire generations globally). (2) The climate change problem can be regarded as being primarily an economic policy problem, rather than merely an environmental one (Edenhofer et al. 2013). (3) Consequently, due to the essential economic character of the climate problem and due to the high impact of many of these economic aspects of climate change on the well-being of many people, an appropriate political treatment of the economic aspects of climate policy is particularly crucial for climate policy.

2.2.3 *Climate Policy: Goals, Scope and Major Conflicts*

Given Dewey's concept of public policy (Sect. 2.1), the collective regulation of the indirect consequences of anthropogenic GHG emissions is clearly required. Climate change affects many people in the present and in the future, particularly in the poor countries, while the major CO_2 emitters in the past have been the wealthy countries. Climate policy then has to define "the" (ambiguous) climate problem, discuss solution strategies and the means (e.g. political, technological, economic) for their realisation, and implement the decisions made as law.

One could well argue for a (mere) prima facie ethical claim for both ambitious climate change mitigation, and adaptation against unavoidable climate impacts, in order to warrant human rights for present and future persons. Climate policy is however, like climate change itself, a broad field that is closely connected with other policy fields. These include economic growth and other economic objectives, poverty reduction and development,[26] social justice, sustainability and environmental issues, reliable energy supply, health and security, technology and R&D ("Research and Development"), and democratic decision-making. Therefore, issue linkage is required because these interrelated policy fields substantially affect human lives and human rights and can restrict the prima facie claim for climate change mitigation (in terms of trade-offs). The interaction between climate policy and other policy fields

[26] See, e.g., Gupta and van der Grijp (2014) and Edenhofer et al. (2012).

should, from a very basic, widely acceptable normative-ethical perspective, be taken into account when deciding the scope, goals and means of climate policy.[27]

If one accepts such a broad view of the task and scope of climate policy, due to the complexity and global reach of the climate problem, it needs to address an abundance of socially relevant aspects, conflicts and problems. Some of them are intergenerational conflicts, and others are intra-generational. Quite a few issues are related to distributive questions (global burden sharing).

Martin Weitzman rightly calls climate policy a wicked "problem from hell" for the following reasons: (1) the large-scale risks (non-linear), huge uncertainty and irreversibility; (2) the global and intergenerational dimensions (justice); and (3) its character of a global common-pool resource problem.[28]

History and agreements of international climate policy

The first international climate change conference was held in 1979, but without extensive political participation (Bodansky 2001). By the end of the 1980s, however, the climate problem had clearly become an international political issue, supported by, among other things, the generally increasing interest in environmental issues and sustainability together with specific reports and statements from scientists. The UN recognised "that climate change is a common concern of mankind, since climate is an essential condition which sustains life on earth" (UN 1988).

Since 1992, international climate policy has been organised under the "United Nations Framework Convention on Climate Change" (UNFCCC) with its annual Conferences of the Parties (COPs) which have taken place since 1995 (Bodansky 2001). The convention, which has since been ratified by all UN member nations (FCCC, UN 1992), aims at a "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".[29] The international community has struggled to reach a global agreement which is important because the *aggregated* global GHG emissions are decisive for climate change (see Sect. 2.2.2). The FCCC acknowledges, "the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response" (UN 1992). Issue linkage, as discussed above, can to some extent be found in the different negotiation groups under the UNFCCC framework.[30]

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[27] Similar arguments can be found in Edenhofer et al. (2012) and the IPCC WG III report (IPCC 2014b, Chaps. 1–4). In fact, there are also political incentives in this direction.

[28] This statement was made during his talk at MCC Berlin in May 2014, see http://www.mcc-berlin.net/en/events/event-detail/article/weitzman-on-geonengineering.html (accessed 30 Mar 2015).

[29] The FCCC defines the "adverse effects of climate change" as "changes in the physical environment or biota resulting from climate change, which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare" (UN 1992).

[30] The FCCC states "that various actions to address climate change can be justified economically in their own right and can also help in solving other environmental problems," "that responses to climate change should be coordinated with social and economic development in an integrated manner with a view to avoiding adverse impacts on the latter, taking into full account the legiti-

More recent COP documents confirm the FCCC: "We underline that climate change is one of the greatest challenges of our time. We emphasise our strong political will to urgently combat climate change" (UNFCCC 2009, COP-15 in Copenhagen). The COP-16 (2010) in Cancun affirmed that "all Parties share a vision for long-term cooperative action in order to achieve the objective of the Convention […], including through the achievement of a global goal, on the basis of equity" (UNFCCC 2010) and the COP-17 in Durban (2011) recognised that "climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires to be urgently addressed by all Parties" (UNFCCC 2011). The COP-18 in Doha (2012) even notes

> *with grave concern* the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020 and aggregate emission pathways consistent with having a likely chance of holding the increase in global average temperature below 2 °C or 1.5 °C above pre-industrial levels (UNFCCC 2012).

However, this does not say anything about the underlying political motives and motivations of the Parties nor the reliability of these usually rather weak "declarations of intent" by the international community.

In 1997, the COP-3 adopted the "Kyoto Protocol," an important international agreement on climate change mitigation that expired in 2012. Some major GHG emitters however, (particularly the US) did not join. Since the COP-13 in Bali ("Bali Road Map," 2007), the international community has been negotiating a new agreement beyond 2012 that should be global and legally binding. After the above mentioned failure of the COP-15 to come to such an agreement, local, regional and other alternative approaches became more attractive, at least in academic debates, criticising global top-down approaches (e.g., Falkner et al. 2010; Keohane and Victor 2010; and Victor 2011). This was also stimulated in part by the Nobel Prize in Economics (in 2009) for Elinor Ostrom's optimistic evaluation of economic governance of the commons and bottom-up approaches. In addition, there was increasing international agreement on the 2 °C goal and a roadmap to a global, binding agreement (UNFCCC 2011, 2012). As already said (Chap. 1), the COP-21 resulted in the relatively ambitious Paris Agreement. Inter alia the agreement between China and the USA in late 2014 regarding their respective domestic emission reduction goals may have substantially contributed to this achievement.[31]

The real net effect of approximately 25 years of climate policy negotiations however, is still very low, both in terms of GHG emission levels and financial support for poorer countries. Despite the ambitious long-term goals in the Paris Agreement ("decarbonisation," etc.), it is not at all clear whether (and how) most countries will

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mate priority needs of developing countries for the achievement of sustained economic growth and the eradication of poverty," and that the objective of the FCCC "should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (UN 1992).

[31] See https://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c (accessed 30 Mar 2015).

actually reduce their GHG emissions voluntarily and significantly, as the Paris Agreement claims. International climate policy is, thus, still far from *actually* accomplishing the above-mentioned aim of the FCCC on which the international community had agreed. Yet, there are some remarkable multi-national (e.g. Paris Agreement), national (e.g. German energy transition) and local political efforts to mitigate climate change and to improve climate change adaptation.

Core conflicts and problems of climate policy-making

There are several different reasons why the COPs have not yet fully met their own goals.[32] Among the reasons are conflicts[33] about different interests, normative assumptions and inter- or intra-generational justice concerning climate change.[34]

These issues are reflected in the political negotiations (Pickering et al. 2009; Beck 2009, p. 19). For instance, while most industrial countries also demand substantial mitigation efforts in both emerging economies and developing countries, poorer countries claim that industrialised countries are primarily responsible for climate change and, therefore, should assume more responsibility for mitigation as well as pay for adaptation in poorer countries. Furthermore, poorer countries argue that they need cheap fossil fuels for economic growth in order to overcome poverty and that developed countries should make their low-carbon technologies (ideally freely) available to them. Many regard conflicting national interests as the most decisive factor in climate negotiations, which have so far prevented the international community from reaching a global agreement (see Brennan 2009; Edenhofer et al. 2013; Dannenberg et al. 2010). Many of these interests and ethical disagreements concern economic aspects, including the distribution of wealth.

A full explanation of international climate policy and public debate is much more complicated however, and presupposes a particular theory of international relations, politics and public choice. The climate problem is, as has already been stated, multi-layered i.e. natural scientific, economic, and technological, etc. It has a global reach, and involves a great number of actors and stakeholders.

The major points of this Sect. 2.2.3 are, thus, *first*, the factual demand and ethical need for an integrated climate policy that takes into account the complex economic (and other) conflicts, risks and benefits related to climate change. *Second*, we saw that the political parties and international community have not yet satisfactorily addressed climate change because there is much disagreement, particularly regarding economic issues and related priorities, values and interests.

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32 See, e.g., Dimitrov (2010) for the COP-15, Szarka (2011) for the changing and interrelated roles of the US and the EU, or Rong (2010) for the positions of developing countries.

33 "Conflict" is understood in a very broad sense in this book, including all kinds of disagreements, trade-offs or aspects that are not easily harmonised.

34 Referencing certain moral standpoints in climate negotiations is, however, sometimes used as an excuse for strong national economic or economy-related interests (Lange et al. 2010), as these (pseudo) moral standpoints sound much more appropriate as a justification for the political decisions taken.

2.2.4 Economic Expertise Is Demanded and Needed for Climate Policy

Climate change would most likely not (yet) have become a subject of public concern and interest had there not been the institution of academia. After Keeling's famous examination of the atmospheric CO_2 concentration on Hawaii,[35] intensive academic research was conducted on climate change in the 1960s and 1970s. Political interest in this issue was awakened with the increasingly strong assumption in the scientific community that anthropogenic climate change exists (Jaeger and O'Riordan 1996; Bodansky 2001; Bolin 2007). Never before in history has scientific advice been so central to an important, globally relevant policy field as in the case of climate policy. Credible scientific expertise is obviously needed for well-informed climate policy-making. It is needed not only to identify indications of climate change and its causes, but also – particularly since the UNFCCC accepted the scientific hypothesis of anthropogenic climate change – for estimating the future evolution of the climate. It also helps determine its impacts and consequences which are not easy to observe and attribute to climate change.

Hardly anyone would doubt the need for natural-science expertise in climate policy. Does an integrated climate policy also, however, require a thorough academic scrutiny of the socio-economic aspects of climate change? In my experience, quite a few scientists and environmental activists reject this view. They assume that the impacts of climate change are severe and that low-carbon technologies are available as alternatives in the energy sector. They regard climate change as primarily an environmental problem. They argue that we are already well aware of what needs to be done in climate policy. If anything, we need (even more) natural sciences to convincingly demonstrate the risk of adverse climate impacts, along with the widely accepted assumption of human rights, some "contextualisation" by political scientists as well as communication psychology.

I disagree with this view. Sections 2.2.2 and 2.2.3 have argued that socio-economic aspects of climate change are among the *most important* issues of our time and therefore politically highly relevant, but they are also *disputed* due to conflicting interests, etc. Moreover, some of the socio-economic risks related to climate policy options are still *poorly understood* and uncertainty is still high (Dietz et al. 2009; IPCC 2014b). The economics of climate change is highly complex due to the many trade-offs and other interdependencies. Multiple scales, governance levels and policy fields are affected.[36] As already stated in Chap. 1, some governments are

[35] In the nineteenth century several academics had already researched the possible climatic effects of GHGs in the atmosphere.

[36] Wagner and Weitzman (2015) as well as the IPCC (2014b) clearly argue that climate change mitigation in particular is all but trivial, and gives rise to several substantial risks and uncertainties as well as huge complexity. Recently, there have been calls for more social-science research on climate change, e.g., Agrawal et al. (2012), Weaver et al. (2014), Victor (2015) and the EU research funding priorities (http://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges, accessed 31 Mar 2015).

increasingly interested in better understanding the climate policy options at stake so they can tackle the issue of climate change and related trade-offs.[37] The COP-17 realised

> that consideration of a global goal for substantially reducing global emissions by 2050 and the time frame for global peaking of greenhouse gas emissions cannot be undertaken in the abstract and will necessarily involve matters related to the context for such considerations (UNFCCC 2011).

Hence, the ethical importance, the high complexity and the gaps of knowledge related to the disputed socio-economics aspects of climate change call for thorough, systematic studies into these aspects. In Dewey's terms, an appropriate regulation of the indirect consequences of climate change in a democratic, well-informed and deliberative manner requires expertise regarding various socio-economic aspects, without discounting the need e.g. for natural sciences.

Socio-economic knowledge based on elaborate and reliable methods of scrutiny is required. The reason why the scientific community is particularly suited to deliver such expertise is their systematic approach. In the scientific community the use of and reflection on systematic methods is highly institutionalised, with fairly long-term and in-depth enquiries being undertaken and reviewed by well educated scientific experts. The knowledge aspired to is particularly provided by the societal institution of economic science, including academic economists at universities, but also professional economic scientists and experts at non-university institutions, such as research institutes, think tanks, industry, etc., who are part of the wider "scientific community. If a tricky, laborious and extensive enquiry is required, as in the case of complex policy issues, it may therefore be best to draw on this competent and capable societal group regarding such an enquiry.[38] Chapter 1 also briefly argued that *scientific assessments* would be the most appropriate format at the science-policy interface to generate and provide the integrated economic knowledge aspired to. This is because despite the existing individual social-science publications on climate change, this research has to be synthesised in an interdisciplinary manner, also given that social science research is often inconclusive and rarely aggregated (Van Slyke et al. 2010).

According to Adler and Rietig (2013), there are four research areas of primary importance for the social sciences and humanities in the area of global environmental change: (1) equity and equality; (2) policy, political systems, governance; (3)

[37] As an extreme, hypothetical example of the relevance of economic knowledge for climate policy, imagine two different fictitious worlds. In one the economic studies show that an ambitious global climate change mitigation target would cost 1 % of the global GDP by the end of the century. In the other it would reach 50 % of the global GDP. This would clearly make a difference to the social acceptance of ambitious mitigation options, other things being equal. See also Beckerman (2011, p. 13). He further states (p. 33): "however compelling is the ethical appeal of certain normative propositions, much will still depend on […] economics."

[38] Dewey (1927) elaborates on these characteristic capacities of the scientific community. Reliability necessarily requires transparency of the epistemic status and the context of scientific statements (see also Sect. 3.1 and Chap. 6).

economic aspects; and (4) social and cultural contexts and transitions.[39] More precisely, integrated economic analyses of climate policy options according to the academic state-of-art, as well as an assessment of their prospects and limitations, including costs, risks and benefits, are particularly needed. Within the political processes, integrated economic expertise may help understand the different issues at stake, their potential solutions, major requirements and trade-offs. The following three examples of research gaps regarding climate change mitigation[40] options indicate that, in fact, it is hard to say which policy options would be best.

1. Side effects, risks, and co-benefits of low-carbon energy technologies: in a world of multiple policy objectives, economic estimates of these aspects according to a social welfare framework would obviously be most interesting for public policy-making.[41]
2. Implications of carbon pricing instruments for public finance and distribution of wealth: what are the macroeconomic and distributional effects of carbon taxation (under different assumptions and design choices)?[42] Can carbon taxation contribute to a fair and efficient public finance policy in times of economic and financial crisis?
3. Climate policy and sustainable development: how do climate policies and national (sustainable) development efforts interact? What are the trade-offs? How realistic is a low-carbon energy production in developing countries in the near future ("leapfrogging")?[43]

Those who argue that there is no need for integrated assessment of socio-economic aspects of climate change are mistaken. They seem to underestimate the complexity and uncertainty, particularly of climate change mitigation. However, the "recognition of the role of social sciences and the humanities in leading and framing global environmental change research agendas has still not been fully realised" (Adler and Rietig 2013, p. 158). Apart from some "ordinary disciplinary inertia" (Parker 2014, 31f), there is yet another reason why many people disagree with the notion that the social sciences can substantially contribute to climate policy. Although these people may agree with the theoretical need for integrated economic knowledge surrounding climate policy options, they doubt that economics and other social sciences can actually deliver reliable, legitimate, and policy-relevant insights into climate policy. Usually they doubt that the methodologies of the social sciences can successfully deal with the uncertainty, complexity and normative dimension of

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[39] One should also consider the meta-level, including social-science and philosophical research on the science-policy interface and assessment-making. Parker (2014) specifies social-science research needs regarding climate change. She states: "So far, however, the social sciences have been somewhat slow to engage with the issue of climate change" (Parker 2014, 31).

[40] There is a need for integrated economic analysis regarding the understanding of climate impacts and also regarding adaptation options.

[41] Some examples can be found in IPCC (2014b).

[42] See, e.g., Siegmeier et al. (2015).

[43] See, e.g., Jakob and Steckel (2014) and IPCC (2014b).

their policy-related research objects. Hence, as they sometimes argue, the discussion of appropriate policies and measures should be left to governmental officials and their agencies (ministries, etc.). These doubts will be addressed in Parts III and IV; I will argue that, to some extent, it is possible to deal with these challenges. Based on Dewey's political philosophy, Sect. 2.2 thus only argued that there is a prima facie need for integrated economic research on climate change and climate policy. This integrated economic research, if taken up in assessments, should, however, allow assessments to comply with the general norms of scientific expertise in climate policy (Sect. 2.1.3).

2.3 The IPCC WG III and Its Assessments of Mitigation Options

Most governments seem to share the view that economic expertise is needed in order to generate well-informed climate policy-making according to the objectives of the FCCC. The FCCC recognises

> that steps required to understand and address climate change will be environmentally, socially and economically most effective if they are based on relevant scientific, technical and economic considerations and continually re-evaluated in the light of new findings in these areas (UN 1992).

This is among the reasons for the formation of the IPCC. What is the IPCC and how is it structured? The IPCC is a big and influential (see Sect. 3.1.3) institution which bridges (all kinds of) scientific expertise and climate policy processes. It is the leading international body for *assessing the scientific knowledge related to climate change*.

The IPCC publishes reports, technical papers and supporting materials. To synthesise the current state of scientific knowledge, the most important products of the IPCC are the periodic (released approximately every 6 years) and multi-volume scientific Assessment Reports (ARs) as well as Special Reports. "The task is extraordinarily complex because of the broad scope of the assessment and the fact that it is assembled by a complex, decentralized, worldwide network of scholars" (IAC 2010, p. 7). In fact, "[w]ritten by over 800 scientists from 80 countries, and assessing over 30,000 scientific papers,"[44] the IPCC AR5 is a quite comprehensive assessment conducted by the scientific community, on a voluntary basis.

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[44] Source: http://www.ipcc.ch/news_and_events/docs/ar5/150318_SYR_final_publication_pr.pdf (accessed 30 Mar 2015).

As an intergovernmental panel,[45] however, the IPCC is not a "pure scientific" institution. Rather, it has a hybrid character where the organisation[46] is driven primarily by governments and the scientific assessments are driven largely by the leadership and network of scientific experts. Having said this, governments are also engaged in scoping and reviewing the reports as well as approving the summary document. This structure is supposed to give the IPCC "muscles" (Beck 2009, p. 95). Under such an umbrella, both scientific authority (credibility) and political commitment (acceptance) can be addressed together. In this sense, "the thousands of scientists and government representatives who work on behalf of the IPCC in this non-traditional partnership are the major strength of the organization" (IAC 2010, p. 1). The intergovernmental, hybrid character of the IPCC at the science-policy interface is rather special.[47]

In addition to the Panel with its high decision-making power, the IPCC has established a Bureau, the "Task Force on National Greenhouse Gas Inventories," and three Working Groups (WGs) that address different scientific aspects of climate change. For the AR4 and the AR5, their mandate was to assess the physical scientific basis of climate change (WG I), impacts, adaptation and vulnerability (WG II), and mitigation of climate change (WG III). To summarise:

> [T]he IPCC assessment process sits at the interface between science and policy and necessarily involves both governments and scientists. Governments – the Member nations of WMO and UNEP – agree on the scope and outline of the periodic reports, nominate authors, review the results, and approve the Summaries for Policy Makers. They also select the scientific leaders of the assessment process. More than a thousand volunteer scientists from around the world – often supported by their universities, government laboratories, and nongovernmental organizations – evaluate the available information on climate change and draft and review the assessment reports (IAC 2010, p. 7).[48]

Why was the IPCC created?

In the 1980s, concerns about anthropogenic climate change increased as a result of some scientific studies. Therefore, in 1988, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the IPCC with the endorsement of the UN General Assembly to assess the scientific

[45] The IPCC "is open to all member countries of the United Nations (UN) and WMO. Currently 195 countries are members of the IPCC. Governments participate in the review process and the plenary Sessions, where major decisions about the IPCC work programme are taken and reports are accepted, adopted and approved. The IPCC Bureau Members, including the Chair, are also elected during the plenary Sessions" (source: http://www.ipcc.ch/organization/organization.shtml; accessed 30 Mar 2015).

[46] The relatively small IPCC Secretariat has the task of coordinating the IPCC work and liaises with the governments.

[47] The core idea, i.e. assessing the scientific literature and involving stakeholders, is also realised in many national science-policy bodies (see Beck 2009, pp. 16 and 24).

[48] For more information about the IPCC's organisational structure and history, see the concise introductions by the IPCC itself: http://www.ipcc.ch/organization/organization_structure.shtml, http://www.ipcc.ch/news_and_events/docs/factsheets/FS_what_ipcc.pdf and http://www.ipcc.ch/news_and_events/docs/factsheets/FS_timeline.pdf (all accessed 30 Mar 2015).

basis of the potential risks and consequences of anthropogenic climate change as well as options for mitigation and adaptation, including economic aspects (Bolin 2007, IAC 2010). The IPCC summarises its mandate, which has changed somewhat over the years (Beck 2009, Chap. 5), as follows[49]:

> The role of the IPCC is to assess […] the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation (IPCC 2004).

The IPCC aspires to scientific robustness, as well as the applicability of its products in policy and politics (Beck 2009, p. 127). Another aspect of the IPCC's mandate is to identify uncertainties and gaps in knowledge (IPCC 2004, p. 2), but also to develop new scientific standards (i.e., standard scientific references such as in scenario building).

> IPCC assessments provide a scientific basis for governments at all levels to develop climate-related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive.[50]

The IPCC's mandate, thus, is neither scientific research[51] nor policy-making, but rather scientific assessment to inform public policy. There were, however, certainly several additional, political reasons for some governments to support the idea of establishing the IPCC.[52]

How does the IPCC work?

The details of the IPCC's assessment process are perfectly summarised on the IPCC website.[53] The core principles guiding the work of the IPCC are, *first*, to assess the available scientific knowledge "on a comprehensive, objective, open and transparent basis" (IPCC 2004). *Second*, "[r]eviews by experts and governments are an essential part of the IPCC process" (IPCC 2004), and *third*, "[t]he work of the organization is therefore policy-relevant and yet policy-neutral, never policy-prescriptive."[54]

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[49] A graphical tour through the IPCC history and the development of the ARs is provided by Jones (2013).

[50] Source: http://www.ipcc.ch/news_and_events/docs/factsheets/FS_what_ipcc.pdf (accessed 30 Mar 2015).

[51] The IPCC does not conduct new research or monitor climate-related data. Yet, scientific assessment-making, i.e., the synthesis exercise, itself can be regarded as a fully respectable and serious scientific task on its own (see Part IV below).

[52] Some academic and political motives, as well as contexts for the foundation of the IPCC, are discussed in Hecht and Tirpak (1995), Agrawala (1998a and b), Beck (2009) and Bolin (2007).

[53] See http://www.ipcc.ch/organization/organization_procedures.shtml. There you can also find the figure summarising the IPCC AR process. The review process is summarised here: http://www.ipcc.ch/news_and_events/docs/factsheets/FS_review_process.pdf. For information on how IPCC authors are selected, see http://www.ipcc.ch/news_and_events/docs/factsheets/FS_select_authors.pdf (all accessed 30 Mar 2015).

[54] See http://www.ipcc.ch/organization/organization.shtml, accessed 30 Mar 2015.

Over the course of several years, three drafts of each AR are produced: The "Zero Order Draft," the "First Order Draft" and the "Second Order Draft." External reviews are organised for the first and the second draft, including a governmental review. The "Summary for Policymakers" (SPM) is drafted by experts, reviewed by governments, and then has to be approved sentence by sentence during the IPCC plenary (usually 1 week, often with several night sessions of negotiation and contact groups). The underlying report, however, is not approved by the plenary, but accepted chapter by chapter.

A rigorous and multi-layered review has always been essential for the work of the IPCC, and scientific credibility is among the highest priorities. An almost incredible number of 142,631 review comments were made on the entire IPCC AR5 at different stages, both by experts and governments.[55]

Economic assessments by the IPCC Working Group III

This book primarily focuses on the WG III (see Chap. 1). The WG III is, largely, about the economics of climate change because the possible response strategies as discussed in WG III, tend to have an economic focus (Sect. 2.2.2). Nonetheless, the WG III also concentrates "on new literature on the scientific, technological, environmental, economic and social aspects of mitigation of climate change" in an interdisciplinary manner (IPCC 2007c, p. 3, SPM). The author structure changes from assessment cycle to assessment cycle, so while the WG III AR4 contribution seems dominated by technological questions from engineers, economics again prevailed in the AR5. Leading economists contributed to the WG III AR5, and this WG III contribution

> provides a comprehensive and transparent assessment of the scientific literature on climate change mitigation […] The report assesses mitigation options at different levels of governance and in different economic sectors. It evaluates the societal implications of different mitigation policies, but does not recommend any particular option for mitigation (IPCC 2014b, Preface).

Compared with WG III AR4, the AR5 provides an "improved treatment of risks and risk perception, uncertainties, ethical questions as well as sustainable development" (IPCC 2014b, Preface). The WG III AR5 report consists of four parts:

- Part I: Introduction (Chap. 1)
- Part II: Framing Issues (Chaps. 2 and 4)
- Part III: Pathways for Mitigating Climate Change (Chaps. 5, 6, 7, 8, 9, 10, 11 and 12)
- Part IV: Assessment of Policies, Institutions and Finance (Chaps. 13, 14, 15 and 16)

The SPM and the underlying chapters of the IPCC WG III AR5 report were approved at the 12th Session of IPCC WG III in April 2014 (Berlin). Both the WG

[55] http://www.ipcc.ch/news_and_events/docs/factsheets/FS_review_process.pdf, accessed 30 Mar 2015.

III contributions to the AR4 and the AR5 will be briefly evaluated in Chap. 10 below; Sect. 3.1.3 discusses the impact and influence of the IPCC assessments.

All of the more recent IPCC reports are available online. Moreover, the IPCC has invested in communications by producing presentations and videos summarising the AR5 results and making them also available online (www.ipcc.ch).

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Chapter 3
Fundamental Perils for Scientific Assessments

Abstract There are some fundamental perils for the role of the sciences in policy, which also affect economic assessments. Based on a discussion of these perils, this chapter identifies the key challenge of bridging scientific expertise and public policy. Section 3.1 provides the background for this by describing that in practice, neither scientific knowledge production nor political decision-making follow simple rationalistic and functionalist ideals. Rather, multiple (often conflicting) motives are involved in, for instance, scientific assessment-making. Yet, scientific assessments can have some desirable influence on policy-making processes if certain requirements are met. Section 3.2 introduces the fundamental problems and perils of scientific policy advice. One of the most challenging issues is the treatment of value judgements, particularly in policy assessments; this issue endangers sound science, policy-relevance and political legitimacy. Section 3.3 provides some examples in terms of existing criticism of the Intergovernmental Panel on Climate Change (IPCC), and, finally, Sect. 3.4 identifies the trade-offs between the general norms for scientific expertise in public policy as being the key challenge of scientific expertise in policy. The framework for the IPCC envisaged in this book has to successfully respond to this key challenge.

The normative ideal developed in the previous chapter states that climate policy requires integrated economic assessments of climate change and of the response options – provided that these assessments comply with the general norms of policy-relevance, sound science, political legitimacy and good communication. Following Dewey's arguments, climate policy can hardly be successful from a social perspective if such assessments are lacking; it may result in policymakers missing or misinterpreting aspects that are ethically crucial. Realistically, however, this envisaged kind of assessment-making faces multiple obstacles, perils and problems. At the end of this chapter, the key challenge – to which the envisaged framework for the IPCC has to respond – should become clear.

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3.1 Motives, Impact and Limitations of Expertise in Policy

One fundamental potential obstacle to the above-mentioned (prima facie) ideal for integrated assessments in climate policy is the allegedly extremely limited degree to which scientific assessments can have directed impact on policy decisions. At least some observations and several policy change theories, discussing the conflicting motives, limited capacities and complex dynamics of the players and processes at the science-policy interface, suggest that the sciences can only have little directed influence on public policy processes (Sabatier 2007). If this were true, our search for an appropriate normative framework for integrated economic assessments would not be overly relevant for policy-making. We thus have to briefly examine whether the sciences can have a considerable impact on policy processes – and, as the underlying assumption, whether scientific knowledge production can be reliable at all given multiple motives and inertia in academia.

Tora Skodvin summarises the flawed and oversimplified, yet popular view of scientific knowledge production and policy/politics with "impartiality and disinterestedness on the one hand, and strategic behaviour and interest realisation on the other" (1999, p. 4). Scientific knowledge production is, she continues, usually and mistakenly seen as a "truth-seeking endeavour," and as "pure, objective, subject to rational analytical reasoning." Politics, in contrast, is characterised as a

> hostage to manipulation tactics and coercive power […and] strategic reasoning where the instrumental utilisation – as well as manipulation and distortion – of knowledge may constitute central elements in political strategies whereby individual interests are sought realised. […] While both theoretical analyses and experience show that the relationship between science and politics by far is as clear-cut as this image suggests, this image has a strong position in the public as well as among practising scientists and policy-makers themselves. Thus, any interactive dialogue between these two systems of behaviour takes place in the shadow of this image which suggests that the interaction itself implies a risk of political "contamination" of the scientific process and a serious loss of legitimacy (Skodvin 1999, p. 4).

Deepening the discussion of the limitations of Dewey's democracy theory (Sect. 2.1.2), we therefore need to know more about the factual motives, rationalities and patterns underlying both scientific knowledge production and public policy-making (Sect. 3.1.1).[1] In order to not fall prey to illusions about the science-policy interface when analysing the IPCC's integrated economic assessments, it is necessary to understand both scientific knowledge production and policy-making processes. Section 3.1.2 describes how this helps us understand their interaction and find out what (directed) role scientific expertise can play in policy processes given the

[1] In contrast to "politics," which is about processes and power struggles, public "policy" refers to contents, i.e., to institutionalised political fields that represent larger, long-term political problems and related (governmental or parliamentary) decisions, negotiations, regulatory measures and actions – for instance climate policy. "Policy systems" consist of: (1) public policies (i.e., the sum of policy decisions), (2) policy agents and stakeholders, (3) the policy environment, i.e., the specific context in which events occur (Dunn 1994, pp. 70f).

existing rationalities and dynamics. Finally, as an example, the IPCC's impact on public policy processes is briefly discussed (Sect. 3.1.3).

3.1.1 Core Characteristics of the Sciences and of Policy-Making

How does scientific knowledge production work? The research field of Science and Technology Studies, with its sociological and historical and furthermore political, anthropological, cultural and philosophical perspectives, has produced a large number of publications.[2] They discuss how scientific knowledge production and technological innovation actually work and how they are shaped by socio-cultural and political values and interests. This kind of research began to emerge as an important field of study in the 1970s and 1980s (especially after Kuhn 1970). One currently widespread theory (though not accepted by all) about the way scientific research activities lead to scientific knowledge is the "Actor-Network Theory." It was developed by Michel Callon, Bruno Latour and John Law in the 1980s and was slightly revised at the end of the 1990s as the "after-Actor-Network-Theory" (see Latour 1999).[3] It is a general social theory, according to which scientific knowledge and technologies are the result of large and strong networks.

> Just as a political actor assembles alliances that allow him or her to maintain power, so do scientists and engineers. However, the actors of [Actor-Network Theory] are heterogeneous in that they include both human and non-human entities, with no methodologically significant distinction between them. Both humans and non-human form associations, linking with other actors to form networks (Sismondo 2010, p. 81).

The focus is on concrete actors (comprising even physical entities) rather than on the macro level. The concept of "translation" plays an important role for this theory: material actions and forces are "translated" into one another, and scientific representations result from material manipulations and such translations.

To better understand this approach, it is useful to briefly describe one of its antagonists, structural functionalism, which was especially debated in the 1970s and is often said to build on Robert Merton's work in the 1940s (e.g., Sismondo 2010, Chap. 3). This popular, yet obviously deficient view suggests that institutions such as academia are homogenous and unified and follow a certain goal in society, i.e., to provide certified knowledge. According to this view, scientists, through hon-

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[2] There are similar or partly identical research activities called "Science, Technology, and Society," "(New) Sociology of Science" or "of Scientific Knowledge," or "Social Studies of Science" (see Bammé 2009). Further literature providing an overview of this field of study includes Sismondo (2010) and Joerges and Nowotny (2003). There are many programmes at different universities all over the globe on Science and Technology Studies, mostly in the tradition of social constructivism. There is a great variety of approaches in this interdisciplinary research field.

[3] This and the following statements on the Actor-Network Theory are mainly based on Sismondo (2010, Chap. 8).

orific rewards and sanctions, follow a related ethos, comprised of four principles: (1) universalism (the individual's race, sex, age, religion, etc. shall be irrelevant for the right to participate in research activities); (2) communism (scientific knowledge is commonly owned); (3) disinterestedness (scholars shall not have a vested interest in a particular research outcome); and (4) organised scepticism (both by methodical standards and by critical peer review in different forms).

Oddly enough, Merton (1942) himself, though often cited in this regard, did not believe in such a view of "homogenous science" following these ideals. Instead, he developed the four principles as clearly normative ideas, rather than a description of actual scientific practice. The Actor-Network Theory, in clear contrast to this functionalist and some other theories, also demonstrates that the production of, e.g., socio-economic knowledge is *not only* driven by the search for truth and general scientific norms. Rather, it is also (and possibly much more) driven by a number of other factors. Moreover, "science" (as well as "economics") is all but a unified group with a common and simple rationality. Yet, the "checks and balances" system (peer review, culture, etc.) within the scientific community at least ensures a relatively high standard of epistemic quality of the knowledge production, despite the various motives underlying it. These insights on scientific knowledge production have to be taken into account particularly when evaluating the objectivity of the available scientific knowledge assessed by the IPCC.[4]

The historical perspective confirms this view. Since the end of the nineteenth century, mainly universities had the task of conducting scientific research. The success of the natural sciences and technology in the last two or three centuries made the sciences powerful, trustworthy and interesting – also for political decision-makers. Yet, some observers assume that we are currently facing a huge change. Financial aspects play a decisive role now, i.e., scholars are increasingly becoming managers; *academic* knowledge production is increasingly losing trust, while alternative forms of producing and communicating scientific knowledge outside of universities are becoming increasingly popular (Bammé 2004, Sect. 6.5 and p. 117). Interestingly, policy advice has evolved into an economic branch on its own that is increasingly in competition with traditional academic policy advice (Grunwald 2008, p. 373). As argued by Bammé (2004, pp. 119–122), the four (mistakenly) descriptive principles of the functionalist view are to be replaced by:

1. "local" – instead of the "universalist" search for truth, research is now more interested in addressing specific policy-relevant or other practically relevant problems through "projects," resulting in "reports" rather than papers;
2. "proprietary" – in contrast to "communalism," scientific products are frequently regarded as the intellectual property of the researcher or research group;

[4] Accepting some core insights of the Actor-Network Theory here does neither imply that one has to follow social constructivism in its more *radical* sense of epistemological pessimism (see also Chaps. 5 and 6), nor that the Actor-Network Theory could not be substantially improved.

3. "authoritarian" and "commissioned" – instead of "disinterestedness," industry, governments and others commission research, which has a strong influence on results and the definition of the problem to be explored; and
4. "expert" – instead of "organised scepticism," it is now perhaps more important to protect one's good reputation as an "expert" among the funders.

Although not comprehensive, these gradual tendencies at least indicate that scientific knowledge production is more than a truth-seeking endeavour.

Let us turn to the structure of policy-making. The process of decision-making in public policy is traditionally described in terms of several phases:

1. Problem formulation (gathering knowledge, mostly external input)
2. Agenda setting and promotion of a particular policy alternative
3. Policy formulation and decision
4. Policy implementation (invocation and application; administrative level)
5. Policy evaluation (appraisal)
6. Policy termination

After the fifth step, policy-making sometimes re-starts with a new cycle beginning from the first step instead of terminating the particular process.[5]

Related to this policy cycle is an "issue attention cycle" (Blum and Schubert 2009 pp. 109–112) that is highly relevant to scientific policy advice because attention from policymakers and the media to certain political issues is given only for a short period. After that, the respective topic disappears from the political agenda again. Grundmann and Stehr (2011, p. 226) illustrate this for the case of climate change. Attention is, thus, a very scarce resource in the political realm, which is particularly problematic for the communication of large-scale, rather inflexible periodic assessments such as those by the IPCC (see Chap. 11).

The regulatory function of the state was enlarged into new and often highly complex fields in the twentieth century, such as health issues, environmental issues as well as global and intergenerational issues (Beck 2009, p. 40). This has implications concerning the need for expertise in policy-making (beyond the governmental experts themselves), particularly in democracies where policymakers have to adequately justify their decisions. However, what are the essential factors leading to one particular policy or another, and to policy change? Can scientific expertise, including economic assessments, at all be among these factors, and under which conditions? Many doubt that scientific expertise can have a "well-directed" impact on policy-making processes (e.g., Haas 1992; Shulock 1999; Keller 2009; Hickmann

[5] This description of the policy process ought to be interpreted as a mere heuristic model: It does not explain why these steps happen (or sometimes do not happen), or why a particular policy is promoted. For the critique on such a policy model, e.g. on the presupposition that there is a certain "point" in time of decision-making, see Kuruvilla and Dorstewitz (2010) as well as Blum and Schubert (2009, Chap. 5).

2014). Yet, explaining policy change is a difficult challenge that has already brought about the development of different theories on public decision-making.[6]

For example, some argue that the given socio-economic, historical and other structures and conditions, including a society's shared goals, are more decisive for policy change than politics and interest groups (structuralist view, as functionalism). In contrast, agent-based rationalist theories (e.g., microeconomic rational choice theory, see Chap. 8) emphasise individual or group rationalities and interests as the most decisive or only factor in policy-making. Related to that are idea-based theories arguing that political ideas and value beliefs play a decisive role in understanding the evolution of policies (e.g., Haas 1992). Yet another assumption is that collectively created political institutions are the most decisive factors for policy change (e.g., the "actor-centred institutionalism" by Scharpf 1997), while others focus on the importance of networks beyond the core political arena (e.g., the Actor-Network Theory introduced above; or Howlett and Ramesh 2009), against monocausal-mechanistic understandings of policy change. In general, policy studies increasingly focus on the – previously somewhat neglected – policy environment and complex "governance" issues rather than merely on analysing the perspectives of national governments.[7]

The approach I find most compelling is the advocacy coalition framework (Sabatier and Jenkins-Smith 1999), also because it helps to overcome the rather one-sided theories by *combining* many of the just-mentioned interesting factors. According to this theory, coalitions advocating for a specific policy are created by policy participants with similar core beliefs. These coalitions often transcend institutions. This much discussed theory (e.g., Sabatier 2007) regards – besides external perturbations or shocks – "policy-oriented learning" as one potential major factor for policy change. This means that scientific findings can, over many years or even decades at least, have an impact on policy decisions not only in terms of informing interest-based policies, but also in terms of leading to changes in value beliefs and interests themselves.

Hence, policy-making is not to be interpreted as an objective, rational problem-solving process that only refers to scientific knowledge or explicit arguments on the greater social good. Rather, several factors are decisive.[8] Scientific ideas such as those provided by the IPCC WG III *can* play a role in policy-making processes, but

[6] Sabatier (2007) and Blum and Schubert (2009, Chaps. 2 and 3) provide excellent overviews of policy change theories. Factors explaining changes in international agreements in particular, e.g., those under the UNFCCC, are discussed within the research field of international relations with the help of regime theory (developed in the 1980s).

[7] Negotiation skills, existing networks and the particular context, as well as all instruments of the exertion of power are certainly factors *in addition to* the respective action-guiding rationality. Neorealist approaches seem to take this into account by pointing out the importance of power resources and capabilities (Haas 1992, p. 6).

[8] See also Grundmann and Stehr (2011, p. 25). This seems in line with Max Weber's observation that politics is about "strong and slow boring of hard boards." Brown (2009, p. 13), making use of Bismarck's famous dictum, even suggests that policy-making processes are very far from being "rational" processes: "laws are like sausages, it is better not to see them being made."

so do interests, institutions, networks (particularly advocacy coalitions), contexts and external conditions. Consequently, the convincing assumption that policy-making is also interest-based etc. does not contradict the assumption that, for example, the IPCC results can inform policy-making processes. The other way round, it is unjustified to assume that scientific experts actually can impose their policy recommendations on policymakers through scientific policy advice in a linear, undistorted and direct manner (see also Chap. 5; Shulock 1999; Beck 2009).

What are more specific factors regarding climate policy change? Howlett and Ramesh (2009) and furthermore Pielke (2007) regard the huge complexity as well as the global and intergenerational scale of climate policy as decisive factors for, and restrictions of, climate policy change in particular. Only incremental adaptation is usually possible in policy-making, rather than far-reaching policy changes within a short period of time. The IPCC assessments should take this into account – instead of presenting abstract ideal world scenarios.

Moreover, the different national political systems and cultures also have to be taken into account when reflecting on the role of scientific expertise for climate policy change. For instance,[9] the German and French style of policy-making tend to be anticipatory, while the Germans focus more on "rationalistic consensus" and the French on "concertation" (in terms of the allocation of duties) with regard to the society. In contrast, the British and Dutch style is more reactive, with the British being more open to negotiation in reaching consensus (but not as rationalistic as in the German case). The Dutch follow a "negotiation and conflict" approach by allocating duties like the French do. Such classifications may be oversimplifications and hard to substantiate scientifically. Yet, these examples at least indicate that there are interesting differences between different political cultures assembled under the IPCC assessment processes, even more so given the fact that UNFCCC comprises both democratic and non-democratic nations. It would therefore be good if the integrated economic assessments by the IPCC addressed the sub-global level of climate governance as well in order to be truly policy-relevant (see Chap. 11), so that scientific expertise can have a significant impact on climate policy in the end, as demanded in Chap. 2.

3.1.2 Basic Structure and Dynamics at the Science-Policy Interface

The brief analysis in the previous section tells us that in principle – despite the distortions and multi-layered motives in both academia and policy-making – the ideas of reliable scientific knowledge and its potential, desirable impact on policy should not be dismissed. Furthermore, the existing analyses of policy-making processes highlight the need for the IPCC and other science-policy institutions to consider the

[9] As argued by Blum and Schubert (2009, p. 149).

issue attention cycle in policy processes in their communication strategy. They also need to address the huge complexity and sub-global levels of climate policy in order to have significant impact on policy. Having discussed these descriptive aspects of scientific knowledge production and policy-making, their interaction and its obstacles need to be examined.[10]

Scientific experts can be both creators and products of a policy system (Dunn 1994, pp. 70f); with their scientific policy advice,[11] they may have an impact on policies, but the current political situation also influences their thinking and actions, and the funding for the experts' research is often provided by governmental agencies (i.e., "science policy"). Thus, the relationship between scientific experts (both within and beyond academia, e.g. in think tanks or ministries) and policy processes is obviously non-linear. Some also argue that there is a "scientification" of policy and politics. This means that policies and public debates have increasingly been legitimised in recent decades by referencing scientific knowledge and expertise. This has resulted in a proliferation of expert advice, but also in substantial perils (see Sect. 3.2). There are also arguments suggesting a "politicisation" of scientific studies and assessments, giving rise to an increase in uncertainties and disputed value judgements, which again implies perils (Sect. 3.2).[12]

Achieving an impact on policy through scientific policy advice, particularly when considering the four general norms (Sect. 2.1.3), is anything but trivial. Scientific policy advice, for instance through the IPCC assessments, is much more than simply providing existing standard academic products to policymakers.[13] The goals as well as target audiences of, for instance, the IPCC assessments are different from those of standard research. Empirically, their effectiveness usually requires, inter alia, applied research on rather specific, policy-relevant aspects (see Sect. 3.1.1), very high credibility and transparency to generate trust (Mitchell et al. 2006; Beck 2009), a balanced, politically acceptable treatment of the many disputed political issues involved (Mitchell et al. 2006) and a different method of communication

[10] Beck (2009, pp. 201–227) offers a more comprehensive overview of current debates on the sociological aspects of scientific policy advice. The two most important disciplines reflecting on the science-policy interface in general include Science and Technology Studies as well as Public Policy Analysis. Public Policy Analysis strongly builds on assumptions about factors for policy change and is about "creating, critically assessing, and communicating policy-relevant knowledge" (Dunn 1994, p. 2). Similar (or even identical) research fields are "Policy Studies," "Policy Sciences" and "Comparative Public Policy" (Blum and Schubert 2009, p. 8).

[11] In this book, this term is used in a very broad sense, and also includes IPCC assessments. There are three fundamentally different kinds of strategic (content-related) policy advice: (1) policy advice by individuals, (2) institutionalised policy advice and (3) the general "dialogue" between academia and society (Grunwald 2008, p. 23). I will focus on the second kind, i.e., formalised science-policy institutions such as the IPCC.

[12] See also the concept of "trans-science" (Weinberg 1972); Funtowicz and Ravetz (1991); Maasen and Weingart (2005); and Beck (2009, Chap. 2).

[13] For the main differences between standard research and scientific policy advice, see the useful table in Jasanoff (1990, p. 80); Skodvin (1999); as well as the table in Kowarsch (2014) with its particular focus on differences between *scientific assessments* and standard scientific research.

of results compared to that of standard research.[14] Also the products themselves, such as the IPCC ARs, as well as their underlying standards, are different from those produced by traditional research activities. Consequently, there are specific institutions (IPCC, etc.) and processes for the science-policy interaction; scientific policy advice is often complex, non-linear and iterative.

Observers note that particular notice is taken of scientific advice by policymakers if it is close to their needs and interests (i.e., "salience").[15] Scientific *consensus* often provides factual clout and credibility for a "scientific argument" in policy and politics. This indicates a high authority and trustworthiness of a particular expert statement.[16] The difficulty is, however, that there is no consensus on climate policy evaluation, and this leads to the issue of legitimacy (see Sect. 3.2).

To specify the target audiences of scientific assessments, it must be understood that, beyond politicians, public officials, business executives, top civil servants and others are also important for scientific policy advice. They are all decision-makers (Blum and Schubert 2009, p. 121). Furthermore, the media, NGOs and religious groups, as well as stakeholders in business and industry etc. are usually among the target audience of global scientific assessments.[17] This explains both the challenge in communicating the results of the IPCC and the number of different viewpoints and conflicting political interests that can be involved in large-scale scientific assessments for public policy.

To complicate matters further, different nations have different cultural approaches to the science-policy interface (Hulme 2009, p. 105; Maasen and Weingart 2005). In contrast to Europe, for instance, the US has the institution of "sub-governments" or "issue networks." This incorporates the "iron triangle," being (1) specialised bureaucrats, (2) lobbyists and (3) Members of Congress, Parliament or government. This allows many far-reaching decisions to be made almost independently from public discussion on these issues (Blum and Schubert 2009, p. 25 and pp. 61). Scientific experts have relatively little access to these processes in the US.[18] In terms of an impact strategy, the IPCC ARs are not yet well adapted to the specific political

[14] In general, the communication between experts and policymakers, as diverse societal groups, is difficult (Grundmann and Stehr 2011, pp. 25ff; Habermas 1968). Policymakers usually cannot spend as much time on the details and uncertainties of a policy problem as academics; often only clear-cut and concise scientific statements attract the attention of policymakers.

[15] See Gormley (2007); Grundmann and Stehr (2011, pp. 27f and 42f); Mitchell et al. (2006).

[16] As stated by a large number of observers; among them are Gormley (2007), Beck (2009), Skodvin (1999), Jasanoff (1990), Elzinga (1996), Haas (1992).

[17] My references to the "science-policy" interface or "scientific policy advice" in this book do not solely refer to the provision of expertise to policymakers in a narrow sense (i.e., governmental representatives or "the state"); they also refer to policy-making as a complex process involving numerous and different agents as the target audience of IPCC assessments – in short: "policymakers and the public."

[18] Moreover, in different political systems (compare e.g. the US, United Kingdom and Germany), the role of governmental policymakers (or Members of Congress or Parliament) and that of their personal advisers is very different. In some countries, scientific advice should ideally be provided directly to politicians, in other countries indirectly to their personal advisers.

cultures of the UN member states; there is essentially only one AR for all the countries and governance levels.

In conclusion, this section shows that achieving effective scientific assessments is a very ambitious and challenging endeavour that presupposes the fulfilment of numerous requirements. Interestingly, these requirements – derived from empirical studies and descriptive theories – are very much in line with, and a specification of, the four general norms for scientific expertise in policy, which are based on normative thoughts (Sect. 2.1.3).[19]

3.1.3 Impacts and Political Influence of the IPCC

Let us briefly analyse the political impact of the IPCC as an example of the above theoretical assumptions. The IPCC regards itself as the *leading* international body for the assessment of climate change.[20] According to the IPCC, the ARs "are the most comprehensive and up-to-date reports available on the subject, and form the standard reference for all concerned with climate change in academia, government and industry worldwide" (IPCC 2007, p. i). Indeed, the scientific discourse relies heavily on the IPCC ARs (Weingart et al. 2007, p. 11).

The IPCC always presents its ARs at the COPs in order to inform the Subsidiary Body for Scientific and Technological Advice (SBSTA), which is an important institution within the UNFCCC, and the first AR (FAR, in 1990) strongly influenced the creation of the UNFCCC. Yet, also the other ARs had a considerable impact on climate policy (Bolin 2007): the second AR (SAR, in 1995) had a substantial influence on the creation of the Kyoto Protocol; the AR4 influenced the Bali Road Map in 2007 to come to an international climate agreement; and the most recent AR5 strongly influenced the negotiations leading to the Paris Agreement (COP 21 in Dec 2015), as many observers noted.[21] In a letter to the IPCC, the Secretariat of the UNFCCC writes that "the Conference of the Parties [to UNFCCC]… acknowledged that AR5 provides the scientific foundation for the Ad Hoc Working Group on the

[19] Yet, there are considerable differences between different cases of institutionalised scientific policy advice, in terms of institutions, topics, targets, products, agents, background conflicts, and so on (see the examples in Jasanoff 1990 and Pielke 2007). All of these cases may require different and specific guidelines due to their various structures and problems. Among other things, that is why this book focuses on the specific case of international climate policy and the integrated economic assessments by the IPCC. Section 12.4.2 will discuss whether the results of this book can also be applied to institutions other than the IPCC.

[20] See also http://www.ipcc.ch/organization/organization.shtml, accessed 30 Mar 2015.

[21] The Copenhagen Accord reads: "We call for an assessment of the implementation of this Accord to be completed by 2015, including in light of the Conventions ultimate objective. This would include consideration of strengthening the long-term goal referencing various matters presented by the science, including in relation to temperature rises of 1.5 degrees Celsius" (UNFCCC 2009). This could be interpreted as follows: Policymakers waited for the next, the Fifth AR to know more about the costs and impacts of different mitigation targets.

Durban Platform for Enhanced Action […] and encouraged Parties to continue to support the work of IPCC" (UNFCCC 2015b).

The IPCC seems to have considerable impact in terms of agenda setting, the constitution of risks and policy options, and identifying the "causers" and "victims" of climate change (Beck 2009, pp. 40f, 62f). The fact that some stakeholders invested so much money to discredit the IPCC's scientific authority (Sect. 3.3.1) suggests that the IPCC ARs can actually have significant political impact.

In 2007, the IPCC received, jointly with Al Gore, the Nobel Peace Prize for "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change."[22] Moreover, the InterAcademy Council (IAC) states that

> at the interface between science and politics, the IPCC assessment process has sustained a working dialog between the world's governments and scientists since its inception in 1988. […] Through its assessment reports, the IPCC has gained enormous respect […] for informing climate policy and raising public awareness worldwide (IAC 2010, p. 1).

What about the specific impact of the IPCC's *economic* assessment of mitigation options? In general, economic ideas seem to have a relatively high influence on public debate and policy-making (Gormley 2007, Kleinewefers 2008, pp. 269–274). "The public at large expects advice from economists, and this advice is liable to be translated into actions. Economics has consequences" (Weston 1994, p. 7). More specifically, the economic results of the ARs and of some individual studies such as those by Nordhaus and the "Stern Review" (Stern 2007; see Part III of this book) had considerable political impacts (DeCanio 2003, Chap. 6, Edenhofer 2006, or Aldred 2009). In my perception, before the Stern Review and the AR4, which prominently refers to the Stern Review, the allegedly high economic costs of ambitious climate change mitigation were – beside the assumed uncertainties regarding the causes of climate change – an important argument against ambitious mitigation policies. After the releases of both the much more optimistic Stern Review and the AR4, the argument that mitigation is too expensive was considerably weakened in public and political discourses, although this issue is still disputed in both scientific and political debates.

Particularly in the case of climate change mitigation policy, on which there is increasing focus (Chap. 1; Part III), there are different and strong interests at work from a wide range of pressure groups (e.g., the influential Global Climate Coalition 1989–2002) that try to influence especially the IPCC WG III because it is seen as the influential cockpit of the climate change policy negotiations (Skodvin 1999, p. 22; Beck 2009, pp. 110 and 115).

It almost suggests itself that the latest WG III report (AR5) on climate change mitigation had significant influence on the very important climate policy agreement between China and the USA in late 2014 (see Sect. 2.2.3). This is due to the fact that WG III has shown – in contrast to the currently widespread doubts among decision-makers – that ambitious climate change mitigation goals, particularly the 2 °C goal,

[22] See http://www.nobelprize.org/nobel_prizes/peace/laureates/2007/, accessed 14 Aug 2014.

can still be achieved at moderate economic costs, given some requirements and the conditions analysed by WG III. Perhaps, without these WG III AR5 findings, the 2 °C goal would already have been given up in climate policy debates. The WG III AR5 also found its way into the UNFCCC negotiation texts prior to the COP 21 in Paris at the end of 2015.

> Consistent with the scientific findings of the IPCC, in order to have a likely chance of keeping the temperature change to below 2 °C, global GHG emissions in 2050 will need to be 40 to 70 per cent lower than in 2010 and reach levels near zero Gt CO2 eq or below in 2100 (UNFCCC 2015a).

Although in the final text of the Paris Agreement some of these points were watered down, this quotation is but one example of a statement in this UNFCCC document that is almost identical with WG III AR5 SPM statements (IPCC 2014). These examples are, however, not full evidence of a targeted and well-directed impact of the IPCC ARs (and especially their economic results) on policy-making. The examples only suggest that the ARs (including the economic parts) are somehow influential in the political arena and for public debate, regardless of how strongly the AR contents are distorted or transformed in the political process.

In Sect. 3.1, I argued from a rather descriptive social-science perspective that, despite the complex motives and dynamics at the science-policy interface, scientific assessments actually can have an impact on policy processes (as implied by Dewey's normative theory, Chap. 2), though not in an undistorted manner. Given empirical studies, the effectiveness of scientific policy advice presupposes the fulfilment of various requirements that are closely related to the general norms for scientific expertise in public policy (Sect. 2.1.3). An additional, very important result of Sect. 3.1 is that – having analysed scientific knowledge production, policy-making and their interaction, particularly in terms of requirements for desirable impact of scientific policy advice – we now have the theoretical backdrop at hand to identify the potential fundamental perils at the science-policy interface.

3.2 Misuse, Flaws and Pitfalls of Scientific Policy Advice

This section identifies the most important (actual or potential) misuses, misguided uses and other fundamental problems and perils of science-policy interactions, including the integrated economic assessments by the IPCC. These fundamental problems and perils of scientific policy advice represent decisive obstacles to the realisation of the four general norms for scientific policy advice – sound science, political legitimacy, policy-relevance and good communication (Sect. 2.1.3), – and are grouped accordingly. The hypotheses on the problems and perils are heavily based on the descriptive analysis of the dynamics and characteristics of scientific expertise in public policy (Sect. 3.1).[23]

3.2.1 Sound Science? Errors and Flaws in Scientific Products

Sound science is represented by both flawless scientific results and state-of-the-art scientific studies. The first peril of scientific policy advice are flawed scientific studies or judgements that violate the claim to "sound science," due to their potentially adverse effects on policies. For instance in economics:

> Fortunately, or unfortunately, depending on one's point of view, the law does not allow malpractice suits against economists. If the world works a certain way, if we are mistaken in our understanding of this, and if this misunderstanding gets translated into misinformed policies, it is not mainly economists who bear the brunt of the ensuing pain and misery. Even if we are not mistaken, implementation of any particular policy will have costs to someone (Weston 1994, p. 7).

Just like money in an economy, trust is seen as the "lubricant" of scientific policy advice. Trust in the epistemic competence and integrity of scientific expertise is crucial because policymakers and the public cannot fully control or understand all the assumptions, methods and resulting work of scientific experts. The "climate war" (Sect. 3.3.1) shows how rapidly trust can deteriorate, resulting in the ineffectiveness of scientific policy advice.

Individual failure as well as institutional shortcomings and ineffective control mechanisms can cause flaws and errors in assessments. As argued above (Sect. 3.1.1), a researcher is not solely driven by ensuring flawed scientific statements are avoided. Moreover, besides the questionable assumption that scientific experts would always follow the "academic ethos" that promises to warrant the production of reliable knowledge, there are also philosophical (epistemological) doubts that reliable and objective scientific knowledge is actually possible, even if the academic ethos and, accordingly, the individual behaviour were perfect. This philosophical concern needs to be carefully addressed (see Chaps. 5, 6 and 9).

The analyses of the current situation and dynamics of the science-policy interface above, including large-scale scientific assessments, reveal that the danger of violating the sound science claim is *particularly high* compared with standard research where other circumstances usually come to bear. For instance, there are specific time constraints for politically timely scientific policy advice, and policymakers expect clear-cut, yet politically acceptable (i.e., legitimate) statements. These pressures can develop into errors and flawed scientific results in scientific

[23] For now, it is not decisive whether these are actual or potential problems and perils of scientific policy advice. There are, however, enough examples in the literature which I will not discuss in this section. A *potential* problem or peril is already reason enough to carefully reflect and critically evaluate the IPCC's work.

policy advice.[24] Moreover, the commercialisation of the sciences (Sect. 3.1.1) also increases such a risk for standard research. In general, the increasingly high uncertainties and complexity of policy-relevant scientific knowledge are major reasons for flawed scientific policy advice. This is particularly valid regarding the social sciences and their evaluation of complex policy options, because policy assessment, although being particularly policy-relevant, clearly goes beyond the epistemic comfort zone of academic research.[25]

3.2.2 *Political Legitimisation? The Misguided Use of the Academic Authority and Influence*

The most important criticism of the IPCC is that it is said to be biased towards particular political or other non-scientific interests, and consequently, that it is policy-prescriptive in an opaque manner.[26] This central peril of scientific policy advice can theoretically be due to (1) the policymakers' demand for biased scientific assessments, (2) the supply of such biased assessments by scientific experts, and (3) unintentional reasons.

3.2.2.1 When Policymakers Misuse Expertise, Seeking "Inherent Necessities"

Since policy-making is also determined by interests and power struggles to some extent (Sect. 3.1.1), scientific findings sometimes have only a symbolic function in policy processes. This contrasts with a "practical-instrumental" function, or a deliberative learning function as envisaged by the normative ideal in Chap. 2. This means that, for instance, the IPCC assessments merely serve to create legitimacy for predetermined political goals and standpoints in the negotiation process (although such a symbolic use of knowledge is rarely a sustainable strategy).[27] This use of scientific authority for political purposes is a "misuse" in the sense that it at least violates the claim to political legitimisation; the intention is to deceive political adversaries through an allegedly neutral scientific assessment of policy options. Skodvin describes this problem as follows:

> Information plays a key role in all negotiations. […] In distributive bargaining, information and knowledge become subject to strategic evaluation in terms of their value as tools for achieving political goals. Hence, parties may perceive their realisation of individual

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[24] Samuelson and Nordhaus (2010, p. 508) point to the implied danger by quoting Solow: "Nobody likes to say 'I don't know'."

[25] See, e.g., Carraro et al. (2015). Related to this point is the "sound science vs. junk science" dispute particularly in the 1990s, as explained by Douglas (2009, Chap. 1).

[26] See Sect. 3.3 and the fears of a "conspiracy" of climate scientists and some policymakers.

[27] See Beck (2009, pp. 37f); Sarewitz (2004); Grundmann and Stehr (2011, p. 29).

> interests as inextricably linked to the concealment, manipulation and distortion of information and knowledge. […] Thus incentives to distort and manipulate information is inherent in the strategic logic of distributive bargaining (Skodvin 1999, p. 9).

The temptation to misuse scientific expertise in this way is particularly high in distributional conflicts and zero-sum games (Skodvin 1999). Sometimes, as in the climate policy realm, several political parties present their own scientific assessment, which unsurprisingly tends to favour the commissioning party. In this sense, policymakers sometimes politicise scientific expertise and take advantage of the given (though currently slightly declining, see Sect. 3.1.1) academic authority. They risk destroying the remaining trust people have in academia.

In the most extreme case, which sadly happens quite often, scientific policy advice provides an "inherent necessity" for a particular policy choice – in the view of some policymakers. The experts supposedly suggest that there is no alternative to the policy option being considered, due to scientific reasons (rather than due to their disputable normative assumptions). Since climate policies are particularly controversial in public debates, such "inherent necessities" suggesting that ambitious climate protection is indispensable (or is unviable) are welcomed by policymakers (Sarewitz 2004). This can result in a sub-optimal climate policy from a global and intergenerational social welfare stance.

The foundation of the IPCC can serve as an example of this peril. Whether the IPCC should be a platform for the political climate change policy negotiations was extensively discussed between 1988 and 1990. US President Bush Sr. wanted to use the IPCC in order to delay climate policy negotiations; in his view, the search for clarity and certainty (as aspired to by the IPCC) would be a never-ending story and would, therefore, reduce the public pressure for ambitious climate change mitigation policy (Beck 2009, pp. 130–132). In contrast, others wanted to make instrumental use of the IPCC to *promote* policy negotiations (Beck 2009, pp. 96f).

Misuse of scientific policy advice in this sense can occur even if the scientific advice is perfectly impartial and unbiased, also because scientific findings often leave room for interpretation. This opens the door for manipulation in terms of a biased transformation of the findings. The misuse of academic authority by policymakers can also take place more indirectly; policymakers sometimes provide incentives for scientific experts to produce biased reports.[28] The current commercialisation of the sciences and the multi-faceted interdependencies of academia and policy seem to facilitate such a misuse (see Sect 3.1).

Although, as an advocate for the public (see Sect. 1.1), my focus in this book is on what scientific experts should do, these problems caused by policymakers should, nonetheless, be addressed by a guideline for the IPCC because experts can, to some extent, help avoid such undesirable phenomena. This is also the case for the other problems and perils of scientific policy advice.

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[28] For instance, the formulation of policy problems is sometimes done in an idiosyncratic manner by policymakers. Furthermore, science policy may be politically biased, given the fact that institutional settings already involve many value judgements (Beck 2009, pp. 96f).

3.2.2.2 Experts Misusing Policy Advice: Bias and Hidden Value Judgements

One of the major perils of policy advice is the intentional misuse of scientific authority and credibility by scientists themselves in order to influence policy decisions, be it in co-operation with policymakers demanding biased expertise, or at the experts' own initiative. This was, and still is, the main public concern surrounding the IPCC and climate-related sciences (see Sect. 3.3). Many people fear that biased assessments and pseudo "inherent necessities" will be willing supplied to policymakers, or used for the experts' own purposes. Imagine, for instance, a scientist dogmatically and aggressively demanding ambitious climate change mitigation, allegedly in the name of "science," in the media or in publications and reports. "Science" would become a political player with its own political agenda.

Long ago, the German sociologist Max Weber (1864–1920) warned of the excessive rule of experts and bureaucrats in national policy-making particularly where there are different conflicting values at stake. On the one hand, modern technology provides valuable opportunities for society, and scientific explanations helped modern societies overcome religion and dynastic rule as sources of authority (Weber 2014). According to this logic, the involvement of experts is key for policy-making. On the other hand, too much emphasis on expertise can lead to an "iron cage of bondage" for policy-making (e.g., Weber 2006 and Weber 1972, p. 835). Experts who determine the "optimal" policy options, despite the value judgements and uncertainty involved, significantly reduce legitimate opportunities for decision-making by governments and parliaments. It is difficult for parliaments to identify and evaluate policy alternatives, if the bureaucracy together with the associated experts already defined the optimal solution. Weber furthermore describes the dilettantism of rulers who make themselves dependent on experts (Weber 1972).[29] Chapters 4 and 5 discuss Weber's proposal to separate facts and value judgements in policy-making in order to avoid the iron cage of bondage.

Possible reasons for such misuse of scientific policy advice by experts were indicated in Sect. 3.1.1, in terms of the numerous motives underlying the production of scientific knowledge. Besides the search for "truth," these motives include, for instance: (1) praise and appreciation both by the public and by fellow scholars; (2) material interests, such as obtaining funds; (3) other personal or institutional advantages; and (4) political or ethical interests.[30] These motives could become reasons for manipulating research to make it more "interesting" (i.e., clearer, stronger, more

[29] In other words, the sciences should not become a "fifth branch" in democracies beside the three classical branches and beside agency officials (Jasanoff 1990, p. 3).

[30] Many experts have their own political interests and ideas concerning themselves, their institutions, academic communities and society. The opportunity to influence policy via scientific assessments might be chosen as a way to exert one's own political opinions. See also Grundmann and Stehr (2011, p. 14), arguing that some scientists want to make the world a better place with the help of their scientific statements. Anyways, a scientist's work can *never* be *fully separated* from one's own personality (see also Chap. 5; Grundmann and Stehr 2011, p. 175).

alarmist, more politically correct, etc.) for the public, the media or policymakers, or simply in order to meet the demands of funders.

Possible additional minor factors promoting biased scientific assessments are: (5) the commercialisation of the sciences and the increasing pressure to obtain external funds (Sect. 3.1.1); (6) the complexity and uncertainties of policy-relevant assessments, which can allow opaque bias; (7) the current high demand for scientific policy advice; and (8) the mutual influence between policymakers and scientists, for instance via science policy etc. Moreover, the sciences often have only a weak, indirect and distorted influence on policy. It could therefore be speculated that this is a further motive to produce intentionally biased assessments, since experts could be understandably disappointed and morally concerned about the failures of policy-making processes and the ignorance of associated scientific results.

Biased assessments can take several different forms, including bias in the choice of personnel, institutional settings or the definition of what counts as “science.” Biased assessments can also deliberately incorporate hidden mistakes and flaws. This would be considered a kind of fraud, although the peer review processes usually help avoid this. More important, however, is the case of opaque value judgements and opaque uncertainties in assessments. Value judgements in scientific reports occur, for example, in the selection of data or the scope of analysis, or in ignoring studies with undesirable results when assessing the current academic literature on a certain subject (Chap. 5). The most disputed value judgements related to climate policy are judgements concerning distributive issues.

Hidden value judgements and uncertainties could undermine the political legitimacy of assessments. Be it the expert’s own initiative (this section) or a demand by policymakers (Sect. 3.2.2.1 above), hidden value judgements and core uncertainties are widely regarded as one of the biggest problems of scientific policy advice. This is especially the case with the IPCC. It is also particularly problematic for the social sciences where many more ethical value judgements are involved than in the natural sciences (Chaps. 5 and 8).

3.2.2.3 Unintentional Misguided Use of Scientific Policy Advice

There can also be unintentional bias in assessments, leading to a misguided use of policy advice. The most important example of this is opaque value judgements in scientific assessments for policy. Even the scholars themselves may not be aware of this, sometimes due to a misguided philosophy of science (see Chaps. 5 and 8). From the policy side, an unintentionally “biased use” of policy advice by policymakers and the public could be due to misunderstandings and miscommunication of the scientific statements.

3.2.3 Degrees of Policy-Relevance

Scientific assessments, even if they are sound and unbiased, are virtually useless if they are not policy-relevant (Sect. 2.1). Scientific assessments are sometimes inconclusive and do not sufficiently demonstrate the potential relevance of the scientific findings for policy. Among the reasons is the fact that the assessments demanded by the policy side force experts to leave their academic "comfort zones" and enter the field of "trans-science" with its huge complexity and uncertainties. Scientists sometimes prefer to remain on the "safe" side, which leads to policy-irrelevant research (see the "Pure Scientist" model in Pielke 2007). Another reason for scholars to avoid policy-relevant research may be the fierce criticism of the IPCC and climate-related sciences in the media etc. This may also be combined with a public loss of trust in academia (Sects. 3.1 and 3.3). The fact that social-science policy assessments may include disputed value judgements (and much uncertainty) is certainly among the reasons why scholars sometimes refrain from engaging in policy-relevant assessments.

An example of a relatively policy-irrelevant assessment is the IPCC's Special Report on extreme weather events (IPCC 2012); in light of the IPCC criticism after Copenhagen, this Special Report was probably too careful and inconclusive in its statements. The IPCC assessments can also, thus, be considered too neutral (see, e.g., Luhmann 2010 for the AR4).

The lack of conversation and discussion with policymakers and the public about the contents of assessment reports could be another reason for policy-irrelevant expertise. Further reasons could be a flawed mandate, insufficient resources (particularly time) for assessment processes, or other aspects determined by the policy side. In some cases, also policymakers may have an interest in policy-irrelevant assessments; these can more easily be used for their own political purposes since they are, for instance, more open to interpretation.

3.2.4 Arrogance and Misunderstandings in Communication

If assessment results are not well communicated to both the policymakers and the public, they will not have much impact. Good communication ensures that assessments are accessible, clear and comprehensible for the target groups – without any arrogant "top-down teaching." This has much to do with trust. Public trust is fragile and can be lost easily and quickly.[31] Critics accuse some climate scientists and some economists of being arrogant, i.e., for being dogmatic, lacking scientific self-

[31] Trust can be lost through the issues discussed above, especially through errors and a bias, including bias in the choice of personnel, as critics have accused the IPCC (see Sect. 3.3). Trust can decline further if the IPCC gives the impression that there are "academic gatekeepers," creating an academic coterie with no access for critical scientists. In the case of climate sciences, the communication between scientists and the public is badly disturbed (see Sect. 3.3).

criticism and aggressively attacking critics. This leads to a hardening of attitudes instead of an "integrative" public debate,[32] which certainly endangers trust.

Some scientists might suffer from these characteristics de facto, many others certainly do not. One possible explanation is that politicised academia is increasingly expecting scientists to be in the spotlight of the media and the public. They are not trained for such a task, however, and they might come across as being arrogant (though in some cases it is more like self-defence). The disappointment surrounding the "boring of hard boards" in policy-making processes could be a further reason for this arrogance. A simple weakness of character or a misguided view of scientific knowledge production can also not be discounted.

In general, interpreting and transforming scientific contents for policymakers and the public is a huge but unavoidable challenge (e.g. the "Summary for Policymakers" of the ARs). If it is not done properly, the messages may become flawed or biased which could result in misunderstandings and illusory expectations. A crucial aspect in this regard is the yearning of policymakers, the public and the media for simple, clear-cut and absolutely certain statements by experts. Experts who fall prey to this temptation too much may heighten their public profile – but risk conveying messages that are not in line with the scientific knowledge base.[33]

3.3 Popular Criticisms of the IPCC's Assessments

To illustrate some of the fundamental perils and problems at the science-policy interface with examples, this section outlines the history of the critique of the IPCC and the climate-related sciences brought forward since the AR4 in 2007. Although my outline of some popular criticisms of the IPCC does not (necessarily) imply endorsement of this criticism, it at least demonstrates that the potential perils and problems at the science-policy interface (Sect. 3.2) are actually relevant for the public debate about the IPCC. There is, thus, not only much positive appraisal of the IPCC's processes and impact, for instance by many governments in their recent statements on IPCC reform,[34] but also concerns and critique.

[32] "There is a kind of arrogance – we are scientists and we know best," Jasanoff said. "That needs to change." (source: http://news.sciencemag.org/sciencenow/2010/02/scientists-grapple-with-complete.html, accessed 20 Mar 2015).

[33] Some scientists and policymakers even argue that people are so stupid or disinterested in scientific subtleties that there is no choice but to transform scientific assessments into clear-cut, simple statements – which however involves all the risks just mentioned.

[34] See http://www.ipcc.ch/apps/eventmanager/documents/11/280220141142-inf1_future_of_ipcc_govt_comments.pdf and the synthesis in http://www.ipcc.ch/apps/eventmanager/documents/11/170320140356-p39_doc7_future_work_of_IPCC_synthesis_of_gov_submissions.pdf, accessed 30 Mar 2015.

3.3.1 Climate War, "Climategate" and Errors in IPCC Assessments

The first type of criticism directed at the IPCC assessments is related to the scepticism of some people against the climate-related sciences in general and the IPCC in particular.

3.3.1.1 Climate War and "Climategate"

Some people (mostly non-scientists) still assume that the strong consensus in the scientific literature about dangerous anthropogenic climate change is not due to real scientific evidence, but is instead due to some kind of conspiracy based on the political and economic interests of governments (possibly to impose more regulations and taxes) and of some climate scientists (to get further funds for their alarmist "doomsday research"):

> When an issue like global warming is around for over twenty years, numerous agendas are developed to exploit the issue. The interests of the environmental movement in acquiring more power, influence, and donations are reasonably clear. So too are the interests of bureaucrats for whom control of CO_2 is a dream-come-true. […] Politicians can see the possibility of taxation that will be cheerfully accepted because it is necessary for 'saving' the earth. Nations have seen how to exploit this issue in order to gain competitive advantages (Richard Lindzen).[35]

Another, more moderate and much more plausible form of scepticism against the climate-related sciences is the critique on the sometimes apocalyptic descriptions of climate impacts – which were often exaggerated particularly in the 1990s and by the media (Weingart et al. 2007). There is currently a widespread distrust in the academic sciences in general (Bammé 2004) and in the climate-scientific community specifically. This consequently suggests a critical examination of the IPCC reports.

Since the 1980s, there has been a kind of cultural "climate war" particularly in the US and the world wide web (Weingart et al. 2007; Pooley 2010) that is precisely about these critical issues. It is a "war" between some scientists and NGOs as apologists of the climate-related sciences on the one hand, and climate sceptics or other critics of the climate-related sciences and their attitudes on the other. The latter often accuse climate scientists of having hidden political interests behind their scientific standpoints.[36]

[35] See http://www.qando.net/?p=10156, accessed 14 Mar 2015. Lindzen is a climate scientist who had been an IPCC author. He is one of very few professional climate scientists today who denies the strong anthropogenic influence on climate change. Using Internet search engines, one will immediately find plenty more statements by him of this kind. For a comprehensive overview of the core controversies in the public (rather than the science-internal) debate on global warming see http://en.wikipedia.org/wiki/Global_warming_controversy, accessed 14 Jan 2015.

[36] Interestingly, the most active critics of climate science are in the US, and climate scepticism in the US can mostly be found among non-scientist, Republican partisans, according to a poll by

One big "battle" within this "climate war" was the so-called "Climategate" affair shortly before the important COP-15 in Copenhagen (this date was presumably no accident), which mostly took place in the public media. The email accounts of some climate scientists, mostly with the Climatic Research Unit East Anglia, where hacked and hundreds of emails published on the Internet. Despite the ado around this affair in the media, there was not really anything exciting in those emails, or at least they cannot be regarded as proof of a conspiracy of climate scientists as intentionally deceiving people by disguising uncertainties, falsifying their scientific work or even withholding important climate data.[37]

Nonetheless, these emails revealed that behind closed doors, some climate scientists talk more frankly about scientific uncertainties than in public, and that there is mutual hatred between the adversaries in the "climate war." Therefore, some media and many bloggers attacked climate scientists not only for allegedly flawed climate science, but also, independently from flawed science, for the bad role climate scientists sometimes play in the policy arena, especially in terms of exaggerating the dangers of climate change (Nerlich 2010).

3.3.1.2 Errors in the AR4: Trust in the Self-Regulation of the Sciences?

Moreover, in the weeks after Copenhagen, some newspapers launched an orchestrated critique on the IPCC, particularly on the AR4.[38] This was another important "battle" in the "climate war." Two clear mistakes in the AR4 concerning glacier meltdown in the Himalayas (transposed digits) and certain details about potentially flooded areas of the Netherlands were found (both exaggerating climate impacts), and some further accusations against the AR4 were raised. In the first months of

Stanford University (http://www.ipsos-na.com/download/pr.aspx?id=10987). Studies discussing the reasons for this and strong political-economic interests behind this latter party of the climate war include Oreskes and Conway (2010), Powell (2010), Mann (2012), and NGO reports such as http://www.greenpeace.org/international/Global/international/planet-2/report/2010/3/dealing-in-doubt.pdf and http://www.ucsusa.org/assets/documents/global_warming/exxon_report.pdf. Also, European companies play a role in this game, see http://ecocentric.blogs.time.com/2010/10/25/politics-european-energy-companies-funding-climate-skeptic-campaigns-in-the-u-s/ (all web links accessed 30 Mar 2015). The climate change "denial industry" (Oreskes and Conway 2010) partly triggered and staged the affairs following below. The idea obviously was to attack the scientific credibility of one of the most important players in climate policy, namely the IPCC.

[37] See, for instance, Russell et al. (2010); Nerlich (2010); and http://www.ucsusa.org/global_warming/solutions/fight-misinformation/debunking-misinformation-stolen-emails-climategate.html#.VTiGzJNqO1k (accessed 30 Mar 2015). The exonerating results of these investigations were far less reported in the media than the initial accusations against the scientists.

[38] See Rahmstorf (2010). See also http://www.fr-online.de/klimawandel/klimawandel-die-wahrheit-ueber-fehler-des-klimarats,1473244,2679180.html, http://www.sueddeutsche.de/wissen/kampagne-gegen-klimaforscher-wo-wuesten-hokuspokus-sind-1.13981 and http://bazonline.ch/wissen/natur/Die-gescheiterten-Angriffe-auf-die-Klimaforscher-/story/26665921 (all accessed 30 Mar 2015) for newspaper articles on the accusations against the IPCC and the reactions of media and scientists.

2010, hardly a week passed without a new alleged mistake and further flaws in the AR4. Scientists rejected these further accusations vehemently, aside from the two mentioned mistakes.

As a reaction to the high-profile affairs of the AR4 errors, no less than six independent and comprehensive critical scientific investigations by the InterAcademy Council, the Netherlands Environmental Assessment Agency, the Royal Meteorological Society, the International Council on Science, the Geological Society of London and the National Research Council of the US were conducted after this attack in 2010. All of them stated that the core results of the IPCC were robust, despite the two minor mistakes in a report of roughly 2800 pages, and despite some flaws in the review process. For instance, the Netherlands Environmental Assessment Agency (PBL) "has found no errors that would undermine the main conclusions in the 2007 report of the [IPCC] on possible future regional impacts of climate change."[39] However, the PBL report criticised the AR4 SPM (Summary for Policymakers) – which the UNFCCC member nations approved line by line – for focusing too much on the risks of climate change. So,

> in some instances the foundations for the summary statements should have been made more transparent. The PBL believes that the IPCC should invest more in quality control in order to prevent mistakes and shortcomings, to the extent possible (PBL 2010).

3.3.1.3 Communication, Self-Criticism and Internal Procedures

For many people, even more annoying than the errors in the AR4 was the reaction (i.e., the bad communication and crisis management) of the IPCC, particularly of its chair, Rajendra Pachauri, who was additionally accused of conflict of interests (Booker and North 2009). For quite a long time, the IPCC denied that there were any mistakes in the reports, and critics were attacked by IPCC officials. So, there are yet other problems of scientific policy advice: communication and the willingness to accept critique. One could argue that worse than errors in scientific reports is the lack of self-criticism – without dissent, there would presumably not be much scientific progress.

Yet another point is to be added: Many criticised the IPCC for not having adequate internal procedures to deal with mistakes and flaws in the ARs and for inadequate self-regulation. The review processes obviously were not satisfactory, as the

[39] PBL (2010). Regarding the objections against climate scientists and the IPCC, Bert Bolin concludes that they are "seldom found in the peer-reviewed scientific literature, but rather in personal interviews and, of course, on the internet. Home pages expressing doubts are quite numerous, but are often simply not trustworthy. However, this 'grey' literature sometimes catches the attention of a wide circle of non-specialists and is misleading the general public" (Bolin 2007, p. 209). Another very clear statement on this reads: "Scientific skepticism is healthy. Scientists should always challenge themselves to improve their understanding. Yet this isn't what happens with climate change denial. Skeptics vigorously criticise any evidence that supports man-made global warming and yet embrace any argument, op-ed, blog or study that purports to refute global warming" (http://www.skepticalscience.com/, accessed 14 Mar 2015).

errors showed. A big topic during this time was the handling of "grey literature" (i.e., non peer-reviewed literature).

3.3.1.4 Underestimated Risks of Climate Change

There are, however, also criticisms of the IPCC asserting that the IPCC AR4 underestimated the risks of climate change. Some scientists argue in this direction by pointing out the underestimated risks of tipping points (Lenton et al. 2008) and of rising sea levels (Brysse et al. 2012).[40] Others observed a significant bias in some media understating the risks of climate change (Antilla 2010; Freudenburg and Muselli 2010).[41]

Furthermore, many are sceptical about the IPCC SPMs, since there is a line-by-line approval by governmental representatives. Some of them are obviously not interested in a balanced account of the current state of climate-related sciences, but rather in their political and economic national interests.

3.3.2 IPCC WG III: Bias and Hidden Value Judgements?

What are the criticisms of the integrated economic assessments by the IPCC in particular? Although this book focuses on these integrated economic assessments, it is important to understand the above criticism of the IPCC concerning natural scientific statements as well. This is because the "climate war" spilled over into the field of the economics of climate change since (at the latest) the Stern Review, which was published shortly before the AR4. There were also critiques of the WG III contribution to the AR4, of the 2011 Special Report of the IPCC WG III on Renewable Energy Sources and Climate Change Mitigation (SRREN; IPCC 2011), and later on the WG III contribution to the AR5. In contrast to the above mentioned "affairs" (Climategate and AR4 errors) that were mostly related to natural science, there was much less criticism of the economics presented in IPCC assessments, and it had much less effective publicity on the internet as well as in printed media, although

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40 See http://www.nature.com/climate/2010/1004/full/climate.2010.29.html. See furthermore http://www.global-warming-forecasts.com/underestimates.php, which also states that the IPCC AR4 underestimated climate risks. All accessed 14 Mar 2015.

41 "During both periods [of the analysis presented in their paper, M.K.], new scientific findings were more than twenty times as likely to support the ASC [Asymmetry of Scientific Challenge, M.K.] perspective than the usual framing of the issue in the U.S. mass media. The findings indicate that supposed challenges to the scientific consensus on global warming need to be subjected to greater scrutiny, as well as showing that, if reporters wish to discuss 'both sides' of the climate issue, the scientifically legitimate 'other side' is that, if anything, global climate disruption may prove to be significantly *worse* than has been suggested in scientific consensus estimates to date" (Freudenburg and Muselli 2010).

some influential US media seemed to be heavily biased in the case of climate economics (“balance as bias,” Pooley 2009).

3.3.2.1 Criticism of AR4 Economics and the SRREN Report

Richard Tol, together with Massimo Tavoni, criticised the IPCC AR4 economics for its rather optimistic view of global economic costs for ambitious climate change mitigation (i.e., the 2 °C goal).[42] Tavoni and Tol point out that very few economic models are able to calculate these costs, while most models assume that such an ambitious policy target would not be feasible in economic terms. Yet, they argue that the AR4 WG III is biased in the selection of studies as well as in their interpretation; they state that the IPCC prefers grey literature to peer-reviewed literature; and they claim the internal review process of the IPCC did not really work. One of the authors of the relevant passages in the AR4, Ottmar Edenhofer, argued that these accusations are not correct and are to be fully rejected.[43]

One year later, in 2011, there was a further attack on the IPCC economics, this time on the SRREN report. The main accusation was that this report is highly dominated by results of a study that was commissioned by the environmental NGO Greenpeace, and that a Greenpeace member, Sven Teske, was a lead author for the SRREN. Both were regarded as severe biases of the IPCC.[44]

3.3.2.2 The Debate About the Stern Review

Another kind of critique focuses on opaque or highly disputed ethical value judgements in the economic assessment of climate policy options. These things have mostly been discussed in academic debates. Examples include Schneider (1997) and Hof et al. (2008). The most prominent discussion is about the influential Stern Review (Stern 2007). There was a very interesting debate after the Stern Review between Stern, Nordhaus, Dasgupta, Dietz, Weitzman and others (see Chap. 8). This debate was mainly about the issue of discounting the future and about how to value non-economic goods in economic assessments (e.g., climate damages). Both

[42] See Tavoni and Tol (2010) and, much stronger, Tol’s assertions in blogs, e.g., http://klimazwiebel.blogspot.com/2010/09/richard-tol-challenges-assertion-by.html, accessed 14 Mar 2015.

[43] See http://www.spiegel.de/wissenschaft/natur/0,1518,686205,00.html, accessed 14 Mar 2015.

[44] See http://www.marklynas.org/2011/06/new-ipcc-error-renewables-report-conclusion-was-dictated-by-greenpeace/ and http://wattsupwiththat.com/2011/07/24/greenpeace-and-the-ipcc-the-edenhofer-excuse/. Compare, however, the reply by Edenhofer (2011) defending the SRREN and rejecting the arguments by the critics. The disputed Greenpeace scenario is only one among others in the report, but it was the IPCC press briefing that did not satisfyingly make this relativity clear. For the danger of bias “in the other political direction” see the role of oil nations and others in the negotiations of the SRREN SPM, e.g. Teske’s report on http://www.tagesspiegel.de/politik/ipcc-report-klimarat-haelt-energiewende-bis-2050-fuer-moeglich/4153282.html (all links accessed 14 Mar 2015).

topics are, to a large extent, about ethical values. Stern was criticised in general for doing normative economics (Nordhaus 2007) and for inconsistent and disputable ethical assumptions (Dasgupta 2007). Some criticised mainstream climate economics for its focus on economic growth instead of a focus on human well-being and on the crucial details of policy instruments such as emissions trading schemes. The crucial underlying fear is that the climate-related sciences, including economics, can create an "iron cage of bondage" for policy-making (see Sect. 3.2.2.2) through opaque value judgements in studies that mistakenly suggest pseudo inherent necessities of certain policy options.

3.3.2.3 Criticism of the WG III Contribution to the AR5

Also the WG III contribution to the AR5 faced criticism. One example was an article in the Economist shortly after the release of the WG III AR5 (IPCC 2014).[45] Inter alia, it states that the IPCC "describes itself as 'policy-relevant and yet policy-neutral'. Its latest report, the third in six months, ignores that fine distinction." The Economist argued that the estimated costs of mitigation are "preposterous" and far too low. For the Economist, the WG III assessment is clearly biased towards ambitious climate change mitigation, ignoring its actual costs and risks for societies. However, in his reply, the WG III Co-Chair Ottmar Edenhofer explained that the Economist had clearly misunderstood the IPCC assessment.[46]

Another criticism of the WG III AR5, at least of an earlier draft version and its communication, mainly came from certain governments, particularly Saudi Arabia (IISD 2014). WG III had produced figures explaining the historical development of CO_2 emissions in different groups of countries. Among these figures was an income-based country grouping from an ex-post perspective on their CO_2 emissions. Some governments considered such a country grouping as policy-prescriptive because it could be used to argue for specific mitigation burden schemes.[47]

> Although the underlying technical report from WGIII was accepted by the IPCC, final, heated negotiations among scientific authors and diplomats led to substantial deletion of figures and text from the influential 'Summary for Policymakers' (SPM). The deleted content focused largely on historic emissions trends analyzed by country income groups and international cooperation. IPCC authors are instructed to be policy-relevant, without being policy-prescriptive, and the SPM is intended to balance governmental and scientific input. But some fear that this redaction of content marks an overstepping of political interests, raising questions about division of labor between scientists and policy-makers and the need for new strategies in assessing complex science. Others argue that SPM should explicitly be coproduced with governments (Wible 2014).

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[45] The article (published 16 Apr 2014) was titled "Another week, another report," see http://www.economist.com/news/science-and-technology/21600967-options-limiting-climate-change-are-narrowing-another-week-another-report, accessed 30 Mar 2015.

[46] See http://www.economist.com/news/letters/21601482-ipcc-russia-afghanistan-banks-jobs-parliament-beer-cheese-adrian-mole, accessed 30 Mar 2015.

[47] For a defence of what the WG III did, see Edenhofer and Minx (2014).

Moreover, many have criticised the IPCC WG III assessment processes for being overly time-consuming and laborious; they do not allow for quick and timely response to policy questions. Additionally, some found the IPCC's social science policy evaluation unsatisfactory, also because in their view, the IPCC did not manage to adequately synthesise the existing social science research (Victor 2015; Carraro et al. 2015).

There are, thus, some perils of IPCC assessments, although many of the accusations against the IPCC were convincingly rejected (both regarding errors and alleged biases) and although several investigations showed that the core results of the IPCC AR4 are reliable and unbiased. Furthermore, we are now aware of the "climate war" as an important backdrop to the topic of this book. Many people distrust the results of the climate-related sciences, including economics; in their view, IPCC assessments are politically biased (in a non-transparent manner). Additional criticisms of IPCC economics can be found in Part III of this book.

3.4 The Need for a New Philosophical Response to the Key Challenge of Integrated Economic Assessment-Making

The discussion of the major perils and problems at the science-policy interface (Sect. 3.2), based on the analyses in Sect. 3.1, is perhaps not comprehensive, but it provides a systematic overview of, and introduction to, these perils. The examples of the actual criticism of the IPCC (Sect. 3.3) illustrate that these perils are more than mere theoretical concerns. The descriptions in Sect. 3.2, especially about the misuses of academic authority, might sound despairing. I did not, however, assert that all agents of the science-policy interface always behave in such undesirable ways. Some do a good job, and much of the criticism of the IPCC can be rejected. Moreover, there may be means to contain such risks and to promote high-quality work at the science-policy interface (Chap. 11).

As was said, the general norms for expertise in policy (Sect. 2.1.3) play a central role in understanding and interpreting these perils and problems. Empirical research on the science-policy interface (see, e.g., Sect. 3.1 and Cash et al. 2003) suggests that these norms are, besides their normative appeal, also relevant in a more descriptive perspective, since meeting these conditions is required for significantly affecting policy anyways (at least in the longer-term perspective).

Besides the clarification of the individual perils themselves, Section 3.2 already indicated that there are fundamental interdependencies and trade-offs between the different general norms for scientific expertise in policy.[48] Let us make these trade-offs more explicit.

The treatment of value judgements, discussed in Chap. 5, is among the main drivers and factors underlying these trade-offs. In order to be highly policy-relevant,

[48] Trade-offs between salience, credibility and legitimacy are also identified by Cash et al. (2003). Similar trade-offs are described by Habermas (1968) and Pielke (2007).

experts ought to assess specific policy options. This, however, may entail disputable ethical assumptions. Such value-laden "post-normal science" is frequently criticised for its lack of scientific rigor and validity based on traditional standards for scientific quality. Obviously, political legitimacy is also endangered if the value judgements in these policy assessments are disputed and one-sided. Hence, scholars often refrain from highly policy-relevant, yet risky social-science policy evaluation. The problem of value judgements in policy assessments is thus crucial to the understanding of the major trade-offs. Another fundamental trade-off exists between good communication and credibility together with political legitimacy. Many other aspects and examples of interlinkages between the general norms were presented in Sect. 3.2.

Mitigating the trade-offs between the general norms for scientific expertise in public policy is the *key challenge* of bridging scientific expertise and public policy – and this must also include dealing with the individual perils and pitfalls. This key challenge needs to be tackled in order to realise the general norms and to meet the normative demands developed in Chap. 2. This is particularly true for the trade-offs between policy-relevance, sound science and political legitimacy in value-laden and uncertain social-science policy assessments, such as the integrated economic assessments by the IPCC.

Hence, the integrated economic assessments by the IPCC require orientation in terms of an appropriate framework to tackle the key challenge and to avoid the other perils of expertise in policy presented in Sect. 3.2. Such orientation is precisely what is currently lacking, because this key challenge is so difficult to address. The framework for the IPCC, envisaged in this book, has to successfully respond to this key challenge. This can be extremely important for climate policy which, to some extent, relies on scientific advice; a failure to provide appropriate scientific assessments, i.e. assessments that meet the four general norms as minimum criteria, could have disastrous impacts on well-being and society. Since the issue of implied value judgements and uncertainty, among other things, plays a crucial role, a philosophical reflection on these issues at the science-policy interface is also needed.

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Part II
A Philosophical Evaluation of Normative Science-Policy Models

Chapter 4
Prevalent Action-Guiding Models of Scientific Expertise in Policy

Abstract Science-policy models guide the practice of the Intergovernmental Panel on Climate Change (IPCC) and other science-policy institutions. Such science-policy models are primarily about the general competence, responsibility and legitimate role of scientific experts, policymakers and other players at the science-policy interface. The central question of Part II is how well they help tackle the key challenge at the science-policy interface, i.e. help comply with the four general norms for expertise in policy (Part I)? The results of the evaluation and refinement of the predominant science-policy models will both contribute to the envisaged framework for the IPCC assessments on a more general level, and serve as useful "lenses" for the more specific evaluation of the integrated economic assessments of the IPCC (Part III). This chapter introduces the decisionist, the technocratic, the pragmatic and the legitimisation models of the role of scientific expertise in policy; these four models are prevalent in practice. Section 4.1 explains core common characteristics of these prevalent models. The systematic analysis of the four models – particularly their philosophical assumptions on scientific knowledge – as potential tools to realise the general norms for expertise in policy follows in Sect. 4.2. Finally, Sect. 4.3 explains how the analysis and evaluation of these models can be used for the evaluation of the IPCC's work.

Mitigating the trade-offs between the general norms (Sect. 3.4) requires guidance for how to appropriately design assessment processes and other science-policy interactions. Different normative models of scientific expertise in public policy have been developed to guide assessment design and other actions at the science-policy interface. These models can be used to translate the widely accepted, yet highly abstract norms from Sect. 2.1.3 into different basic ideas for a division of labour at the science-policy interface. These science-policy models are primarily about the general competence as well as legitimate role and responsibility of scientific experts, policymakers and other players in scientific policy advice.

Are the prevalent science-policy models that inter alia guide the practice of the IPCC suitable means (on their rather general level) for tackling the key challenge of expertise in policy as outlined in Sect. 3.4, i.e. for complying with the general norms for expertise in policy? If not, how can these models be improved? These are the

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core questions of Part II which analyses, critically evaluates and refines the science-policy models. It will be argued that refining the most promising models is necessary because most of the existing science-policy models more or less fail to satisfactorily mitigate the trade-offs between the general norms. Consequently, to date, there is still a certain lack of orientation in the theory and practice of expert-policy institutions, as many observers note (Sect. 1.2).

The discussion of the action-guiding science-policy models in Part II serves a dual purpose: *First*, it aims to directly contribute to the envisaged framework for the integrated economic assessments of the IPCC in terms of *general* guidance for scientific expertise in policy through a refined science-policy model (Chap. 6). Such a model that helps to realise the ideals developed in Part I is currently lacking; this is mainly because of philosophical issues that can be discussed independently from the more specific aspects of the IPCC economics (Parts III and IV). *Second*, it provides a well-justified evaluative viewpoint that is indispensable as an intermediate step towards the successful evaluation and improvement specifically of the IPCC WG III economics (Parts III and IV). This evaluative viewpoint builds on both the insights on the strengths and weaknesses of the prevalent science-policy models, and the refined normative model (Chaps. 5 and 6): (1) insights on the prevalent, largely flawed science-policy models can be employed as “perceptual lenses” for the analysis of the integrated economic assessments of the IPCC where some players make use of these science-policy models as well, and they direct the attention to specific problems of these particular assessments that might otherwise have been overlooked; (2) the refined science-policy model provides general normative criteria for integrated economic assessment-making that are more differentiated than the normative standpoint developed in Chap. 2.

This chapter introduces the decisionist, the technocratic, the pragmatic and the legitimisation models of the role of scientific expertise in policy; these four models are prevalent in practice. Section 4.1 first explains some common aspects of these prevalent models. The systematic explanation and analysis of the four models as potential tools to realise the general norms for expertise in policy follows in Sect. 4.2. Finally, Sect. 4.3 points out how the analysis and evaluation of these models can be used for the evaluation of the IPCC’s work.

4.1 Introduction to the Science-Policy Models

Critics, apologists and all practitioners of science-policy institutions, such as the IPCC, generally work with concepts of both what the role of scientific expertise in public policy actually is, and in particular of what it should ideally be. This comprises some action-guiding principles. Yet, in my experience, many players at the science-policy interface do not have clear, consistent and elaborate normative assumptions about the role of expertise in policy; frequently, such normative assumptions are only implicitly employed, and sometimes not fully consciously.

One can, however, *reconstruct* such assumptions as models of the science-policy interface in a systematic and consistent manner. This will help to better understand the alternative viewpoints at stake and to critically discuss them.[1] This conceptual reconstruction can be understood as an interpretative "ideal type" exercise. In his essay on social-science objectivity, Max Weber explains ideal types as conceptual tools that facilitate social-science analyses; they are hypothetical ideas or idealised models which distil the core characteristics from complex social realities in a clear, descriptive and simplified manner (Weber 1988, pp. 146–214). Based on the various practices and assumptions identified at the science-policy interface, one can thus conceive of a consistent, broader and hypothetical "science-policy model" in terms of an ideal type. As such, this does not necessarily imply that the players at the science-policy interface actually make use of *precisely* these reconstructed, differentiated and systematic science-policy models. Yet, many empirical observations of science-policy interactions back the way these models are reconstructed in this chapter (see Sect. 4.3); most assumptions in the prevalent science-policy models presented here are in fact relatively widespread among the agents at the science-policy interface so that only minor interpretation and reconstruction is necessary. Therefore and for the sake of simplicity, I will talk about, e.g., "the proponents" of these science-policy models in the remainder of this book, even though these models are (partially) reconstructed by myself or other observers of science-policy interactions.

The concept 'ideal types' shall not blind us from the normative, action-guiding character of the science-policy assumptions as such, held by the science-policy players. Thus, although the goal of reconstructing their views is to *describe* the prevalent science-policy models, the nature of these action-guiding models itself is largely normative. Once the prevalent science-policy models are reconstructed, they could also allow for a heuristic-hermeneutic use. Observers of science-policy interactions can use such models as conceptual instruments, terminology and helpful categorisation to describe what they observe, while the players at the science-policy interface may use such science-policy models to express their own normative views of science-policy interactions more clearly and consistently. A major purpose of reconstructing science-policy models – and of criticising them in terms of their practical implications – is to enable a more explicit, constructive discussion about such general normative ideas for scientific assessment-making.

All of the prevalent science-policy models imply assumptions about (1) how scientific knowledge production, policy-making and the science-policy interface actually work, (2) the general goals and norms for policy-making, (3) what kind of valuable, reliable knowledge the sciences can offer (i.e., about the competence of the sciences), (4) which role knowledge can play in policy, and (5) whether it is legitimate to give the sciences a substantial role in policy, and to what extent.

On a general level (abstracting, e.g., from more specific institutional aspects and procedures), these models primarily, although not exclusively, address the division of power and responsibility at the science-policy interface. More precisely, the

[1] This presupposes that the systematic reconstruction of existing viewpoints is kindly disposed towards these viewpoints; it should try to make the assumptions that are *de facto* held by science-policy players as consistent and plausible as possible, i.e.: to make them worthwhile discussing.

models address the question of who should be tasked to infer the policy problem, policy ends and the means for achieving these ends[2]: scientists only; politicians and public officials only; or different groups together, for example in a participatory public discourse? The respective answers to these questions have implications for how well sound, policy-relevant, well-communicated and unbiased scientific knowledge can be achieved. The answers have also implications for the strength of the impact of the sciences on policy. Theoretically, as will become clear below, all science-policy models discussed here can be used as ideas for how to deal with the perils at the science-policy interface (Chap. 3), even though not all of the proponents of these models would agree with my definition of the key challenge (Sect. 3.4). However, the sheer fact that at least some models subscribe to the general norms for expertise in policy (Sect. 2.1.3) does not necessarily mean that all of these models *actually* help fulfil these norms.

The science-policy models are decisive when evaluating the work of a science-policy institution. In fact, such models are – in their heuristic-hermeneutic function – already a prerequisite for describing and explaining such institutions (Beck 2009, pp. 19 and 24). Even more importantly, the inherent normative ideas about the role of experts guide both the shaping of institutional frameworks of scientific policy advice and concrete institutional or individual practices, since they are action-guiding for the agents at the science-policy interface. So, these models are a kind of effective and very generic, but often only implicit, orientation for the science-policy interactions. In this action-guiding function, the prevalent models of expertise in policy considerably contribute to the success or flaws of the IPCC.[3]

The prevalent science-policy models are, thus, very likely to be among the main reasons for the flaws in scientific policy advice (Sect. 3.2) and the criticism of the IPCC assessments (Sect. 3.3). Hence, the prevalent models can be seen both as a

[2] In this sense, science-policy models are loosely related to the hypothesis of a policy cycle (see Sect. 3.1.1 and Dunn 2012, Chap. 1). By (policy) "ends" I mean (policy) objectives, i.e., ends in the sense of ends-in-view, in contrast to "ends actually attained" (see Chap. 6). The term "policy objectives" can either refer to (1) general goals, ethical values, basic interests, priorities or fundamental constraints related to a particular framing (agenda) of the problem or risk assessments, such as "planetary boundaries" (Rockström et al. 2009); or (b) their translation into more specific, possibly subordinate, policy targets, such as specific climate change mitigation goals. Policy means can be understood as courses of action decided on by governments or governmental institutions that can include a variety of policy instruments from carbon taxation to education funding; these instruments are intended to result in specific measures (i.e., technologies, behaviour, etc.). Such policy options can be decided through legislative acts, executive orders or court decisions at different governance levels.

[3] There are obviously also many other factors concerning the work of the IPCC and other science-policy institutions, such as personal or structural inertia and restrictions faced by attempts to reform structures of scientific policy advice (Kitcher 2011, p. 11), but also the individual rationalities of the players at the science-policy interface (Sect. 3.1). Yet, the models of the science-policy interface – as "ideas" and partly action-guiding values, or "role models," or "basic principles" – are effective as well. Even in the case that the underlying assumptions about policy processes or the quality of scientific knowledge production are flawed in these models, they can wield high influence on the actual behaviour of individual players at the science-policy interface, or on the institutional arrangements of assessment bodies.

source of ideas for how to tackle the key challenge and as a possible reason for some of the misguided uses and flaws of scientific expertise in policy. Large-scale policy assessments by the IPCC are the paradigmatic case I have in mind for the choice of the predominant science-policy models discussed in the following sections (in contrast to, for instance, more "technical" scientific policy advice).

4.2 Four Prevalent Models of Expertise in Policy

The philosopher Jürgen Habermas provided a seminal description of three models of scientific expertise in policy (Habermas 1968, pp. 120–131). They are termed the "decisionist" model, the "technocratic" model and the "pragmatic" model. These three stylised models will be briefly portrayed, as inspired by and based on the work of Habermas (1968). In principle, these models are still appropriate to describe the normative concepts at the science-policy interface that are predominant in current practice, although meanwhile more fine-grained empirical studies exist. Yet, the Habermasian models need to be analysed in a more differentiated manner for the purposes of this book, particularly regarding their sometimes neglected epistemological and other philosophical implications. The analysis of these models below primarily focuses on the normative aspects of these models because these are the most interesting ones given the topic of this book.

In the debate of the 1960s about science-policy interactions in general and technocracy in particular, when Habermas also wrote his salient book (Habermas 1968), the issues of science policy and the agenda of the sciences were primarily discussed, in terms of which kind of research is to be funded by the public. Nonetheless, the models discussed below – though developed in this early context – are still clearly applicable to today's science-policy interaction – which is mainly about problem formulation and assessing policy options (Grunwald 2008, p. 283).

Furthermore, the so-called "legitimisation model" is introduced as a fourth stylised model. Theoretically, there are various other science-policy models, but they can be understood as mere variations or mixtures of the three models presented by Habermas (1968, pp. 120–131). Sometimes there is a rather thin conceptual line between the models. A more differentiated discussion of the pragmatic model cluster and its numerous variations – which currently dominates the literature on the science-policy interface – follows in Chap. 6.

4.2.1 The Decisionist Model

The "decisionist model" is presumably the one with the longest history (Hulme 2009, p. 100). It can be traced back to the thinking of Machiavelli, Morus and Hobbes (Beck 2009, p. 25; Habermas 1968, p. 121). Yet, it is ascribed to Max Weber and his critical analysis of bureaucracy and technocratic rationalisation, even though

Weber would not agree with all aspects of the decisionist model (Dunn 1994, p. 47). More than many other social scientists and philosophers, Weber reflected on the difficult relationship between the sciences and policy.

For Weber, the sciences could possibly make policy more rational, but the rule of experts can lead to an "iron cage of bondage" for policy-making that reduces legitimate opportunities for the actions and decisions of policymakers (see Sect. 3.2 and Weber 2006). The decisionist model assumes that determining policy ends necessarily requires normative-ethical judgements[4] which are regarded as "subjective" (i.e., dependent on personal bias) and which cannot be made in a rational manner; experts therefore cannot better judge such value-laden issues than non-experts. Accordingly, scientific experts, nor anyone else for that matter, could never infer these policy ends in a credible, reliable and widely acceptable manner, as some bureaucrats and experts mistakenly promised in Weber's view. Therefore, a determination of policy ends by experts can lead to this iron cage for policy. From the perspective of the proponents of the decisionist model, the determination of policy ends is regarded as a political struggle between interests[5] that can only be described and explained, but not decided nor terminated by the sciences (Weber 1988, 1949).

To overcome the perils, the decisionist model suggests that policy ends should be negotiated, formulated and decided "irrationally" (Weber 1988, 1949; Habermas 1968) by public policymakers only, without any guidance from experts – because there cannot be any experts on value issues. According to the decisionist model, the role of the sciences is solely to provide instrumental reason, i.e., reliable and sound knowledge about the technological means to the policy ends. This knowledge should be value-free,[6] and has to be based on a scientific consensus. The policy means are, then, to be implemented by politicians (as law, etc.). That leads to the simplified scheme described below (Fig. 4.1), which promises to avoid a political misuse of the academic authority and to provide reliable knowledge on policy means.

The slogan of the decisionist model is "politics first, then experts" (Millstone 2005, p. 13). This is also valid for the problem formulation that should be based on public debates and political negotiation – rather than on scientific studies. Scientists may at best deliver some facts about the underlying natural system dynamics etc.; but it is the politicians who decide whether there is a need to act, i.e., whether a situation should be regarded as highly problematic or not.

An example may illustrate the decisionist model. In the case of long-term global climate change mitigation goals, which are subject to conflicting ethical values and many uncertainties, the decisionist model would suggest that only policymakers can

[4] See Chap. 1, footnote 2 for an explanation, and Chap. 5 for a differentiated discussion of the nature of value judgements.

[5] The "choice of a given policy alternative symbolizes the victory of one segment of the community over another" (Dunn 1994, p. 55), rather than a victory of "reason," "truth" or "the public good."

[6] For Weber, "value-free" simply denotes not directly evaluating something in *ethical* terms. Weber was, however, well aware that judgements in the social sciences are always related to non-ethical values and subjective world views (Weber 1949). See Chap. 5 for more details.

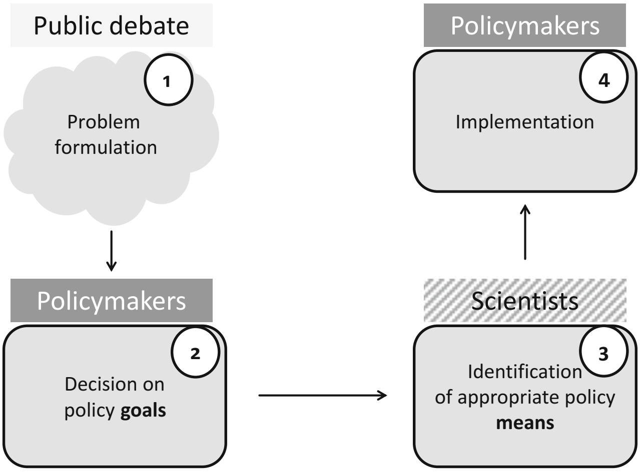

Fig. 4.1 The decisionist model of scientific expertise in policy argues that policymakers are to determine the policy goals, while scientists identify the best means

decide on a mitigation goal without any direct scientific support or a rational debate since a rational debate could not solve the problem at stake. For instance, policymakers simply decide on the goal to limit the mean global temperature rise to two 2 °C above the pre-industrial level ("2 °C goal," see Sect. 2.2.2). Experts, then, attempt to explore the possible means (technologies, economic policy instruments, measures etc.) to meet this goal, which are implemented by policymakers in the end. This does not, however, mean that the decisions by policymakers cannot somehow be based on certain scientific factual statements (e.g., about the physics of climate change).

Variations of the decisionist model include, e.g., "inverted" decisionism – where the ends are rationally determined by the sciences, and the means are decided by policy – that was developed in the US in the late 1950s (Millstone 2005, pp. 19ff). Later, this inverted decisionist model was refined by speaking of "risk assessment" instead of policy ends, and "risk management" instead of means (Millstone 2005, p. 25) – although these concepts are also used by those who do not subscribe to the inverted decisionist model.

The high yet risky influence of experts on policy is the main problem to which the decisionist model responds; it intends to solve this main problem of political legitimacy by a clear division of labour. The public does not play a very important role in the decisionist view. Both policymakers and experts have to be controlled in order to avoid the "iron cage of bondage" of bureaucracy. The decisionist model suggests more specifically that policymakers are controlled by the public, e.g., by democratic elections; moreover, the sciences must establish or maintain an internal review and control system, and the role of the sciences is confined to exploring policy means.

4.2.2 The Technocratic Model

The "technocratic model" as a second traditional model of scientific policy advice can be traced back to Saint-Simon and F. Bacon (Habermas 1968).[7]

The proponents of the technocratic model argue that due to the increasing and huge complexity as well as the novelty of current policy problems, they can no longer be solved by politicians, as suggested by the decisionist model.[8] Rather, they assume that the policy problems can only be successfully managed by sophisticated expert knowledge (Dunn 1994, pp. 54f). This scientific optimism relies heavily on the assumption of constant progress in science and technology.

This results in the idea to let scientific experts determine policy ends and perhaps even the underlying broader problem formulations, for instance in terms of "planetary boundaries" (Rockström et al. 2009; see Sect. 5.4 for a critical discussion). The remainder of society does not make substantial contributions to the determination of policy problems and policy ends. In addition, scientific experts should also propose some means for achieving these ends. Politicians are then no longer "policy *makers*" in the actual sense of the term. Their task is – beside more generic agenda-setting – reduced to formal decision-making and implementation of these scientific proposals, and to make decisions in those few cases where scientific rationalisation does not yet provide solutions.

In its most naïve version which is rarely defended by anybody who is reflecting on the science-policy interface, the technocratic model claims that science can and should evaluate both policy ends and means in a way that is completely value-free and, based on that, "purely scientific" (economic, technological, etc.) and highly reliable. Hence, in their view, sound science[9] is – apart from the inevitable value judgements in the selection of research questions – neither implying nor prescribing any values because science is about pure facts and value-free, as long as it is produced according to the state-of-the-art.

In contrast to this naïve view, most proponents of the technocratic model only argue, however, that there are no *ethical* value judgements involved in scientific argumentation – which provides the basis for research results that can be true for all. This does not exclude the involvement of other, allegedly unproblematic types of value judgements, such as cognitive value judgements (see Chap. 5).

Figure 4.2 illustrates the core structure of the technocratic model that promises to lead to scientifically well justified policy decisions.

In our example of climate change mitigation goals, the technocratic model implies that science can determine the best policy option, for instance a 3.5 °C goal that is based on a cost-benefit analysis. At the same time, scientific experts may also

[7] A widely cited proponent of the technocratic model is, for instance, Schelsky (1979).

[8] Particularly in the 1960s, the decisionist model came under increasing attack for precisely this reason (Grunwald 2008, p. 11).

[9] From the perspective of most proponents of the technocratic model, the methodology of natural science is the only reliable foundation of scientific knowledge. That is why they usually do not use the plural ("the sciences"), but rather talk about "science."

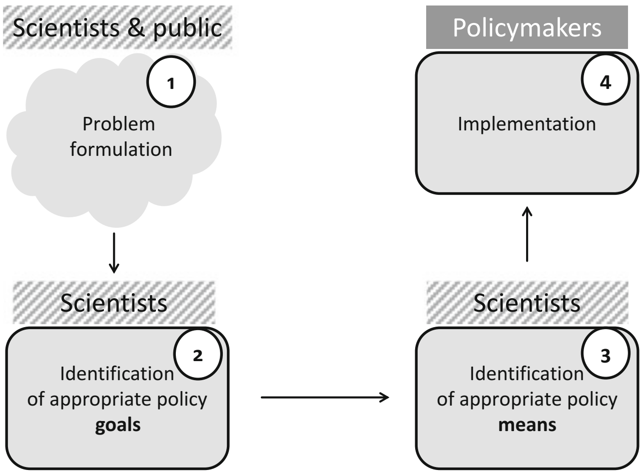

Fig. 4.2 The technocratic model of scientific expertise in policy argues that scientists should determine both the policy ends and the means

propose a set of means, such as a CO_2 emissions trading scheme and geo-engineering. The obvious uncertainties in climate-related science are interpreted as temporary and surmountable; as scientific knowledge production constantly evolves and progresses, these uncertainties can be substantially reduced.

A crucial premise of the technocratic model is that science can provide rational, reliable and policy-relevant knowledge, better than any other social group, and that the solution to the public policy problem at stake does not require questionable (ethical) value judgements. Skodvin summarises this view:

> The traditional view of science portrays research as a rational, rule-governed process, in which the implementation of the scientific method is the main mechanism […]. 'Knowledge' is what the community of scientists holds to be true on the basis of extensive scrutiny in accordance with demanding and discriminating methods (1999, p. 7).

As a variation of the technocratic model, some proponents would admit that also ethical value judgements are (at least sometimes) unavoidable for determining policy *ends*. However, this can be resolved, as it is assumed, by seeking a consensus within the "epistemic communities" (Haas 1992), which would render even these judgements "objective"[10] (i.e., trustworthy for all) and "factual." Alternatively, methods like rational choice theory, some kind of decision algorithm or, if necessary, a mere axiomatic treatment of disputed general values could help make policy ends "value-free" again, from a technocratic perspective. Such specific aspects are the basis for possible variations of the technocratic model.[11]

[10] See Chap. 5 for a discussion of this term and its implications.

[11] Another (still widespread) variation is the so-called "Red Book model" of assessment-making developed by NRC (1983). Yet, this could be interpreted as a variation of the decisionist model.

The technocratic model suggests that scientific consensus can and should be created only through pure science itself, and denies the role of society, culture or politics in scientific knowledge production. This consensus not only includes scientific results, but also a common definition of the societal or political problem at stake, a common understanding of good scientific practices, methods, and so on. According to this view, there is only one possible consensus and only one possible, true policy proposal, i.e., "consensus" is equated with "the truth," or is at least a necessary precondition for it. The technocratic (and to some extent decisionist) assumption is that

> [s]hould scientific dispute occur, there are only two possible explanations; either, one of the dissenters is (value) biased (i.e., not genuinely seeking the truth), or the scientific method is applied erroneously. […] Accordingly, ("true") knowledge can – with some reservations – be distinguished from mere knowledge claims by the operational criterion of *consensus* within the scientific community (Skodvin 1999, p. 7).

The technocratic model implies that scientific knowledge is always cognitively superior to other, non-scientific forms of knowledge. Hence, the technocratic model is sometimes called the model of "scientism" or "speaking truth to power" (e.g., Jasanoff 1990, p. 236). These thoughts about the one, science-internal consensus are compatible with the decisionist model; but in contrast to the technocratic model, the decisionist model neither puts much emphasis on science-internal procedures (since the focus is on avoiding the iron cage for policy), nor does it assume that scientifically determined policy ends can be true for all.

Both the technocratic and the decisionist model assume that science and policy-making are two fields that can and should be strictly separated. Or, as Brown (Brown 2009, p. 103) puts it: "experts do not have interests, and representatives do not have expertise." The arguments put forward in favour of both the technocratic model and the decisionist model are often based on a rather linear understanding of scientific policy advice (Jasanoff 1990; Beck 2009; Pielke 2007). According to this notion, scientific experts provide their knowledge to politicians in a more or less linear and monocausal fashion that is effective without substantial further interaction, with minimal distortion of the scientific content and with no substantial societal influence on the scientific ideas; the technocratic model assumes that policy-making can be a *rational* process in which well-founded scientific studies are more or less readily taken into account for policy design (compare Sect. 3.1).[12] Moreover, some proponents of the technocratic model assume that policymakers and the public are – in contrast to (some) scientific experts – not intelligent or knowing enough to tackle the challenges of our time.

For the proponents of the technocratic model, their recommendations – including those for policy goals – are to be regarded as highly reliable for everyone. Accordingly, the main problem to which the technocratic model responds is fundamentally different from the problem phrasing of the proponents of the decisionist model. For the proponents of the technocratic model, the main concern regarding the science-policy interface is that policy does not sufficiently make use of sound

[12] The technocratic model is often related to an etatist view of democracy (Immergut 2011).

scientific knowledge (see also Chap. 2). The aim of sufficiently taking into account expertise is achieved by giving scientific experts the power and responsibility to determine both the means and ends of (climate) policy. The technocratic model puts also emphasis on the issue of scientific credibility (i.e., ensuring sound science) as well as on the possible misuse of expertise and scientific authority for political ("subjective") purposes by establishing strict standards for scientific knowledge production. From the perspective of the proponents of the technocratic model, these standards ensure reliable and, therefore, politically legitimate knowledge. According to the technocratic model, scientific experts usually follow – due to institutional incentives and the academic ethos – the widely accepted scientific norms in their scientific activities, rather than their personal interests etc.

4.2.3 The Pragmatic Model (Cluster)

Next is the "pragmatic model," which represents a whole cluster or family of "pragmatic models" – as do the first two models, but there are far more variations of the pragmatic model. It was first developed by the pragmatist philosopher, G.H. Mead (Habermas 1968), and later introduced into the technocracy debate by Habermas (1968). The pragmatic model is also termed the "co-production model" (Hulme 2009), "democratic model" (Jasanoff 1990) or "co-evolutionary model" (Millstone 2005), to mention just a few examples. Habermas's (1968) presentation of the three science-policy models particularly inspired the further development of this pragmatic model in the literature; the majority of the scholars reflecting on the science-policy interface prefer the pragmatic model – in contrast to the practice at the science-policy interface where the decisionist and technocratic models are still prevalent. Based on that, numerous refined concepts were developed in recent years by scholars from various disciplinary backgrounds (see Sect. 6.1). This section only introduces some basic characteristics for the sake of completing the overview of prevalent science-policy models.

In order to avoid an "iron cage" for the public just like the decisionist model, the pragmatic model rejects the technocratic belief in absolutely reliable and more or less value-free scientific recommendations of policy ends by scientific experts. But the pragmatic model also rejects the decisionist view that the sciences should at least determine the policy means, since this could also undermine political legitimacy from the perspective of the pragmatic model. Instead, advocates of the pragmatic model usually state that the sciences cannot offer, roughly spoken, "absolutely true" knowledge and that scientific knowledge is always highly value-laden. Nonetheless, at least the Habermasian variation of the pragmatic model (Habermas 1968) assumes that the sciences can and should provide useful judgements about both policy ends and means.

Therefore, in contrast to the other models, a (public) discussion between scientific experts, policymakers and the citizenry about value-laden problem formulations, policy ends and means is desirable under the condition that certain formal, fair rules are complied with. Such a discussion could, according to the pragmatic model, help develop new technologies (means) and even policy ends in accordance with explicit and widely-debated values and societal needs. Instead of a strict separation between the sciences and technology on the one hand and the political arena on the other, the pragmatic model, thus, demands a critical interaction between the sciences, policy and the public. The need for much communication between these very different societal sub-systems in order to clarify things and understand each other is but one reason for the need for such an exchange. Another reason is that scientific experts are not regarded as capable of reliably and legitimately determining policy ends and means on their own; experts are called on to give inputs, yet not to *determine* the most adequate ends and means. The following simplified scheme (Fig. 4.3) is typical for most versions of the pragmatic model, which primarily promise to lead to pluralism, "deliberative democracy" and a more democratic control of expertise in policy:

In the case of climate change mitigation, the pragmatic model proposes that policymakers formulate a global mitigation goal and the means for achieving it, exclusively on the basis of a democratic discourse between scientists, policymakers and the public.

Scientific knowledge is no longer regarded as strictly true for all and largely value-free, as in the other models; it is assumed that there are only gradual and qualitative differences (if at all) between scientific knowledge and other forms of knowledge, for instance gut feelings, proverbs and rules of the thumb, "local knowledge" or everyday experience (Beck 2009, p. 35). Instead of the "one rationality" of "science" leading to a consensus as proposed by the technocratic model, the pragmatic model aims to establish a consensus via democratic participation and a discourse that may include different "rationalities" (Habermas 1968; Weingart 2001,

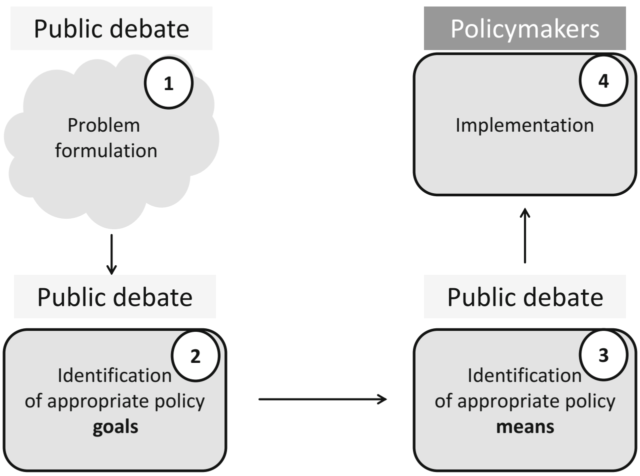

Fig. 4.3 The pragmatic model of scientific expertise in policy favours public debate (including the scientists) both for the determination of the policy ends and means

p. 23). That is why this model allows for decision-making in a pluralistic universe of facts and values.

This model does not believe in a linear transfer of scientific knowledge into policy, but rather in a substantial transformation of scientific contents during the discourse about them (Beck 2009, p. 34), which requires a dialogue and closer co-operation between the sciences, policymakers and the public. Proponents of the pragmatic model often assume that policy-making can only be an incremental "muddling through" (Lindblom 1959; Grundmann and Stehr 2011; and Sect. 3.1.1 of this book) with many conflicts of interests and power struggles, rather than a far-reaching rational, public problem-solving process. Accordingly, some proponents of the pragmatic model also do not claim a rational public discourse and deliberation, but rather emphasise (fair) bargaining and procedures.

A few scholars (mainly political scientists) seem to – often implicitly – follow a particular and very radical variation of the pragmatic model. This radical variation states, in contrast to the Habermasian variation, that one should take scientific evaluations of policy ends and means no more seriously than inputs from any other societal lobby group. According to this radical pragmatic model, the sciences are *in general* incapable of producing particularly reliable knowledge or any kind of judgements on such policy issues that could be regarded as superior to non-scientific judgements by laymen. So, laying particular stress on scientific judgements in public policy-making is not adequate. In this sense, the radical pragmatic model suggests to completely withdraw the privileged status from the scientific experts in public policy processes in order to avoid the perils discussed in Sects. 3.2.1 and 3.2.2. I call this radical stance a "science-policy pessimism," as it is pessimistic regarding the possibility of useful and legitimate scientific policy advice. The only reasonable role for science in society, if at all, is to provide pure and theoretical research on natural and social system dynamics etc. (see, e.g., the "Pure Scientist" model in Pielke 2007).

Another variation of the pragmatic model argues that the normative-democratic claim for equally engaging everyone in the process of determining of policy ends and means is the decisive reason for not leaving this determination to scientific experts alone – even if scientific experts could rationally and reasonably determine policy ends and means. In this case, political democracy is regarded as the more high-ranking value, compared with strictly "evidence-based" policy-making.

For the proponents of the pragmatic model, the main problem of scientific policy advice is not necessarily that scientific expertise is insufficiently recognised, as feared by proponents of the technocratic model. Neither is it *only* the danger of misuse or misguided use of academic authority (as in the decisionist model); but in addition, the issue of a flawed communication between experts, policy and the public is regarded as a core problem at the science-policy interface. Thus, the problem description by the classical variation of the pragmatic model is broader, compared with the other models, and the solution proposed is, first and foremost, an extensive public dialogue on policy issues between experts, policymakers and the public. However, from both the technocratic and decisionist perspectives, this dialogue might endanger the recognition of scientific competence. The pragmatic model, in contrast, is usually more sceptical regarding the competence of the sciences than the other models, but – at least in the Habermasian variation – still attempts to draw on scientific expertise regarding both policy ends and means.

4.2.4 The Legitimisation Model

Finally, the "legitimisation model" will be introduced. In contrast to the first three models of scientific policy advice, this model is not regarded as a separate normative model by Habermas (1968, pp. 120–131), although he discusses at least some aspects of what I call the legitimisation model. Furthermore, I am not aware of any scholar working on the science-policy interface who actually advocates the legitimisation model. However, since it is a widespread model in practice and is often criticised in the literature (many observers simply interpret it in technocratic terms), the "legitimisation model" is presented here as a separate model.

The core idea of the legitimisation model is to make instrumental use of authority, which academia still enjoys in the public, for clearly political purposes: Policy options are legitimated by referencing scientific expertise, although – in contrast to the technocratic model – at least some of the players involved are well aware of the fact that the particular policy cannot be determined by the sciences in a largely "value-free and objective" manner, as in the technocratic case described above. Hence, the legitimisation model is about scientifically founded "inherent necessities" or "constraints" regarding policy options in order to be able to impose certain preferred measures, drawing on the legitimising function of science.

On the surface, the legitimisation model seems to be completely identical with the technocratic model: scientific experts determine both the policy ends and means while policymakers implement these proposals. Therefore, no figure or example from climate policy is required in addition to what was presented in Sect. 4.2.2 on the technocratic model (Fig. 4.2). From a deeper point of view, however, either the policymakers, the scientific experts, or both – in contrast to the remainder of the public – know about the deception. Thus, given the general normative standpoint developed in Part I, this is clearly a case of misuse of scientific policy advice. What was previously described as a "peril" of scientific policy advice (Sect. 3.2.2) is turned into a virtue by the legitimisation model.

This is certainly a decisive reason why hardly anybody advocates this model. The legitimisation model presupposes an audience that is amenable to accepting the technocratic model (see also Beck 2009, pp. 48f). Otherwise, the public legitimisation of policy ends – determined by the sciences in a reliable and impartial manner – would not work. Moreover, the higher the academic consensus on a certain issue, the easier it is to make use of the legitimisation model.

The mind-set of a proponent of this model seems fundamentally different from the other models, because the legitimisation model violates some of the general norms pointed out in Sect. 2.1.3. The legitimisation model is precisely what is criticised by Max Weber's concept of the "iron cage of bondage" of bureaucracy. On the other hand, a proponent of this model could, theoretically, also argue that it is ethically required to put upon the scientific authority in such a way in order to achieve a "higher" political good; the proponent of the legitimisation model assumes the underlying scientific facts to be clear enough to morally act in such a way – and assumes the public to be either too stupid or too selfish for a successful application of another science-policy model. In their view, the scientific authority has to be used as a political instrument; thus, scientific assessments are regarded as the "continuation of politics with other means" (Brown 2009, p. 185).[13]

A variation of the legitimisation model is the "delegitimisation model." Instead of legitimising policies by referencing science, one can also delegitimise policy options, for instance, by attacking scientific credibility. In that case, this attack is not motivated by a scientific ethos or the political ideals pointed out in Sect. 2.1, but rather by individual political interests. An example is the campaign against the IPCC and climate science by the – quite successful – "denial industry" within the "climate war" described in Sect. 3.3.1 (particularly in the USA).

Another variation of the legitimisation model is related to the decisionist model, and dependent on the acceptance of the decisionist model. In this sense, given some policy goals that are already determined by policymakers, the scientific authority is used to argue for a specific set of policy *means*, even though at least some players involved are aware of the fact that these means cannot really be reliably determined by the sciences in the way pretended.

4.2.5 Brief Discussion of Roger Pielke's Four Models

Roger Pielke Jr. (2007) provided another, very popular study analysing models of expertise in policy. Pielke puts less emphasis on a comprehensive, systematic description of the existing science-policy models, let alone their philosophical aspects, as is primarily required in the context of the present volume. Rather, Pielke describes four alternative, concrete *roles*[14] that scientific experts can and should take under some conditions in the science-policy arena if there is a demand for scientific advice. According to Pielke (2007), experts can choose to be (1) a "pure scientist," providing basic scientific studies with almost no direct policy-relevance, while staying away from the political arena as much as possible in order to not endanger the "scientific purity;"[15] or (2) an "issue arbiter," providing specific scientific informa-

[13] The existence of this "legitimisation" phenomenon in practice also suggests that scientific advice has a considerable impact on policy (otherwise, policymakers would not use the legitimisation model so often in the political arena), although not in a direct manner (see Sect. 3.1).

[14] Some of which were already described by other authors, e.g., Weimer and Vining (1992, p. 18) regarding the "issue advocate."

[15] This model ignores the value of scientific policy advice in general. Moreover, some also advocate for the above-mentioned "science-policy pessimism" – which is similar to the "pure scientist" model – because they do not believe (for empirical reasons) that science can have a significant

tion regarding a certain narrow political question (e.g., “is this particular industrial product toxic or not?”), particularly in cases without conflicting values. In cases of conflicting values, high uncertainties and the political demand for more policy-relevant knowledge, the expert can choose to be either (3) an “issue advocate,” working out a particular policy option that reflects a certain set of values (his or her own, or the values and interests held by the policymaker for whom the respective study is conducted), or (4) an “honest broker” of policy alternatives, reflecting different values and assumptions (see also Chap. 6 below). Pielke points out that all of the four models – except for the stealth issue advocate – can well be justified, but this highly depends on the respective policy context, i.e., conflicting values or not, and high uncertainties or not.

Yet, Pielke’s models are not very different than what was presented by Habermas (1968), but rather only highlight particular aspects of Habermas’s models. The roles described by Pielke can be translated into the four science-policy models introduced above. The role of the issue advocate who scientifically argues for particular policy ends and means is closely related to the technocratic model. The honest broker can be interpreted as a variation of the pragmatic model, as it aims to avoid policy-prescription and to put emphasis on a dialogue between the sciences and the policy realm.[16] The stealth issue advocate – as a variation of the issue advocate, which also argues for a particular policy but does not make political bias in the scientific studies explicit and transparent – is obviously related to the legitimisation model. Finally, the science arbiter who scientifically analyses the implications of *given* policy objectives seems related to the decisionist model. The main value added of Pielke’s approach is that it clearly points out that researchers have choices at the science-policy interface; all of these choices can have severe implications from a societal perspective.

4.3 Implications for the Evaluation of the IPCC’s Work

Beck (2009, p. 25) argues that the science-policy models introduced above have a sole heuristic function that denies a normative function. Grunwald (2008, p. 373), in contrast, argues that only the pragmatic model – which is most advocated for in the science-policy literature – is a normative idea and the other models are mainly descriptive; he thus highlights the heuristic-hermeneutic function of the science-policy models. Yet, both Beck’s and Grunwald’s statements are misleading, since all

impact on policy due to the given rationalities in the policy realm (compare Sect. 3.1.1), independently from the quality of the scientific advice as such.

[16] In some passages, however, Pielke creates the impression that the “honest broker” focuses on “if-then” statements similar to a decisionist understanding of science-policy. This view is shared by Brown who argues (2008, p. 487), “Despite his repeated assertion that science and policy are ‘inextricably interconnected’ (p. 79), and despite his endorsement of constructivist research on the co-production of facts and values (p. 122), Pielke sometimes seems to want to insulate politics from science.”

of these models also have an *action-guiding function* for their proponents, as Beck (2009) argues herself when she discusses the influence of such science-policy models on the practices of the IPCC.

All four of the normative models presented in Sect. 4.2 – at least some variations of them – can frequently be found in the practice of and the debates about scientific policy advice, albeit often implicitly (Grunwald 2008, p. 371; Hulme 2009, pp. 102–110; Beck 2009; Jasanoff 1990). Several observers have noted that different versions of the technocratic model and (even more frequently) the above discussed variation, the legitimisation model, remain dominant in practice (perhaps including the IPCC).[17] However, there are decisive differences between, for example, the US and Europe (Maasen and Weingart 2005; Hulme 2009, p. 105); the technocratic and the legitimisation models seem to have more appeal in Europe. The success of the legitimisation model is due to both a high demand by policymakers and a willing supply by scientific experts – although many researchers pretend to follow the decisionist model when they are asked and almost no one explicitly defends the technocratic model, let alone the legitimisation model.

Apart from a few variations (as argued, e.g., by Habermas 1968 and Grunwald 2008, p. 16), the four science-policy models presented above are not necessarily confined to democracies in the sense of a formal system of government (i.e., political democracy, see Sect. 2.1); what these models propose might also be interesting for non-democratic governments.

Do these models help mitigate the key challenge of expertise in policy, i.e. the trade-offs between the four general norms (Sect. 3.4)? Do they help avoid the major perils of scientific policy advice? To sum up roughly, according to both the decisionist and the technocratic models, the resolution of today's problems of the science-policy relationship (Sect. 3.2) would be to keep a clear demarcation between the domains of the sciences and policy and to keep the sciences away from (a value-laden) society in order to better represent nature (Brown 2009, p. vii). In contrast, the pragmatic model cluster makes the case for an enhanced dialogue between expert knowledge, stakeholders and the entire citizenry in order to better represent the public's will and needs (Brown 2009, p. vii).

At first sight,[18] the first three models seem more or less compatible with the general, yet vague normative stance developed in Part I – which is open to interpretation. For instance, they all assume that scientific expertise shall be used to inform policy processes if the expertise is truly reliable, whereas policy-related judgements that cannot be scientifically substantiated shall be left to policymakers or the public as a whole. Regarding the legitimate scope of the scientific influence on policy,

[17] E.g., Jasanoff (1990, p. 229), Pielke (2007, p. 34), Beck (2009, p. 191), Valente et al. (2015). Concerning scientific reports and assessments in climate and energy policy, there is a huge number of studies that can be interpreted in terms of the legitimisation model. Some of these reports advocate e.g. nuclear power, while others advocate renewable energy sources, while yet another group of studies argues that geo-engineering is essential. Sarewitz (2004) points out that such a technocratic legitimisation approach frequently triggers "counter-expertise." This is possible due to the many uncertainties and value judgements involved in such studies (see Part III).

[18] Compare the deeper and critical analysis of the science-policy models in Chaps. 5 and 6.

there is the technocratic model on one side, which assumes that policy ends and means can and should be determined by the sciences alone; although one could call the technocratic model "policy-prescriptive," it is nonetheless fully legitimate from the perspective of the proponents of the technocratic model, as this model does not allow for the presentation of biased results, but only for knowledge that is true for all. On the other side is the radical variation of the pragmatic model that argues that scientific input is only as valuable (for political or for epistemological reasons) as any other input from any other interest group and should therefore be limited. The decisionist model is somehow situated between these two poles. These different (mostly implicit) suggestions by the first three science-policy models to tackle the key challenge at the science-policy interface are thus worthwhile being scrutinised (Chaps. 5 and 6). The legitimisation model does not provide any potential solution to the key challenge (Sect. 3.4), but instead regards the instrumental use of scientific policy advice as ethically legitimate (given the incapability of the public to realise deliberative democracy).

Which model does the IPCC follow?

There is no easy answer to the question of which model the IPCC follows, particularly since "the IPCC" consists of a large number of diverse experts and other stakeholders. Every one of them might have another model of the role of experts in policy in mind. There is no official IPCC document or guideline determining such a science-policy model for the entire institution explicitly. However, there are some documents that at least point out the need for "policy-relevant, but not policy-prescriptive assessments," and there are a few pieces of circumstantial evidence. According to Beck, Bert Bolin (one of the founders of the IPCC) and some other former IPCC representatives seem to have favoured the technocratic model (Beck 2009, pp. 20 and 150). Bolin assumed, as Beck writes, that a fact-value separation is possible and desirable and that the IPCC could provide policy advice according to a linear input-output model of science in policy. The analysis by Grundmann and Stehr (2011) also suggests that the IPCC partly followed the technocratic model. The former IPCC Chair, Rajendra Pachauri, perhaps seemed to favour a technocratic approach as well. At least he believes that

> we should spark interest in the science of climate change and on knowledge that has been developed in the field. Climate negotiations need to listen to the voice of science on sustainability, and get away from short term and narrow interests. […] The recently released IPCC report on extreme events has demonstrated that a delay in action could lead to more frequent heat waves and extreme precipitation events as well as other extreme events […]. The global community has to be sensitive to these scientific realities.[19]

Another interpretation of the IPCC is, for example, that many IPCC representatives merely *pretend* to believe in value-free science in order to sustain the authority of the sciences in the face of the dangerously blurring lines between the sciences

[19] Source: http://www.clickgreen.org.uk/opinion/opinion/122949-scientists-say-durban-deal-is-inadequate-and-call-for-raise-in-ambitions.html, accessed 16 Mar 2015. As this document reveals, many share Pachauri's view in that regard.

and policy/politics within the IPCC (Beck 2009, p. 101; Jasanoff 1990, pp. 14 and 236), and that the IPCC attempts to keep its "monopoly" (and the idea of a scientific consensus) over the interpretation of the state-of-the-art in the climate related sciences (Beck 2009, p. 104; Weingart 2001, p. 164; Tol 2011). These hypotheses imply that the IPCC sometimes follows the legitimisation model, as the "dark sister" of the technocratic model.

If asked directly, quite a few climate-related scientists prefer the decisionist model and state that a definition of "dangerous climate change," for example, or the decision on global mitigation goals, are clearly value-laden "political" issues instead of "scientific" issues (e.g., Luhmann 2010).

Moreover, variations of the pragmatic model – which is the most advocated in the recent literature on the science-policy interface – are favoured by some other IPCC researchers and officials (see, e.g., Chap. 10 on the IPCC WG III AR5).

The evidence base for such hypotheses is rather thin yet, however. To truly find out what model most assessment practitioners actually follow, a thorough study would be necessary, which is far beyond the scope of this volume. Yet, the views of these stakeholders are changing now and then, inter alia through academic discussions about science-policy models. Despite these analytical constraints and limitations, the four models described above seem relevant for an explanation of what guides the actions of the players involved in the IPCC assessments. Therefore, these prevalent science-policy models should be well scrutinised and evaluated in order to find out whether or to what extent these models help the IPCC to mitigate the key challenge at the science-policy interface.

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Chapter 5
Fact/Value Conflation and the Danger of the Traditional Models

Abstract The decisionist and technocratic models of scientific expertise in policy are critically evaluated in this chapter regarding their potential to address the major pitfalls of scientific expertise in policy. The mistaken philosophical assumption of a fact/value dichotomy, which is underlying these two traditional science-policy models, is identified as the main weakness of these models. The assumption that factual statements and (ethical) value judgements can be neatly separated in policy-relevant research is crucial for these models and a necessary precondition for their understanding of scientific objectivity. However, there is an inevitable fact/value entanglement in scientific statements; values, including ethical ones, permeate all experience and scientific knowledge. Hence, the decisionist and technocratic models cannot ensure that expertise in policy-making processes is reliable for everyone. Instead, due to their mistaken assumption of fact/value separability, they often lead to a misguided use or even misuse of expertise in policy in terms of the legitimisation model. Consequently, the decisionist and technocratic models are unable to realise the general norms developed in Sect. 2.1.

The predominant science-policy models introduced in the previous chapter are critically evaluated in the following sections in terms of their potential to mitigate the key challenge of scientific expertise in policy, i.e. the trade-offs between, and threats to, policy-relevance, sound science, political legitimacy and good communication (Sect. 3.4). The legitimisation model can already be excluded; it has already been argued (Sect. 4.3) that the legitimisation model is not compatible with the normative ideas for expertise in policy (Part I). This chapter focuses on the two "traditional models" existing among the predominant science-policy models, that is, the decisionist model and the technocratic model. The pragmatic model (cluster) is discussed in Chap. 6.

Section 5.1 addresses the various prevalent criticisms of the traditional models, highlighting the importance of analysing the associated philosophical assumptions. Section 5.2 explains why the core philosophical assumption of the traditional models, i.e. the value-free ideal, is seriously flawed. This also questions the assumption that the sciences can provide reliable, objective knowledge. Section 5.3 rejects some attempts to rescue the traditional models despite the collapse of their core assumption. In light of these insights, Sect. 5.4 concludes that the traditional models

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cannot be regarded as appropriate for the IPCC because they are prone to the misguided use of scientific expertise in policy.

5.1 The Role of Epistemology in the Model Evaluation

Of the three Habermasian models, the technocratic model has been the most heavily and critically scrutinised in the literature of Science and Technology Studies and Critical Theory.[1] A large part of this valuable literature is dedicated to the analysis of science-policy case studies. The two major themes resulting from these many case studies are empirical and normative issues of policy-making (Sect. 5.1.1) and questionable assumptions on the epistemic quality of scientific knowledge (Sect. 5.1.2).

5.1.1 Flawed Assumptions Regarding Policy-Making and Democracy?

The discussions in Sect. 3.1 help us to understand the first type of criticism of the traditional models from an empirical political-science perspective. The literature shows that the technocratic and decisionist assumption of a linear, "clean" transfer (i.e., impact) of scientific knowledge into allegedly "rational" policy-making (see Sect. 4.2.2) is considered to be flawed, both empirically and theoretically (e.g., Jasanoff 1990; Beck 2011; Grundmann and Stehr 2011; Koetz et al. 2012).[2] This linear view is misleading since expert advice for policy can never be a pure one-way issue. Since scientific results have to be "transformed" in order to be policy-relevant, and since the problem framing and scope is not usually determined by scientific experts alone, there is usually a lot of science-policy interaction and communication, in contrast to what the traditional science-policy models assume (Skodvin 1999, p. 4). This unrealistic, rationalistic view of policy-making taken by some proponents of the traditional models (particularly by scientists) can be contrasted with the view of incremental "muddling through," which realistically assumes that policymakers cannot evaluate and take into account all possible aspects of a policy

[1] See, for instance, Jasanoff (1990), Shulock (1999), Fischer (1990), Sarewitz (2004), Beck (2009), Koetz et al. (2012), Mulkay (1978) and Pielke's (2007) description of the "stealth issue advocate." In the 1960s, there was already an intensive debate about technocracy (see Maasen and Weingart 2005; Beck 2009, p. 23).

[2] Grundmann and Stehr (2011, p. 12) develop a slightly different definition of linear models. They explain "(non-)linear models" as supply-based (linear) versus demand-based (non-linear) science-policy interactions. According to Grundmann and Stehr, scientists follow the idea of the linear model bringing knowledge to the people on their own initiative and directly; the non-linear model, however, regards science-policy interaction as resulting from demand by the policy side ("mandated science," see Salter 1988), which focuses on pressing political problems.

problem analysed by experts; in reality, only very few concrete policy alternatives are usually discussed by policymakers (see Sect. 3.1; Lindblom 1959; Grundmann and Stehr 2011).

Another severe and closely related critique of the two traditional models based on empirical findings states that reducing uncertainty does not necessarily lead to a resolution of political conflict, as assumed by the technocrats (Shulock 1999). This is also because value conflicts are often decisive in these policy cases (Jasanoff 1990, pp. 7f; Pielke 2007; Sarewitz 2004).

Furthermore, there is increasing and partly irreducible uncertainty in the politicised sciences today (this is also known as post-normal trans-science, see Sect. 3.1). This makes both the decisionist and the technocratic models increasingly difficult to apply (Funtowicz and Ravetz 1991). Due to the uncertainty, it is hard to determine the appropriate policy means or ends. All of this also implies that the (mistaken) decisionist and technocratic assumption of linear and overly rational policy-making may also endanger successful communication between the sciences and policy in the end. This can considerably reduce the effectiveness of policy advice (although some modifications of the models might, at least to some extent, help address these particular flaws of the traditional models).

Traditional models in line with normative ideas of democracy?

A more fundamental critique of the technocratic model, but partly also of the decisionist model, assumes that these models are not in line with the normative idea of democracy (see Weber 1972; Habermas 1968). However, this criticism would not necessarily rule out the technocratic model and decisionist model, since the minimum general norms for expertise in policy (Sect. 2.1.3) were explicitly not confined to democracies.[3] Moreover, this criticism does not take into account that both the decisionist and the technocratic models can be interpreted as being in line with at least *one particular* (perhaps questionable) idea of democracy. This particular (rather etatist; see Immergut 2011) idea of democracy, which is implied in the (reconstructed) decisionist and technocratic models, is to allow policymakers and the public to discuss and democratically decide all aspects of the indirect consequences of human actions – apart from those aspects that are regarded as reliable scientific facts and findings. In other words, the traditional models imply that it would not make sense to politically debate things that are regarded as absolutely true (or false). According to their view, it is legitimate to let scientific experts determine policy means (or even ends) without a democratic debate, if the "facts" (regarding the past, present or future) are fully clear.

So, the criticism that the traditional models are supposedly built on undemocratic ideas of the state that may lead to a dangerous accumulation of power on the science side is not quite accurate in this generalisation. The traditional models do not necessarily contradict the abstract, political-formal idea of democracy, although I do not find this particular notion of democracy implied in the traditional models very

[3] Among the IPCC member nations are also non-democratic states, and the fundamental normative ideals developed in Part I were explicitly not confined to democracies.

appealing. In any case, all science-policy models are related to particular normative concepts of policy-making that should be critically reflected.

As said, however, the science-policy models are to be evaluated primarily regarding their potential to help realise the general norms for scientific expertise in policy, as derived from Dewey's political philosophy (Sect. 2.1). Therefore, I do not further discuss the normative concepts of democracy that underlie the predominant science-policy models.[4] Besides, there is yet another reason why the discussion of the traditional science-policy models in this chapter focuses on their epistemological assumptions and their philosophy of science. Regardless of whether the *political* theories underlying the traditional models are appropriate, it is, as will become clear below, sufficient for their evaluation to show that the traditional models substantially suffer from mistaken ideas for the philosophy of science and epistemology, because such ideas are decisive for these science-policy models.[5]

5.1.2 The Role of Scientific Competence for the Evaluation

As explained in Chap. 4, the traditional models assume – rightly so, one should add – that scientific *competence* is key; it ensures high epistemic quality of the experts' policy-related advice. Scientific competence is a necessary precondition for the legitimacy and social acceptability of granting scientific arguments a considerable influence over policy (as done by the traditional science-policy models), particularly if there is no public participation in the production of the scientific policy advice. The traditional models optimistically claim that the sciences, on their own, can deliver largely *objective* – trustworthy for all – results concerning policy means (decisionist model), or ends and means (technocratic model).[6] This assumed

[4] In his popular book, Pielke (2007, Chap. 2), for instance, distinguishes between (1) the "Madisonian democracy," where democracy is understood as a liberal battle between different and equally valuable interest groups, including academia (see Pooley 2010 for the example of the USA where the climate scientists are regarded as just another interest group); and (2) the "Schattschneiderian democracy," which emphasises the need for elites such as scientific experts in a democracy who develop clear proposals for policy options – as claimed by the traditional models. Brown (2008) criticises that Pielke's account of democracies is very poor and oversimplified, and that Schattschneider also claimed public participation. More differentiated works on the relationship between different theories of democracy and expertise are provided, for instance, by Brown (2009) and Immergut (2011). They can be used to criticise the predominant science-policy models more deeply regarding their underlying political theory.

[5] As explained in Sect. 4.2, for the technocratic model, even policy ends can sometimes be objectively inferred through scientific insights. On the other end of the pole, the pragmatic model assumes that there are no policy-relevant scientific assumptions that policymakers or the public regard, or should regard, as absolutely reliable or "true facts."

[6] This precondition is theoretically valid in both democratic and non-democratic states. A privileged role for experts does, however, not preclude that policymakers *formally* make decisions about policy objectives and policy means, as they may do even in the technocratic model.

scientific competence is the central reason why experts should determine policy means, or even policy ends, according to the traditional models.

The success and the legitimacy (from the perspective of Part I) of the privileged roles of expertise proposed by the traditional science-policy models thus essentially hinges on the promised delivery of (policy-relevant) *objective* scientific knowledge. The traditional models regard this scientific competence as the decisive protective measure against the potential misuse of their privileged role in policy. However, if the sciences did not have political power based on their assumed high epistemic competence, they could hardly be misused in policy processes.

> If rule by experts is out, with it goes any theocratic or otherwise authoritarian conception of right political rule, any basis for the censorship of ideas and opinions, any legitimacy to having a fixed and durable political hierarchy. The idea that there are experts who have reliable techniques for getting in touch with the antecedently real in morality and science is inconsistent with democracy, which is rule by people who have no claim to have such a pipeline (Posner 2004, p. 171).

This makes a careful evaluation of the legitimacy of the privileged role of experts demanded by the traditional models even more important, in terms of scrutinising the objectivity claim. The remainder of this chapter will be devoted to this difficult, crucial topic. The reflection on the traditional models thus requires the addressing of difficult questions concerning epistemology, philosophy of science, meta-ethics, etc. This includes questions about the (potential or factual) quality of scientific contributions to policy and especially "objectivity," value judgements, uncertainties, etc. Already the descriptions of the science-policy models have made clear that these aspects are essential for the systematic understanding of the science-policy models. This is due to the close connection between questions of power and democratic governance on the one side, and "truth," or "objectivity" on the other (Dewey 1927; Kitcher 2011; Brown 2009; Posner 2004).

Although a number of scholars state that these issues – particularly value judgements – are decisive for the evaluation of the roles of scientific experts in policy,[7] only a few really scrutinise these philosophical aspects with regard to models of expertise in policy.[8] Fortunately however, a large number of elaborate philosophical studies on objectivity and the roles of values in the sciences in general have been published, particularly over the last two decades (see the literature discussed below). The bulk of the *science-policy* literature focuses on the sociological and historical analyses of expertise in policy (as also observed by Hands 2001). Beck (2009, pp. 24f), for instance, argues that the discussion of the models of scientific policy advice is mainly a matter for the social sciences. In contrast with her and Grundmann and Stehr (2011, p. 13), who argue that the philosophy of science has been

[7] For examples see Fischer (1990), Jasanoff (1990), Pielke (2007) and Beck (2009).

[8] For instance, Lacey (2005), Douglas (2009), Kitcher (2001, 2011), Elliot (2011), Munro (2014) and other literature on the philosophy of scientific expertise in policy mentioned in Sect. 6.1 on refinements of the pragmatic model. According to Douglas (2009, p. 46), until the 1980s most philosophers of science argued for keeping the sciences away from policy advice in order to avoid the problematic value-saturation of scientific statements.

disappointing in terms of answering the core problems of the science-policy interaction, I am more optimistic about the problem-solving potential of the philosophy of science (see Chap. 6); a systematic exploration of the epistemological aspects of expertise in policy is imperative when evaluating traditional science-policy models. By no means, however, does this imply that the sociological and historical analyses are useless and unnecessary for understanding and improving integrated economic assessments.

5.2 The Fact/Value Dichotomy Collapses

The remainder of this chapter aims to scrutinise the possibility of objective scientific knowledge as a central promise of the traditional models. What does objectivity mean more precisely? As always in philosophy, such central terms are hard to define. Objectivity currently means slightly different things to different scholars, and in the history of philosophy the meaning of the concept has changed from time to time. Moreover, many different things are described as objective: scientific products, processes (methods, criteria, procedures), but also sometimes persons and institutions (Reiss and Sprenger 2014). Given our context – the evaluation of science-policy models – the focus here is on products, i.e., on the objectivity of all sorts of scientific statements (including, for instance, knowledge claims, hypotheses, judgements, observations, inferences, etc. – be they descriptive, analytic, normative or whatever) that are relevant to scientific policy advice.

5.2.1 Two Main Camps

The core and common meaning underlying most of the contemporary uses of the term ‘objectivity’ in philosophy (and beyond) is a “sense of strong trust and persuasive endorsement” (Douglas 2009, p. 116); objective statements are usually regarded as approved, valuable and, as such, have a certain importance to us. They are mostly regarded as sound and reliable *irrespective of* the perspective and interests of a particular individual (‘disinterestedness’), i.e. objective claims are usually regarded as trustworthy for *everyone* and

> should not be influenced by particular perspectives, value commitments, community bias or personal interests, to name a few relevant factors. Objectivity is often considered as an ideal for scientific inquiry, as a good reason for valuing scientific knowledge, and as the basis of the authority of science in society (Reiss and Sprenger 2014).

Objectivity is usually conceptualised as a gradual concept (Reiss and Sprenger 2014; Douglas 2009, p. 117), i.e. there are degrees of objectivity – which does not preclude minimum requirements for objectivity. The more objective a statement is, the better it is.

Besides this widely shared, core meaning of the concept, scholars often disagree over several nuances in their respective definitions. Most of these nuances discussed in the literature are, however, de facto about the more precise *bases* for achieving objectivity in the core sense described above (Douglas 2009, Chap. 6). There are mainly three groups of such bases, but they are not necessarily mutually exclusive (Douglas 2009, Chap. 6; Lloyd and Schweizer 2014): (1) the quality of the argumentation and thought processes; (2) effective social processes; and (3) appropriate interactions with reality.

Concerning the first group, some scholars replace 'disinterested and detached' by 'unbiased' (e.g., in a statistical sense) or, more indirectly, by 'publicly accessible' hypotheses (i.e., publicly available for inspection, in principle). This group mainly refers to particular scientific methods (or methodological conditions) that, if applied (or met) by the researchers, ensure the objectivity of their research.

The second group explains objective statements as those that can repeatedly be "reproduced" through applying a particular method or process ('procedural objectivity') (Lloyd and Schweizer 2014), or as those based on 'interactive or structural objectivity' (Lloyd and Schweizer 2014), for instance Longino (1990). Interactive objectivity mainly (not exclusively) refers to consensus among researchers on a particular hypothesis after the intense scrutiny and discussion of the hypothesis.

The third group – emphasised inter alia by many proponents of the traditional models – defines scientific objectivity *primarily* in light of the "promise to gain real knowledge of reality itself" (Lloyd and Schweizer 2014). Scientific statements are then regarded as objective if they indicate truth by referring to, or by directly representing, the reality as it is.[9] Frequently, the metaphysically oriented definitions of objective knowledge also presuppose the fulfilment of most of the methodological aspects of objectivity mentioned above (i.e., disinterested, unbiased, publicly accessible, can be procedurally replicated, consensus based on interactive and structural scrutiny) (Lloyd and Schweizer 2014).[10]

A quite extreme version assumes, as a *minimum requirement* for this metaphysically oriented definition of objectivity, or perhaps also for other understandings of objectivity, that scientific statements have to be completely value-free in order to be objective, including in the sense of unbiased and disinterested. This specific requirement, which belongs to the first group mentioned above (Douglas 2009, pp. 121–124), means that scientific hypotheses must not imply any ethical, cognitive or other kinds of value judgements (i.e., value-laden normative assumptions; see Chap. 1, footnote 2). This standpoint is particularly taken by what I called the naïve variation

[9] Similar concepts in this direction include, e.g., the predictive competency of a theory (Douglas 2009, Chap. 5) or – degrees of – conformation, as the relation between scientific content and objects in the real world (Longino 2002, Chap. 5). Some positivists regarded objective knowledge as direct corresponding to real objects and as a pure description of the world; such a radical standpoint, however, excludes a huge number of scientific statements that most people regard as – at least potentially – objective today and that do not have a real-world object, or go far beyond a pure description (see Sects. 5.2.2, 5.2.3, 5.2.4 and 5.3 and Putnam 2004, p. 33).

[10] This group can, however, also be interpreted in terms of a *basis* for achieving objectivity (Douglas 2009, pp. 118–121).

of the technocratic model (Sect. 4.2.2).[11] From this perspective, all kinds of value judgements are usually regarded as hopelessly subjective (as opposed to objective); "values are beyond the scope of reason, and a threat to science" (Sayer 2011, p. 28). This standpoint is usually justified by assuming a (metaphysically or epistemologically founded) fact/value dichotomy, which denotes a dualism that represents a strict separability of (1) value judgements and (2) purely factual (or analytic) statements; this dichotomy is applicable to all possible scientific statements. This is a much stronger assumption than a mere conceptual distinction between value judgements and facts in the sciences. This radical position is influenced by David Hume's (often misinterpreted) dictum that an 'ought' cannot be inferred from what 'is.'[12]

Much more widespread among the proponents of the traditional models is, however, the assumption that scientific statements usually imply cognitive or epistemic value judgements, and consequently have to be free from any entanglement with *ethical* normative assumptions only (including what some people call social values) in order to ensure objectivity, at least beyond the stage of choosing a scientific problem and method. Heather Douglas explains this more moderate view:

> It does not hold that science is a completely value-free enterprise, acknowledging that social and ethical values help to direct the particular projects scientists undertake, and that scientists as humans cannot completely eliminate other value judgments. However, the value judgments internal to science, involving the evaluation and acceptance of scientific results at the heart of the research process, are to be as free as humanly possible of all social and ethical values. Those scientific judgments are to be driven by values wholly internal to the scientific community (Douglas 2009, p. 45).

Both versions of value-free scientific objectivity,[13] the extreme one and the more moderate one, are critically examined in Sects. the remainder of Chap. 5 in order to philosophically evaluate the two traditional models of expertise in policy. As key assumptions of the traditional models, these issues of objectivity and the fact/value relationship in scientific knowledge production are not only relevant to the philosophy of science, but also to the science-policy interface and even the practice of scientific knowledge production in general. Putnam (2004, p. 2) rightly points out that the related question "as to what the differences are between 'factual' judgments and 'value' judgments is no ivory-tower issue. Matters of – literally – life and death may well be at stake." Implied disputed value judgements in, for instance, policy-relevant economic modelling can have an impact on policy decisions (if based on economic recommendations) and, with it, affect many lives.

Among other things, the long-disputed issue of the appropriate roles of values in scientific knowledge production, with regard to its objectivity, split the entire

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[11] See also the criticism of naïve realism by Putnam (1999).

[12] To illustrate this radical view: arguing that torturing little children is morally bad is just one's taste, i.e., it is beyond reason to say that this should not be done. This view of value judgements is frequently related to the standpoint of "emotivism." "Emotivism is the doctrine that all evaluative judgments and more specifically all moral judgments are *nothing but* expressions of preference, expressions of attitude or feeling, insofar as they are moral or evaluative in character," as MacIntyre (1981, p. 11) explains this view.

[13] The meaning of the value-free ideal is complex and shifted over the centuries (Proctor 1991).

scientific community into two major irreconcilable camps.[14] The proponents of the first camp includes many economists and natural scientists given their traditional methodological roots in logical positivism and empiricism (Hands 2001), and many practitioners of scientific policy advice (Beck 2009) and the proponents of the decisionist and technocratic models. They adhere to (or pretend to adhere to) the value-free ideal either in the extreme (naïve) sense, or, much more often, in the moderate sense, as just described. This presupposes that factual statements and ethical value judgements (or, in the extreme version, all kinds of value judgements) can actually be neatly separated; otherwise objective knowledge would be unattainable in their view. The moderate value-free ideal is still the *predominant* view in the philosophy of science regarding the role of values in scientific knowledge production (Douglas 2009, p. 63). Also beyond this community,

> The image of science as objective and value-free, de-linked from social and political controversy has a strong position in the public, among practising scientists and among policymakers (Skodvin 1999, p. 9).

To realise the value-free ideal, most proponents of the first camp claim that the sciences need to be insulated from society and their values – which for them became particularly obvious during the Cold War with its heated dispute over capitalism and communism. There is thus an analogy between the strict science/policy and fact/value separation in the traditional science-policy models. Despite the assumed need for such a clear demarcation (boundary) between the sciences and society, the traditional models believe that scientific knowledge can and should be applied in the policy realm to inform decisions on policy means (decisionist model), or on both policy means and goals (technocratic model).

The second camp, to a considerable extent, consists of some post-modern social constructivists (e.g., from philosophy and Science and Technology Studies) and many proponents of the pragmatic model of scientific expertise in policy (Sect. 3.2.3). This second camp claims that scientific statements are often, or always, related to value-laden, individually- or culturally-specific worldviews and contexts. Therefore, they cast doubt on the possibility of objective scientific knowledge, or are at least agnostic in this regard. Douglas explains:

> Social constructivists suggested that scientific *knowledge* (not just scientific institutions or practices) was socially constructed and thus should be treated on a par with other knowledge claims, from folklore to mythology to communal beliefs (2009, p. 5).

[14] In the 1990s, the "science wars" in the US resulted from this fundamental split, which reaches back as far as ancient Greek philosophy and, later, the discussion on logical positivism (Brown 2009, p. 16; Douglas 2009, pp. 5–8, Putnam 1999, 4). These debates are a continuation of the controversies over value judgements in the social sciences, which are, inter alia, driven by Max Weber (Dunn 1994, p. 47; see Douglas 2009, Chap. 3, for the history of the value-free ideal). However, these debates are actually almost as old as philosophy itself (Dewey 1988, p. 161). The "camps" refer to a whole epistemic and scientific worldview, rather than solely an opinion about the fact/value issue. The science wars need to be distinguished from the "sound science versus junk science" dispute, see Douglas (2009, Chap. 1) and Chap. 7 below.

My approach to discussing the traditional science-policy models can be summarised as follows: (1) these models claim a highly privileged role for the sciences in policy-making processes; (2) legitimising this privileged role necessarily presupposes, in the traditional model view, the scientific provision of objective knowledge; (3) objective knowledge, as defined by the first camp that includes the proponents of the traditional science-policy models, has to be value-free – either in the extreme or in the moderate version; (4) value-free scientific knowledge presupposes that facts and the unacceptable values can be neatly separated in the sciences; the naïve variation of the technocratic model even assumes an all-encompassing, strict fact/value dichotomy.

5.2.2 The Fact/Theory Dichotomy

Let us first scrutinise the extreme view of the first camp, i.e. the naïve variation of the technocratic model assuming an all-encompassing fact/value dichotomy (Sects. 5.2.2, 5.2.3, 5.2.4 and 5.3). This dichotomy is closely related to an even more fundamental dichotomy – the "synthetic/analytic dichotomy," which is also regarded as the "fact/theory dichotomy" (Putnam 2004). This fact/theory dichotomy was mainly claimed by logical positivism, the most influential philosophy of science in the twentieth century. In the tradition of classical empiricism, logical positivism stated that there can only exist two kinds of objective scientific statements, which are to be strictly separated: (1) purely factual ("synthetic") statements from experience (*a posteriori*) and (2) purely conventional ("analytic") statements that are tautologically true merely because of logical rules or linguistic conventions, e.g., "all bachelors are unmarried." In the positivist view, all other kinds of statements – particularly (ethical) value judgements and metaphysical statements – are simply meaningless "nonsense" from a scientific perspective, although these concepts may have some practical relevance in life. Logical positivism postulates that facts can be recognised and described without any analytical statements (e.g., theories and interpretations) under certain conditions.

However, Willard Van Orman Quine (1953) shows that, in many cases, synthetic and analytic statements cannot be separated neatly, such as in mathematics. Any recognition and description of facts must draw on theories and interpretations, although theories are partly justified by referring to facts that support them. The core concepts of modern physics – as the paradigm for logical positivism and for the proponents of the strict fact/value dichotomy – that describe "facts," such as "atoms," can be considered a mockery of the (early) logical positivists' understanding of "facts" as mere sensible impressions. Among the reasons for this mistaken positivist view of the fact-theory relationship is a – still prevailing – mistaken conception of how people perceive "facts" and how closely facts are actually related to concepts.

"Perception is not innocent; it is an exercise of our concepts" (Putnam 2004, p. 102).[15]

The collapse of the fact/theory (synthetic/analytic) dichotomy led to the collapse of logical positivism, at least as perceived by the majority of scientists (Caldwell 1994). Some assumptions of logical positivism survived in the practice and thinking of many scientists today, despite the debates in the philosophy of scienceb suggesting that logical positivism in its classical form is untenable.

The assumption of an all-encompassing fact/value dichotomy is usually based on the just-discussed fact/theory (synthetic/analytic) dichotomy, which has collapsed. What does this mean for the fact/value dichotomy and, consequently, for the possibility of value-free science? Interestingly, unlike the fact/theory dichotomy, the all-encompassing fact/value dichotomy is still occasionally defended – although hardly ever by contemporary philosophers (Douglas 2009, p. 90).

5.2.3 Entanglement of Facts and Cognitive Values

Achieving reliable scientific knowledge is often regarded as a *value* in itself. Yet, virtually everyone would agree that determining the scope of a particular scientific enquiry as well as selecting appropriate methods involve value judgements.[16] The more difficult question is, however: do values also and necessarily play a role in determining scientific results once a scientific problem and a methodology are chosen (i.e., in undertaking the research and cognitively evaluating the results)? Are value judgements inevitable in empirical studies when it comes to creating and interpreting data-sets and drawing scientific conclusions? The answer given by most contemporary philosophers is yes. The acceptance of scientific statements is unavoidably dependent on value judgements, and thus "normative judgments are essential to the practice of science itself" (Putnam 2004, p. 30).

In particular, scientific statements always and inevitably imply normative judgements related to the production of scientific knowledge, also beyond the early stage of choosing a scientific problem and the methodology. These are called "epistemic" or "cognitive" value judgements.[17] They are normative judgements of what ought to be, or what is valuable, in the case of scientific reasoning (Putnam 2004, p. 31). The category of value judgements thus does not only comprise ethical value judgements,

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[15] See also the compelling argumentation by Putnam (1999, Part I). Moreover, Dewey (1986, pp. 510f) states that "Kant […] affirmed that conception without perception is empty and perception without conception blind, so that a union of the two is required for any knowledge of nature. However, his doctrine held that the two materials proceed from two different and independent sources, not seeing that they emerge as cooperative conjugate functions" in scientific studies.

[16] So-called "pre-scientific" value judgements (see Brown 2009, p. 13; Douglas 2009, Chap. 5).

[17] Sometimes also called theoretical virtues or scientific value judgements. Kuhn (1977) was among the pioneers regarding the identification and discussion of such epistemic and cognitive values (in their very capacity as values).

but also other kinds, including, for instance, epistemic, cognitive, aesthetic and religious ones.

Among the rather few differentiated and systematic discussions in the philosophy of science of the different types of epistemic or cognitive values, and their more precise ideal role in scientific knowledge production, are those by Douglas (2009; 2013), for example. As argued by Douglas (see also Laudan 2004), one should mainly distinguish between basic *epistemic criteria* and *cognitive values*. Epistemic criteria are minimal requirements for the acceptance of scientific theories, for instance internal consistency and empirical adequacy (i.e., predictive competence)[18]; they are directly truth indicative and, with it, genuinely epistemic, "in the minimal sense that their absence indicates a clear epistemic problem" (Douglas 2013). A theory that is internally inconsistent or a theory that lacks predictive competence can hardly be accepted as true and reliable. Although these epistemic baseline requirements are not ideal desiderata or values per se, they translate values – particularly the fundamental epistemic value of reliable and objective knowledge – into more concrete criteria.

In contrast, cognitive values are not directly truth indicative (at least for most philosophers). Rather, they should be understood as means for achieving true and reliable scientific knowledge, and thus indicate truth only indirectly. They address

> those aspects of scientific work that help one think through the evidential and inferential aspects of one's theories and data [;…] cognitive values embody the goal of assisting scientists with their cognition in science (Douglas 2009, p. 93).

For Douglas (2009, p. 93), cognitive values include, for instance, explanatory power, simplicity, external consistency (with other areas of science), broad scope and predictive precision. These examples are values in the sense of ideal desiderata. "We might prefer one grand, simple, unified theory of great scope that explains everything, but in practice we are willing to settle for less" (Douglas 2013).

With an appropriate terminology now at hand, where do cognitive and epistemic value judgements occur in scientific knowledge production, and what is their more precise role? They either (1) contribute to the justification of theories (or scientific statements) as such, or they (2) apply to the cognitive evaluation of theories and statements in relation to evidence (Douglas 2013).

As a widely accepted *epistemic* criterion, for instance, internal consistency applies to theories. Accepting or rejecting, i.e. rationally choosing between competing theories and statements, necessarily presupposes the existence of such epistemic criteria, because facts as such cannot fully determine a particular theory.[19] Likewise, as *cognitive* values, simplicity, broad scope and explanatory power are frequently applied to theories. Instead of indicating truth, these particular cognitive values are very often understood to merely increase the fruitfulness of scientific research; they

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[18] See also Chap. 1, footnote 2: value *judgements* can be made about values directly or about principles, norms, criteria, virtues etc. (which presuppose valuation and, with it, values).

[19] See Sect. 5.2.2. and Putnam (2004, p. 31) as well as many other philosophers discussing the problem of induction. Interestingly, theories are often rejected on non-observational grounds (Putnam 2004, p. 142) which supports this hypothesis.

allow, as Douglas explains, for more "productivity of an area of science," which basically means "more predictions, new avenues of testing, expansion of theoretical implications, and new lines of research" – as "an insurance policy against mistakes" (Douglas 2009, pp. 93 and 107). Hence, in the presence of these particular and frequently applied cognitive values, "one is more likely to find problems with the theory sooner rather than later" (Douglas 2009, p. 108).

In contrast, the epistemic criterion of empirical adequacy and the cognitive values of precision, unification (i.e., coherence, external consistency, etc.) or novel prediction, for example, apply to the evaluation of theories *in relation to evidence*. These cognitive values help avoid "ad hocery" in scientific knowledge production. Therefore, they "have genuine positive epistemic import" (Douglas 2013), although they are not directly truth assuring. This function of these particular cognitive values is crucial in inductive cases where the evidence for a particular theory or claim is relatively weak or ambiguous (Douglas 2009, Chap. 5); cognitive values then help us (and are necessarily required) to evaluate the uncertainty.

While many researchers use these values and criteria in the just-described way for scientific knowledge production, others disagree; they interpret and use some of the cognitive values as epistemic values or criteria, thus giving them a *direct* role in accepting or rejecting scientific statements and theories. This is strongly criticised by Douglas (2009, Chap. 5). For instance, a "simple theory, though elegant, may just be wishful thinking in a complex world;" and even "a theory that makes a precise prediction may not be a true one" (Douglas 2009, p. 107). This already shows, in contrast to what is assumed by the extreme view of the first camp (Sect. 5.2.1), that one can indeed rationally discuss (cognitive and other) disputed value judgements (see Chap. 6).

Despite the clear need to normatively reflect on the appropriate role of value judgements in the sciences (Douglas 2009, Chap. 5), it is sufficient for now to learn that – even under ideal conditions of knowledge production from the perspective of the first camp – epistemic criteria and cognitive values are necessarily required in scientific knowledge production, both regarding theories per se and theories in relation to evidence.[20] Accepting scientific theories rationally commits one to particular epistemic and cognitive value judgements (Lacey 1999, p. 248). Physics, for instance, cannot "account for its own possibility" (Putnam 2004, p. 106). Ironically, even objectivity and value-free scientific knowledge are themselves (epistemic or cognitive) values (see also Lacey 1999, p. 55). Thomas Kuhn's (e.g. 1970) analyses of scientific paradigm changes support the view that at least[21] epistemic and

[20] Value judgements are even required for the acceptance of a claim if the evidence is strong and certain (which is hardly ever the case in the sciences). Based on what was said in Sect. 5.2.2, already the perception and description of facts is never "innocent;" we inevitably filter reality through what we value, and we do not have *direct* epistemic access to reality. "All perception involves concepts" (Putnam 2004, p. 109). Putnam (2004, p. 32) argues that the attempts by Carnap, Popper and others to avoid the fundamental dependence of what researchers call "evidence" on value judgements has clearly failed (see also Chap. 6 below and Putnam 1999, Part I).

[21] Kuhn argued, however, for a strict demarcation between the sciences and society (Douglas 2009, pp. 60f), in contrast to what is argued in Sect. 5.2.4.

cognitive value judgements play a central role in scientific knowledge production (Hands 2001).

The core arguments for the collapse of the *all-encompassing*, strict fact/value dichotomy are thus analogous to the collapse of the fact/theory dichotomy, inasmuch as one can again clearly point out an inevitable entanglement of different kinds of judgements.[22] In summary, scientific expertise is always and inevitably value-laden; there are no facts without values. In particular, the various roles of *cognitive* values are interesting in this regard. Consequently, the naïve version of the technocratic model, i.e. the extreme view of the first camp assuming an all-encompassing fact/value dichotomy, is mistaken, because it is an impossible-to-achieve ideal from the perspective of most contemporary philosophers.

5.2.4 The Roles of Ethical and Social Values in Scientific Knowledge

The more difficult part is to reject the more *moderate* standpoint of the first camp. Is it theoretically possible to be free from at least ethical and social values[23] in scientific knowledge production – particularly at the stage of cognitively evaluating theories and scientific statements? Besides the interesting hypothesis that the valuing of the scientific knowledge production itself is partly based on social considerations,[24] three popular arguments that question the moderate value-free ideal will be briefly introduced and discussed.

Social consequences of error

A first and much debated argument for a conflation of epistemic or cognitive with social or ethical value judgements in the sciences surrounds the social consequences of scientific error. It is often presented as a far-reaching argument concerning virtually all scientific statements. Scientific knowledge production is to be understood as a social enterprise (Longino 1990, 2002), and scientific experts have some authority in public debates. Based on that, the argument states that when accepting or rejecting a scientific claim of whatever kind, if there is uncertainty and limited evidence, scientists have to make value-laden judgements on the potential

[22] The communication and dissemination of scientific results to non-scientists also requires value judgements due to the necessary selection, simplification and assessment of scientific results (examples can be found, e.g., in Hulme 2009; Haas 1992; Brown 2009, p. 259).

[23] Social values could reasonably be subsumed under ethical values, since ethics inter alia reflects on precisely such social values. As this terminology is, however, not decisive for this chapter, I will keep to the predominant conceptual distinction between social and ethical values, as, e.g., explained by Douglas (2009, pp. 92f).

[24] See Douglas (2009, pp. 95f). The *prima facie* appreciation of scientific knowledge itself, however, may still be called an *epistemic* value, while this does not imply a dichotomy between such science-related values and other values (social, ethical, etc.).

consequences of error.[25] These usually include and should include, in particular, social consequences of error, given that decision-makers might rely on the scientific statement at stake at some point in time. This argument was most prominently developed by Richard Rudner (1953) and has since been developed and much discussed (Douglas 2009, pp. 50ff).[26]

An example of the need to consider the consequences of error is given by a tradeoff implied in almost every statistical analysis (for example, whether or not genetically modified seeds have significant undesirable effects in animal experiments). Scientists inevitably face a normative choice regarding the level of statistical significance in terms of risking either more false negative results – which might lead to underestimating risks – or more false positive results – which might lead to costly alarmism (Douglas 2009, p. 104).

From a normative-ethical perspective, some philosophers argue that scientists should consider the social consequences of potential error in every study. Douglas (2009, Chap. 4) argues that scientists, just as anybody else, are ethically responsible, not for perfect, but for reasonable foresight and recommendations as a kind of action, besides their more specific obligations in terms of research ethics. This means that they can be morally praised or blamed (e.g., for being negligent or reckless) for their choices regarding the reliability of *uncertain* scientific claims in light of the social practical consequences, including severe harm, that scientific errors might entail for other people. There is no other person or institution that could fully take over the responsibility of the individual researchers in this regard.

Pointing out the extremely broad range and high uncertainty of social consequences of scientific error, however, scholars including Ernest Nagel, Carl Hempel, Isaac Levi, Ernan McMullin and others (to a greater or lesser extent) reject the assumed need to evaluate social consequences of error in scientific knowledge production.[27] In most or all cases of assessing inductive risk and uncertainty related to scientific claims, there is, as they argue, neither an epistemological nor a normative-ethical need to involve value judgements beyond the inevitable science-internal (i.e., cognitive or epistemic) ones (Douglas 2009, pp. 59; 90). The intuition that most critics seem to have in mind is that – analogous to natural scientific empirical studies when the evidence is relatively clear and certain – social considerations should not have any influence on how the uncertain empirical hypotheses about facts are cognitively evaluated in natural science, even though de facto, as they are

[25] This means that they compare the consequences (including their likelihood) of different alternative, uncertain decisions, i.e. mainly of accepting or rejecting an uncertain hypothesis.

[26] Also C. West Churchman, Philip Frank and more recently Douglas, among others, argue in a similar direction (see Douglas 2009, Chaps. 3 and 4).

[27] If at all, taking social contexts into account in their view only makes sense in the case of scientific policy recommendations or other highly applied scientific statements. See below for a discussion of this standpoint.

ready to admit, this ideal might indeed sometimes be unattained in scientific practice.[28]

Extending Rudner's argument

Given some clarifications, however, Rudner's argument can be seen as an effective attack on the moderate value-free ideal in the end – although some limitations of this argument may have to be accepted. While the general and prima facie normative thought that scientific researchers are morally responsible for their actions and decisions, also with regard to social consequences, is hard to dismiss, the more precise ethical responsibilities of researchers in light of social consequences of error are certainly disputable.[29] But, is it possible at all to avoid taking any normative stand (at least implicitly) on the social consequences of error in evaluating scientific uncertainty? Not really.

To avoid misunderstandings, it is important to clarify that the arguments by Rudner and Douglas etc. particularly make sense in the paradigmatic case of 'recommendations for decision-making under risk and uncertainty.' Think of, for instance, the hypothetical decision by experts not to recommend a costly evacuation of people in a particular region because the existing geological risk for an earthquake is judged to be rather low (compared with the assumed costs of false alarmism).[30] Explicitly or implicitly recommending a particular risk management strategy (e.g., in terms of policy ends or means, see Sect. 4.2) is essentially about envisaging, or avoiding, particular social consequences under uncertainty (see also Sect. 2.1). It is hardly surprising that the normative evaluation of the possible (instead of only the expected) social consequences of the recommendation at stake is crucial and unavoidable in such cases.

In Rudner's and Douglas' view, cognitively evaluating (i.e., accepting or rejecting) scientific theories or statements under uncertainty *always* has to be understood under this paradigm, i.e. as implying proposals for risk management. Critics of the arguments by Rudner and Douglas etc., including all proponents of the first camp

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[28] For example, scientific statements on whether or not to believe in anthropogenic climate change *de facto* often seem to involve social and ethical considerations regarding the consequences of error, particularly given the understandable nervousness of some scientists about public criticism of climate change research (see Sect. 3.3).

[29] After the L'Aquila earthquake (2009; see, e.g., http://www.nature.com/news/2011/110914/full/477264a.html, accessed 30 Mar 2015), there was much discussion precisely about the social responsibility of experts for scientific error (e.g., OECD 2015). One could argue, e.g., that the researchers' responsibility consists of conducting research according to the scientific state-of-the-art and standard research ethics. Compare, however, the argumentation below as well as in Chap. 6 where I develop a slightly different position than Douglas (although I do not develop a full research ethic).

[30] To determine a 'risk' one needs to understand both how likely an outcome is and how to value the (ethical) relevance of this outcome. In the tragic case of the L'Aquila earthquake (2009), for instance, more than 300 people died inter alia because of such an expert judgement. The problem was not that the experts were not able to predict the earthquake, but rather their disputable ethical recommendation to stay at home with regard to the low probability of an earthquake.

(Sect. 5.2.1), would have to show that risk management proposals is *not* the appropriate paradigm for much of the scientific research.

They could argue – which would, however, question the traditional science-policy models – that scientists should not engage in policy advice at all and should focus on "pure science" in order to avoid cases where social consequences of error are so important. Agreeing with Douglas (2009, Chaps. 3 and 4), however, *all* scientific findings are, or can theoretically become – more or less, sooner or later – relevant to policy processes or to the way we live our lives. This also means that the moderate value-free ideal cannot reasonably be built on a sharp separation between policy-relevant and theoretical ("pure") scientific research. At best, one could refer to scientific cases where social implications are *relatively* small and "pure" epistemic purposes are predominant, e.g. in astrophysics. But this can only be *gradually* different from the paradigmatic case of risk management proposals, given that one cannot exclude the possibility that this will have political or social relevance at some point in time (e.g., in terms of costly space travel programs).

Rudner's critics may still argue that in these cases of relatively low social impact, the cognitive and epistemic value judgements more or less suffice to guide our uncertainty evaluations if conducted according to the scientific state-of-the-art and standard research ethics. But, when we call a scientific statement 'uncertain,' this means that even our best epistemic and cognitive tools are insufficient to achieve certainty. This already implies that accepting or rejecting an uncertain scientific statement inevitably requires value judgements beyond the standard epistemic and cognitive ones. In the case of empirical natural scientific research, for instance, the facts alone cannot tell us which uncertain statement to accept or reject.[31] Even if a researcher is not so interested in the potential social consequences of error, personal self-interests (career, etc.) or "peer pressure"[32] may be decisive in her or his uncertainty evaluation, for instance. Such criteria and values do not belong to those value judgements that the proponents (first camp) of the moderate value-free ideal usually accept as "science-internal." There are even some potential social implications of astrophysical error, for example. All rejection or acceptance of uncertain scientific statements – based on whatever purpose, criteria or values of the researcher – may thus, willy-nilly, imply a normative standpoint (i.e., a preference) regarding the theoretically possible social consequences.

[31] More generally, what the arguments by Rudner and Douglas etc. suggest is that scientific research always has practical purposes as well, and therefore practical consequences of error should also matter in some way or other. I will support this standpoint in Sect. 6.2 by introducing Dewey's pragmatist philosophy which basically regards scientific hypotheses as a means of resolving problematic situations of whatever kind.

[32] For example, internalisations such as: "What would my scientific peers and reviewers do? What would they expect from me as comprehensible decision?" However, such peer pressure cannot consist of epistemic or cognitive value judgements when it comes to uncertainty evaluation, as argued above. Rather, it just shifts the problem one step back, because then the scientific community as a whole then – willy-nilly – has to make the explicit or implicit judgements about social and other consequences of error.

If indeed uncertainty evaluation cannot avoid social implications, critics might claim that it is nonetheless theoretically possible (under good conditions) to at least *avoid taking a clear normative stance* regarding these social consequences. Or, in a similar direction, they may claim that the social consequences of error do not necessarily have any *specific* implications for the scientific evaluation of uncertainty. Given that there are usually difficult and complex social trade-offs, i.e. winners and losers of certain scientific errors (see also Douglas 2009, Chap. 5), neither direction of judgement seems clearly preferable when evaluating uncertainty; this may be particularly valid if one only faces the rather simple choice between accepting or rejecting an uncertain scientific claim, even though the social consequences of error are often complex, indirect and unclear. For instance, whether or not to practically rely (e.g., in political decisions) on the disputed scientific claim that "genetically modified seeds are safe" has numerous socio-economic, ecological and other implications for society in both directions. The scientific community may develop certain standards, rules, etc. for such complex cases, including: high transparency; initiating more research on the issue; sophisticated statistical and stochastic approaches to decision-making under uncertainty; referring to a given value consensus, dominance or compromise in society; fixed principles such as the precautionary principle; and additionally providing robust strategies for how to overcome the social trade-offs. But all of these strategies do not help avoid the necessity of taking at least an implicit normative stance on the social implications if an uncertain scientific statement is accepted or rejected. All of these ideas *presuppose* an initial evaluation of (the complexity of) social consequences and the trade-offs. There is no "safe side" or neutral mean value for the researchers when evaluating uncertain claims.

Furthermore, the research stages of setting research priorities (based on societal needs), choosing methodologies (think of potential consequences of research experiments for human beings or animals) and disseminating research results to the public often involve normative judgements about potential social consequences.

Provided that Rudner and Douglas are right and normative-ethical (social) judgements are inevitable when accepting or rejecting an uncertain scientific statement, researchers could still try to avoid decision-making under uncertainty altogether in scientific knowledge production and only work with rather certain (though less policy-relevant) scientific statements. If possible, the researchers could step back and just try to make reliable, well-justified statements about the level of uncertainty of a scientific statement, instead of accepting or rejecting it. This issue may be among the reasons why the IPCC puts so much emphasis on making uncertainty transparent (see Chap. 10). Perhaps scientists would be less often forced to accept or reject uncertain statements if academics more clearly conveyed the message to the public that scientific research is always fallible (see Sect. 6.2) and only rarely certain, and that there are usually a lot of assumptions, constraints and limitations to be taken into account when relying on particular scientific studies which should be made more transparent.

Indeed, only very few statements and theories in scientific research are widely accepted as being certain – which is particularly true for the highly disputed scientific claims in the fields of public policy analysis and the economics of climate change (see also Chap. 9). That is why frequently uncertain statements are accepted in the sciences. There would not be much left for the traditional science-policy models to recommend to the public if they only focused on *certain* statements.

Another difficulty of this approach is that also the certain scientific statements are not necessarily free from social and ethical value judgements. Direct policy recommendations (as offered, e.g., by the traditional science-policy models) imply normative-ethical assumptions beyond evaluating the consequences *of error*. Whether scientific studies on the appropriate action in the social and political realm are certain or uncertain, they directly evaluate social consequences of possible decisions (see the examples discussed in Chap. 8). For instance, when a scientific study recommends action A with the certain, normatively reflected effects X, rather than action B with the certain, normatively reflected effects Y, evaluating the social consequences of action is imperative (even without uncertainty). As the core research objects, ethical and social values, or socially or ethically valued social states and effects, play the same role in these cases as the evidence in natural scientific analyses, and thus have an epistemic function.[33]

To defend the traditional science-policy models, some scientific researchers may argue that certain algorithms or other approaches (such as the ordinal utility school in microeconomics, see Chap. 8) avoid making normative-ethical judgements in these cases while still providing clear-cut and objective scientific policy recommendations. But, as Chap. 8 will show in detail, there is no such socio-economic algorithm or approach that does not involve (disputable) normative-ethical assumptions in direct policy recommendations. Even exploring alternative scenarios based on different normative assumptions usually requires social and ethical value judgements (see Sect. 5.3 on the axiomatic approach).

To conclude the discussion of the arguments by Rudner and Douglas etc., they can largely be defended given the clarifications and refinements above. These arguments can even be extended with regard to scientific recommendations for policy (ends or means) in cases where there is no uncertainty.[34] There is little ground left for the defenders of the moderate value-free ideal in light of these arguments. At least in some cases of empirical research under certainty, and of accepting or rejecting uncertain scientific statements, one could gradually, more or less, avoid social and ethical value judgements, given the above arguments. The first camp, including the proponents of the traditional science-policy models, are increasingly finding their foundations undermined.

Science-internal values influenced by social values

Given the limited scope of the Rudner argument, Hugh Lacey (1999) defends the moderate version of the value-free ideal at least for standard empirical studies in a highly sophisticated and intriguing manner. He particularly specifies the value-free

[33] Douglas (2009) does not discuss such cases, but rather empirical natural-science research.

[34] I nonetheless share Douglas' argument that for normative reasons one should not manipulate *certain* scientific statements even if they might have undesirable social consequences (see also my criticism of the legitimisation model in Sect. 4.3).

ideal as the "impartiality" standpoint in scientific knowledge production.[35] For Lacey, impartiality presupposes that epistemic and cognitive values (1999, 57–62) are clearly distinct from other (e.g., social and ethical) values, and "they may be manifested in theories developed under a variety of different strategies" (1999, p. 230). Theories are only acceptable if they manifest the epistemic and cognitive values "according to the most rigorous available standards; and to a higher degree than any rival theory" (1999, p. 230). The different strategies[36] required to conduct the research are often influenced inter alia by social and ethical values, he admits. Lacey's crucial point is, however, that the cognitive evaluation of a theory (i.e., drawing scientific conclusions with regard to the evidence) is theoretically *independent* from the specific strategies chosen (ideally, many different strategies are taken to justify a theory), and does not necessarily require any social or ethical assumptions (Lacey 1999, p. 230). Rather, only cognitive and epistemic value judgements are required, including empirical adequacy.

Is Lacey right in assuming such a clear demarcation between the evaluation of a theory based on allegedly science-internal (cognitive and epistemic) value judgements on the one hand, and on the other hand the social context with its social and ethical values? More specific sub-questions include whether the evaluation of theories really can be separated from the choice of more particular strategies as assumed by Lacey (1999, p. 108); remember that these strategies are typically influenced by social, ethical and other values and do, in his view, not directly follow from certain cognitive or epistemic value judgements (including the fundamental objectives for the scientific enterprise).

Lacey's value-free ideal can be questioned by showing that epistemic and cognitive value judgements themselves are influenced by social and ethical considerations. This is the second major argument against the moderate value-free ideal and suggests that even empirical scientific research under certainty cannot avoid normative social and ethical implications. Helen Longino (1990, 1996, 2002) and Phyllis Rooney (1992) argue that at least some cognitive or epistemic values or criteria are influenced by (or reflect) social, political or ethical ideals. Rooney claims, for instance, that theological assumptions about the role of randomness in the universe underlay the Bohr-Einstein debate, and that these theological views are based on social or cultural values. Thus, social value judgements shaped Bohr's or Einstein's views and "acted as guides for epistemic choice, thus operating as epistemic values" (Douglas 2009, p. 90). Longino's (1996, pp. 41–50) comparison between standard cognitive values and some alternative cognitive values building on feminist

[35] Lacey (1999; Chaps. 4 and 10) argues that two other possible hypotheses of the value-free ideal are rather difficult to sustain. *Neutrality* (scientific theories are in line with various value complexes, i.e. neither support nor undermine them) and particularly *autonomy* (the direction of research should be independent from societal concerns) cannot be easily realised in many cases and require specific conditions (Lacey 1999; e.g., p. 224). Lacey (1999, pp. 72–74) rejects Rudner's argument mainly by reinterpreting it as demand for high general standards in terms of epistemic criteria and cognitive values *in general* (independently from the social context).

[36] This mainly refers to a particular approach, including methods, selection of data, etc., which necessarily limits the phenomena, possible hypotheses etc. of a particular scientific enquiry.

philosophy also indicates the socio-political implications of some cognitive values. Perhaps even the epistemic criterion of internal consistency builds on social ideals to some extent (law and order, control and predictability?); compared with, for instance, traditional East-Asian approaches to philosophical logic that embrace what we call logical contradiction. Moreover, some cognitive and epistemic value judgements, for instance simplicity or the beauty of a hypothesis, are also influenced by socially structured aesthetic values (Douglas 2009, p. 91; Rooney 1992). In general, Longino (1990, 2002) shows that scientific knowledge production interacts with the social context in several regards and all phases of scientific research, through both constitutive and contextual values, as she calls it (1990), with a focus on the gender issue. She also shows that there are valuable (perhaps indispensable), complex self-corrective social mechanisms in scientific knowledge production (Longino 1990, 2002). These are again compelling arguments for abandoning a dichotomy between cognitive and epistemic value judgements on the one hand and social and ethical aspects on the other.

Lacey, who is perfectly aware of Longino's and similar arguments, at least admits that the socially influenced scientific strategies *contribute to* the interpretation of some cognitive or epistemic values or criteria (Lacey 1999, p. 221).[37] Moreover, in contrast to Lacey's interpretation, some of the scientific strategies (or some of their elements) sometimes actually operate on the same level as cognitive values (as explained in Sect. 5.2.3 above).[38]

The work by Longino and Rooney suggests that what guides scientific knowledge production is not completely separated from what guides our lives in general. Rather, scientific research is only a particular action field of life (see also Sect. 6.2), embedded in and interacting with its broader social contexts.

Thick ethical concepts

Finally, the third argument against the moderate value-free ideal refers to thick ethical concepts.[39] These concepts comprise both descriptive and normative aspects, such as the terms 'crime' and 'cruelty' – or think of "the fantastic combinations of fact and value in a wine taster's description of a wine" (Putnam 2004, p. 103). Such thick ethical concepts are often resorted to in risk assessments, the treatment of

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[37] As Lacey argues, alternative scientific strategies to the predominant materialist strategy of controlling nature (and perhaps even society) could, for instance, be based on human flourishing instead of control, or on authentic development (Lacey 1999; especially Chaps. 8 and 9).

[38] It would be surprising to me if these strategies, only because they are further down on the ends-means continuum of what guides scientific research, are entangled with social considerations, while cognitive values are not at all, as assumed by Lacey. I assume the differences between strategies and cognitive values to be much more gradual than fundamental.

[39] Elstein and Hurka (2009, p. 521) explain that "at one extreme is a thin concept like 'good,' which says nothing about the good-making properties of items falling under it, at the other extreme is a descriptively determinate concept like 'Kraut,' which specifies those properties completely and therefore fully determines the concept's extension. Surely there is room between these extremes for a category of thick (or 'thick-ish') concepts whose descriptive component specifies good- or right-making properties to some degree but not completely."

uncertainties, problem definitions in policy analyses and economics. Examples include terms such as efficiency, development and undernourishment; some technological concepts, such as geoengineering, may also be interpreted as thick ethical concepts.[40] Such concepts are often regarded as purely descriptive, but in fact, they are also ethically normative. A proper linguistic and epistemological analysis shows that facts and ethical (or social) values cannot be neatly separated in (at least some of) the cases of thick ethical concepts, as the close interplay between these facts and values is so essential to the meaning of these concepts.[41]

The argument that the existence of thick ethical concepts threatens the moderate value-free ideal is criticised, for instance, by Elstein and Hurka (2009). They defend the fact/value separability, at least in the case of some thick ethical concepts. Frequently, however, both the underlying concepts of ethics and the epistemology of facts are more or less untenable or overly narrow in such criticisms. At least some meaningful judgements or concepts frequently used in scientific studies and assessments inevitably imply social or ethical value judgements. By definition, a dualist dichotomy between scientific statements (including cognitive and epistemic value judgements) and ethical or social values would be incompatible with such ranges of application to scientific statements.

Lacy (1999) largely neglects the thick ethical concepts, presumably due to his exclusive focus on natural scientific studies. With it, he and others perhaps underestimate the entanglement of ethical and other assumptions already on the level of individual concepts and observations ("evidence") in scientific knowledge production, rather than only in theory evaluation (see also Sect. 6.2).

5.3 Further Failed Attempts to Rescue Reliable Science

The previous section suggests that scientific statements can never be completely value-free and that many scientific statements, particularly on public policy issues, also imply social and ethical value judgements.[42] Given the quasi-breakdown of both the naïve and the moderate value-free ideal as the assumed basis for objective knowledge (Sect. 5.2.1), are there any strategies that would perhaps rescue the traditional science-policy models? A few popular examples of such strategies will be briefly presented, including their core weaknesses. One group of strategies

[40] For further examples and a discussion, see Dupré (2007). See also Elliott (2011) for examples of thick concepts in the natural sciences.

[41] See also Walsh (2009), Kitcher (2011) and Putnam (2004), as well as the philosophical schools of pragmatism and Aristotelian (meta-)ethics. However, such an interpretation of thick ethical concepts is criticised by, for instance, R.M. Hare and John Mackie in several writings (see Putnam 2004, p. 35), Smart (1999), Väyrynen (2012) and Elstein and Hurka (2009). Although I think the critics are largely misguided, one should, in any case, be careful with using thick ethical concepts in the sciences, as they can at least be easily (mis-)interpreted in normative terms.

[42] One can nonetheless *conceptually* distinguish between value judgements and factual (including analytical) statements according to their primary function, i.e. normative or descriptive.

(Sect. 5.3.1) attempts to keep as far as possible to the original understanding of objectivity of the first camp. As this enterprise cannot be successful, another group of strategies (Sect. 5.3.2) accepts more far-reaching modifications of the epistemology underlying the traditional science-policy models. This, however, questions the appropriateness of the traditional models in their original form.

5.3.1 Rescuing Objectivity in Light of Value-Laden Science

A first strategy could be to argue that the sciences should content themselves with those few statements that are relatively free from normative social and ethical implications (which are regarded as being subjective). The previous section made clear, however, that there is hardly any scientific statement left that does not have considerable social and ethical implications. Moreover, on a more fundamental level, it is highly questionable whether the desperate attempt to be free from social and ethical judgements is at all philosophically reasonable, be it feasible in practice or not. The key point is that if the first camp assumes that social and ethical judgements cannot become objective, how can the inevitable epistemic and cognitive value judgements in the sciences become objective? As inter alia argued by Putnam (2004, p. 19), the different types of value judgements – ethical, social, cognitive, epistemic, aesthetic, etc. – can be conceptually distinguished, but there is no compelling indication for an epistemic or ontological barrier or dichotomy between them.[43] To avoid a misunderstanding, "no epistemic barrier" means that in identifying, justifying and critically discussing the different types of values, principles, etc. as such, the same category of arguments are to be used. For instance, it would be odd from an epistemological perspective to argue that one type of values can be justified a priori and become objective, while other types of values are merely subjective, based on a *de facto* and highly contingent social convention. Either all kinds or no kind of values can become objective. Douglas (2009, p. 89) rightly states that if there is no clear and sharp distinction between different kinds of values, this is "another reason to reject the value-free ideal." This undermines the moderate value-free ideal (e.g. Weber 1949) claiming that objective knowledge must only be free from social and ethical value judgements.

But this does not mean that different types of value judgements cannot play very different roles within scientific knowledge production (e.g., direct or indirect roles). Consequently, there may be other arguments to restrict the more specific roles of ethical and social value judgements in scientific knowledge production than arguing that they can never be objective *per se* (Douglas 2009); but this does not necessarily require their complete exclusion, as proposed by the first camp.

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[43] See also Sect. 6.2 on philosophical pragmatism. If one adopts a broader (e.g., Aristotelian) understanding of ethics, one could argue that all of the value types are somehow "ethical values," as all of them provide fundamental guidance and orientation for human action fields.

Normative neutrality? The axiomatic if-then approach

A second possible strategy in light of all this criticism on the value-free ideal is to make the inevitably implied value judgements in scientific knowledge production transparent while not endorsing these judgements as normatively appropriate. For example, value-laden scientific claims could be presented in the form of "if-then" statements: if value judgements X were true, this would have consequences Y, given theory Z and the evidence. Such scientific statements are supposed to be true *conditional upon* certain value-laden assumptions without, however, evaluating or endorsing these normative assumptions. This may remind us of the decisionist model to some extent which aims to refer to given political decisions on policy objectives in a neutral manner. This axiomatic approach is quite popular inter alia among economists (see Chap. 8) and has some appeal, since it seems to avoid the challenge of making value judgements objective.[44]

This approach already deviates significantly from the original idea of the first camp and the traditional science-policy models. However, this strategy is also unsuccessful in avoiding any normative standpoint on the inevitable value-laden implications in scientific statements. Obviously, so many cognitive, epistemic and other value judgements are implied in scientific expertise that it would be extremely challenging (or impossible) to make all of them transparent as pure axioms. Moreover, even if one only focuses on ethical and social value judgements and transforms them into axioms, the if-then statements *in themselves* frequently imply social and ethical value judgements. These include thick ethical concepts; epistemic value judgements influenced by social and ethical considerations; uncertainty evaluation in light of social consequences of error; and direct implicit ethical judgements.

Think of, for instance, an if-then statement by scientists in their capacity as policy advisers adhering to the decisionist science-policy model. They may argue that *given* the policy objective of increasing agricultural yield with regard to infestation of pests, this can be appropriately achieved through genetically modified seeds. This advice may be based on some studies showing that these seeds are more resilient against pests (and the yield is at least as high as with conventional seeds). Or they may argue that *given* the 2 °C goal in climate policy, a certain energy mix would be most appropriate to ensure climate-friendly and secure energy supply worldwide. In both cases, their allegedly neutral statement that the proposed means would be *appropriate* necessarily implies a comprehensive assessment and weighing of all relevant effects (pros and cons) of these technological options. This usually entails a lot of highly disputable ethical and social value judgements and goes far beyond simply stating that these proposed means would at least have certain direct effects,

[44] In the context of evaluating the Rudner argument (Sect. 5.2.4), some rather unsuccessful attempts to avoid taking a normative-ethical stance regarding inevitable social implications of (particular types of) scientific statements were already discussed. In contrast to these approaches, the if-then approach may seem more promising as it does not require indirect (when accepting/rejecting uncertain theories) or even direct policy recommendations.

irrespective of any second-order direct effects (e.g., rebound effects), side effects or co-benefits.

Another hypothetical example is examining the health impacts of a new drug. Instead of making a normative decision about the appropriate level of statistical significance (i.e., the Rudner case), researchers could present alternative, scientifically sound "if-then" scenarios to *neutrally* inform the decision-makers about the risk at stake. These scenarios would ideally reflect different possible normative assumptions (e.g., regarding the level of statistical significance) and their uncertain consequences – without preferring one particular option and without hiding uncertainty. However, this again usually involves a normative selection and, to some degree, evaluation of relevant social consequences of different options (including thick ethical concepts). Furthermore, it perhaps does not avoid normative decision-making under uncertainty on *other* levels of the scientific research (e.g., within the scenario development or selection).

My point is not that if-then scenarios are bad or useless (see Sect. 6.4), but rather that they can hardly avoid ethical, social and other value judgements. In particular, as argued in more detail in Chap. 8, I am not aware of any convincing scientific methodology which comes up with objective scientific recommendations on policy means or ends – as suggested by the traditional science-policy models – without somehow implying social and ethical normative judgements; there is no perfectly value-neutral way to do this, provided the value judgements at stake are disputable, which is virtually always the case.

Objectivity of value judgements – the consensus approach

Hence, in order to potentially rescue the first camp in light of necessarily value-laden expertise, one obviously has to slightly redefine objectivity and particularly its preconditions regarding normative judgements in scientific research. There are two very popular (types of) strategies in this regard that might still be roughly in line with most of the core assumptions of the traditional science-policy models: the consensus approach that will be introduced now, and the rationalistic approach that will be discussed afterwards.[45] Both approaches try to ensure the objectivity of at least the *inevitable* value judgements (be it ethical, cognitive or whatever normative assumptions) in scientific research.

The consensus approach is popular inter alia among the proponents of the traditional science-policy models, independently from what they think about the value-free ideal. In order to ensure objective scientific expertise, it states that only *disputed* social and ethical value judgements need to be excluded, at least in the research phase of drawing scientific conclusions (i.e., evaluating scientific theories and statements). If there is unanimity (i.e., de facto consensus, also referred to as 'concordant

[45] Douglas (2009, Chap. 6) discusses eight possible bases for objectivity in general, related to the three groups presented in Sect. 5.2.1 above. For the question of how normative judgements can become objective, only a few of these bases make sense, particularly if one wants to keep to the traditional science-policy models which assume that no interaction with society and stakeholders is required to provide scientifically objective, reliable, clear-cut policy recommendations.

objectivity') regarding a particular value judgement that cannot be avoided in scientific knowledge production, it can be called objective. If people agree on a value judgement, it is no longer to be regarded as a threat to objectivity (in the core sense of reliability).

There are several substantial problems with this strategy, however. *First*, it involves a rather far-reaching (ad hoc?) revision of the epistemological worldview (i.e. the value-free ideal) underlying the first camp and the traditional models. This raises questions about their appropriateness. *Second*, hardly any social or ethical value judgements are really undisputed, particularly when it comes to global and complex problems such as climate change and scientific recommendations for how to resolve them. *Third* and most importantly, the sheer factual consensus among some people at a particular point in time is not a compelling philosophical indication of truth in these cases, particularly if the group of people taken into account is too small or lacks diversity (think of, for instance, agreement on some racist values among a particular group of people).

Objectivity of value judgements – rationalistic approaches

The rationalistic approaches, as I call them, are another attempt to render at least some of the inevitable normative judgements in scientific research objective, while defending as many characteristics and claims of the traditional science-policy models as possible. According to these approaches, (some) value judgements can be justified in an a priori manner, and can be regarded as true. In the context of climate policy, some scientists argue that given both scientific evidence and some allegedly undisputable ethical claims (e.g. human rights), it is clear that scientists should recommend very ambitious climate change mitigation efforts.

True, a few normative claims such as "slavery is wrong," or "everyone is entitled to enjoy a minimum of human rights," are nowadays widely accepted for good reasons. However, while not disagreeing with the notion that value judgements can be philosophically well-justified and become objective (see Sect. 6.2), most of the strong ethical beliefs are usually not widely accepted today and can easily lead to ethical fundamentalism (Putnam 2010, p. 35). Religious justifications of objective morality are also not widely accepted. Rather, especially in light of the phenomenon of cultural and value pluralism in Western societies, many scholars (particularly non-ethicists) assume that most ethical value judgements can neither be objective nor universal. Moreover, simplified and dogmatic moral standpoints as in the climate change example (even if they were widely accepted on an abstract and general level) are insufficient to guide policy-making in light of the huge complexity, uncertainty and interdependencies of the climate problem as outlined in Sect. 2.2. In any case, in the realm of public policy, there is no straightforward, widely accepted rationality for how to make normative-ethical judgements objective in this rationalistic, dogmatic sense.

5.3.2 Attempts Other than Objectivity

The above thoughts and examples show that it is very hard for the traditional science-policy models to defend their original epistemological ideals of objectivity in light of the insight that the value-free ideal collapsed due to the inevitable fact/value entanglement. The consensus approach, as perhaps the last resort for the first camp, also fails. Thus, rather than ensuring value-free scientific knowledge, the *real* problem is – much less than a dichotomy – the appropriate treatment of some controversial ethical assumptions so that distrust and authoritarian (ideological) argument are avoided at the science-policy interface.

What the proponents of the traditional science-policy models could do is to more fundamentally revise their understanding of scientific objectivity and its conditions. Beyond the approaches discussed above, there are many more – and far more promising – ideas of how to make scientific research objective despite being value-laden (see Chap. 6), which of course cannot be discussed here comprehensively.[46] However, most of these other ideas for redefining objectivity or for revising the science-policy models are so far-reaching that they can be equated with *dismissing* the traditional science-policy models.

The same is valid for proposals that suggest giving up the ambition of objective knowledge altogether at the science-policy interface. In view of the difficulties, one is inclined to drop the idea that value-laden scientific judgements can be objective at all and rather look for alternative ways to justify why scientific judgements can nonetheless be useful for policy-making. One could argue that to justify the privileged role of scientists in policy, it is sufficient to show that scientific judgements are relatively reliable and useful (though perhaps not objective). In any case, I am not aware of an approach that drops the idea of objectivity as a whole and that could simultaneously rescue the traditional science-policy models that so heavily rely on the idea of objectivity.

5.4 Danger of Misuse

The core assumptions of both the technocratic and the decisionist models are misguided; the value-free ideal is untenable. A perfect example of a highly policy-relevant scientific viewpoint that is shared by many proponents of the traditional science-policy models is the concept of "planetary boundaries" (e.g. Rockström et al. 2009). This popular concept assumes that humanity can operate safely if we do not transgress certain planetary boundaries, which may trigger non-linear, abrupt

[46] Two examples. One is what Reiss and Sprenger (2014) call instrumentalism, which is a highly constructivist approach to objectivity. Another (partly similar) approach is the interactive objectivity developed by Longino (1990); see Chap. 6 below. Agreeing with Douglas (2009) and Putnam (2004), the key question is no longer which kinds of value judgements to abandon (as there is no clear divide between them), but rather what role they should play more precisely.

environmental change. This concept, however, involves much more, and more problematic, ethical value judgements than widely assumed. It focuses exclusively on biophysical thresholds, it involves value judgements regarding the evaluation of uncertainty, and largely ignores dynamic (inter-temporal) aspects, interdependencies, technological lock-ins, economic developments, etc. Although I agree that, somehow, we have to make decisions on what to regard as "safe operating space" for humanity, it would be a mistake to believe that this can solely be based on scientific "facts." Chapter 8 will provide further examples of potentially problematic ethical value judgements at the science-policy interface – namely those implied in the economics of climate change and their policy recommendations.

The sheer fact that the traditional models cannot keep their promise to ensure the provision of sound, objective and value-free knowledge for policy, however, may not be a sufficient reason to rule out these two models as practical guidance at the science-policy interface. Rather, the practical consequences of the misleading assumptions that underlie these models are decisive. In addition to the flaws discussed in Sect. 5.1, a considerable peril of the traditional models is that the flawed epistemological assumptions could lead to *distrust* of scientific policy advice, as there will be many cases where it becomes clear that the promise of the traditional models cannot be delivered (which may also result in flawed scientific policy recommendations). People will then perhaps increasingly focus on revealing ethical value judgements in the scientific studies, for instance. Even worse, the application of the traditional science-policy models (particularly the technocratic model), in practice, opens the door wide for the deliberate misuse or unintentionally misguided use (e.g., via bias through unrevealed value judgements) of scientific policy advice (see Sect. 3.2), especially in the heated context of climate policy. Instead of making society and policy-making more rational, the technocratic model represents a huge seduction in terms of following the legitimisation model,[47] which was already ruled out above in normative terms. Given the promise of infallibly objective, value-free scientific knowledge, one may use scientific uncertainties and value judgements as a symbolic political resource (Beck 2009, pp. 119f, 123; 155f; see also Sarewitz 2004).[48] So, the science-policy interface

> can easily turn into a political battleground where political debate is couched in the guise of a debate over science (and the expert may not even be aware of his/her arguing politics through science) (Pielke 2007, p. 6).

In this sense, instead of making policy issues and related conflicts clearer and better understood, scientific policy advice according to the technocratic model leads to the transformation of political conflicts into almost unsolvable and dogmatic scientific-technical conflicts (see Sect. 3.1). Therefore, "although political conflict may be promoted and sustained by scientific uncertainty, it is by no means safe to assume that reducing uncertainty automatically reduces conflict" (Jasanoff 1990,

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[47] See also Skodvin (1999, p. 9) or Pielke's (2007) descriptions of the "stealth issue advocate."

[48] For a more comprehensive critique on technocracy at the science-policy interface, see e.g. Fischer (1990), Beck (2009), Brown (2009), Jasanoff (1990).

pp. 7f). Instead of giving power to truth in the technocratic model, in fact, some scientists (or politicians) may gain power through hidden value judgements.

The decisionist model could be particularly put upon to merely sustain political power and to protect the pursuit of self-interest from undesirable scientific facts (Beck 2009, pp. 25f). Furthermore, regarding the means for achieving policy ends, there could be hidden value judgements and biases in scientific advice. The main danger of the decisionist model is, thus, that scientists think they are (or pretend to be) "science arbiters" or "pure scientists" that do not deal with any disputed, value-laden issues, when in reality, they are "stealth issue advocates," knowingly or not (see Sect. 4.2.5; Pielke 2007). This does not mean that being a science arbiter or pure scientist is inacceptable or infeasible. Rather, it just means that their scientific claims can never be value-free. As the above argumentation on the fact/value entanglement goes far beyond an analysis of value judgements only in policy recommendations, the results do not only question the traditional science-policy models but also the idea of completely staying away from policy and society to avoid social and ethical value judgements in scientific knowledge production. In *Values in Social Science*, Douglas (2014) explains that the (both factual and ideal) roles of value judgements are similar in the social and natural sciences. Moreover, Chap. 6 will argue that the value-free ideal is not only infeasible but also undesirable for scientific policy assessments.

Consequently, following or pretending to follow the technocratic model in practice often leads to the misuse and misguided use of scientific authority (Sect. 3.2); even the decisionist model can be misused as a political "legitimisation model," at least with regard to policy means. These perils of the misguided use or misuse of the traditional science-policy models are mainly due to their flawed assumptions about what the sciences can actually deliver, i.e. due to their concept of scientific objectivity. This flaw of both the technocratic and decisionist models is indeed *fundamental* and virtually irremediable – and can result in the biggest perils at the science-policy interface – which is that they almost unavoidably promote the misguided use or misuse of scientific expertise in policy (Sect. 3.2).

My intention here is not to show empirically that this actually happens, as this has already been done by a large body of Science and Technology Studies literature. Rather, the intention is to show that the core characteristics of the traditional models, in terms of their epistemological implications, make these models highly prone to the misguided use or misuse. The pragmatic models can also possibly be exploited to obtain some political influence.[49] In contrast, however, the great danger of the traditional models in this regard is irremediable, because it is about the epistemological core and the essence of these models.

Another conclusion of this Chap. 5 is that the philosophical studies into objectivity and value judgements left us with a right mess and huge philosophical challenges.

[49] A public discourse about policy ends and means could, for instance, be dominated by a strong political interest group. Politicians can make instrumental use of the pragmatic model to merely sustain their power and protect the pursuit of their selfish interests from undesirable scientific facts, for instance, by promoting endless public debates.

Lacey's main fear is that we lose "all prospects of gaining significant *knowledge*" (Lacey 1999, p. 216) and "replace rationally acceptable theories with 'wishing' about the way the world is" (Lacey 1999, p. 214) if ethical or social value judgements play a significant role in scientific knowledge production. Then, "we would just have the back and fourth play of biases, with only power to settle the matter" (Lacey 1999, p. 215). Let us see how the pragmatic models perform in this regard (Chap. 6). If they fail to show how value-laden scientific knowledge can be objective and more than "wishful thinking" or hidden ideology based on normative assumptions, the radical pragmatic model ("science-policy pessimism," i.e., treating scientific experts as just another political interest group) would be the only choice left from an epistemological perspective.

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Chapter 6
Pragmatism: Objectivity Despite Fact/Value Entanglement

Abstract Can the pragmatic science-policy model cluster that emphasises democratic public participation and deliberation ensure reliable, politically legitimate and useful scientific assessments, despite the implied ethical and social value judgements? Section 6.1 will analyse the weaknesses of some variations of the pragmatic model cluster, including substantial open questions with regard to scientific objectivity. In order to philosophically substantiate the possibility of objective knowledge despite the value judgements involved, Sect. 6.2 will introduce pragmatist philosophy in the tradition of John Dewey and Hilary Putnam as a fundamental, convincing philosophy of science, epistemology and meta-ethics. Pragmatism combines anti-scepticism with fallibilism and fact/value entanglement. Some implications of this philosophy are discussed in Sect. 6.3, before Sect. 6.4 develops a refined variation of the pragmatic science-policy model based on this Deweyan-Putnamian pragmatism. In a highly interdisciplinary manner, and jointly with stakeholders and the public, this refined pragmatic model suggests (i) careful exploration of alternative problem framings and (ii) critical reflection on different policy ends and means in light of the practical implications of the means (while making disputed ethical assumptions transparent). This may require a substantial revision of initial policy goals if the best available means have severe side effects. The four general norms for scientific expertise in policy (Sect 2.1.3) may be realisable when employing this refined pragmatic model.

The basic challenge of bridging scientific expertise and public policy (see Sect. 3.4) was identified as ensuring in particular – and simultaneously – sound science, policy-relevance and political legitimacy. The analysis of value judgements in scientific knowledge production (Chap. 5) shows that the traditional science-policy models fail to ensure sound and legitimate scientific assessments due to their fundamentally flawed philosophical assumptions. The idea of a strict boundary between scientific expertise and public policy processes is untenable. The issue of value judgements, however, may also raise more general doubts and concerns regarding the possibility of objective, legitimate scientific policy assessments. The main question of this chapter is whether the pragmatic model performs better as a guide for the IPCC assessments than the traditional models. Can the pragmatic science-policy

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model cluster ensure reliable, legitimate and politically useful scientific assessments despite the implied ethical and social value judgements?

Section 6.1 will analyse the weaknesses of some variations of the pragmatic model cluster as well as some substantial open questions. Many variations of the pragmatic model unfortunately do not convincingly explain how scientific knowledge can be objective and reliable, rather than being "junk science."[1] In contrast to the traditional science-policy models, however, the weaknesses of the pragmatic model cluster seem remediable, as some highly promising philosophical approaches in the literature demonstrate. In order to claim that objective, value-laden knowledge is indeed possible, Sect. 6.2 will introduce pragmatist philosophy in the tradition of John Dewey and Hilary Putnam. Some implications of this pragmatist philosophy are discussed in Sect. 6.3, before Sect. 6.4 develops a refined variation of the pragmatic science-policy model based on Deweyan-Putnamian pragmatism that builds convincingly on the assumption of an epistemological ends-means interdependency.

6.1 The Main Weakness of the Pragmatic Model Cluster

In Sect. 4.2.3, the core characteristics of the pragmatic model cluster were introduced: a (public) discussion and critical interaction between scientific experts, policymakers and the citizenry into value-laden problem formulations, policy ends and means, under the condition that certain formal, fair rules are complied with. This ideally results in pluralism, deliberative democracy and a more democratic control of expertise in policy. The philosophical underpinnings of this model cluster, as well as some of its more specific claims, will be briefly introduced and evaluated now in light of the general norms for expertise in policy (Part I).

Chapter 5 concluded that the *radical* variation of the pragmatic model (Sect. 4.2.3, the "science-policy pessimism") would be the only choice left under the assumption that scientific knowledge cannot be objective, reliable and legitimate. This radical variation claims that one should take *scientific* evaluations of policy ends and means no more seriously than the beliefs, opinions or gut feeling of anyone. Only a few proponents of the second camp (Sect. 5.2.1) would defend this model, however. It would mean nothing less than the end of any meaningful scientific assessment projects that could support climate policy. By avoiding a substantial role for the sciences in policy altogether, the radical pragmatic model seems to avoid misuse of academic authority through hidden value judgements better than the other models. But it obviously throws the baby out with the bath water. The need for scientific analyses of climate policy problems and potential solutions, particularly with regard to the economic dimension of climate policy, was pointed out in Chap. 2; understanding the effects of potential policy responses is essential for appropriately regulating and managing indirect practical consequences of human

[1] Douglas explains this concept (2009, p. 150).

actions. The radical variation of the pragmatic model cannot ensure the effective provision of reliable, legitimate and policy-relevant scientific assessments that would be required for these purposes. It should therefore be dismissed. There is no need for science-policy pessimism; the sciences can indeed deliver reliable insights on policy-related issues, as is assumed in this book, although these insights are not to be regarded as "absolute truth."

Hence, what is needed for the pragmatic model cluster to meet the norms from Part I is to develop a science-policy model based on a compelling philosophical idea for how sound and objective scientific expertise on policy issues could be achieved, while acknowledging the far-reaching fact/value entanglement and the need for political legitimacy.[2] This would presuppose a research agenda that brings together the philosophy of science, (meta-)ethics and political philosophy. Related central questions are, more concretely stated, as follows: (i) Can social and ethical value judgements become objective in principle, and in what sense are they objective (see Sects. 5.2 and 5.3)? (ii) More precisely, which role should value judgements play in scientific research? (iii) Are the responses to the first two questions in line with the goal to avoid ideology, illegitimate bias and authoritarianism at the science-policy interface?

However, a considerable number of the proposals for a pragmatic model of scientific expertise in policy – for instance, some of those developed by the disciplines of political sciences, sociology and science communication – do not fully or satisfactorily address these philosophical challenges; the question remains as to how value-laden, policy-relevant research can be, at least to some degree, objective. This is the *main weakness* of large parts of the pragmatic model cluster. Those who criticise the first camp (Sect. 5.2.1) sometimes "struggle to explain what makes science objective, trustworthy and special" (Reiss and Sprenger 2014). Most of the variations of the pragmatic model in the literature highlight important and valuable aspects of the science-policy interface, such as, for instance, the need for a public discourse based on a highly participatory assessment process with fair procedures. But some of these publications on the science-policy interface seem to slightly underestimate how challenging and deep this philosophical issue of objectivity really is – as demonstrated in the previous chapter – and how far-reaching its implications for scientific expertise in policy are.[3] Sometimes it remains unclear what the sciences can reasonably contribute at all to the evaluation of policy ends or means.

Moreover, although philosophers usually do not tend to underestimate these challenges of objectivity, the philosophy of science in public policy, in general, is "an issue much neglected by philosophers in the past forty years" (Douglas 2009, p. 21). In the last few years, however, more attention has been paid to this topic. In

[2] Political legitimacy is emphasised by the pragmatic models anyways.

[3] The lack of convincing philosophical orientation in this regard seems to be among the reasons why logical positivism and logical empiricism still guide the practice of some economist and natural scientists (Caldwell 1994), and why the technocratic and decisionist models are still rather dominant in practice.

the highly value-laden and uncertain social-science research on policy options, the objectivity issue is particularly challenging for philosophers.[4]

Besides the fundamental need to justify that objective knowledge is possible at all, despite the value judgements involved, there is yet another reason why discussing these issues may be beneficial at the science-policy interface. Presumably, more explicit discussion and transparency in the literature on pragmatic science-policy models regarding the underlying epistemology (including a theory of objective scientific knowledge) would also – by avoiding wrong expectations towards the sciences – help reduce the risk of flawed interpretation of expertise at the science-policy interface. It may even remedy the current public distrust of scientific advice on climate policy in the long term.

Furthermore, besides their nebulosity regarding the issue of scientific objectivity at the science-policy interface, some of the pragmatic models proposed in the literature do not satisfactorily address the accountability for dealing with the actual, practical consequences of the policy means for achieving policy objectives. Their concepts usually stop at the development of the means to the pre-determined policy ends. These particular pragmatic models share this shortcoming with the traditional science-policy models.

Cartwright and Hardie (2012, e.g. pp. 3f) provide some illustrative examples of how different the envisaged outcomes and the actual outcomes of a specific policy decision can be, even if the policy at stake was well justified and scientifically evaluated ex ante. Policies often yield unexpected, undesirable consequences. Who is responsible for such effects? Is it the policymakers who made the decisions? Or is it rather the scientific experts who recommended this policy (e.g., in case of the traditional science-policy models)? Learning from practical consequences of policy actions is key. Sections 6.2, 6.3 and 6.4 will reveal the importance of an appropriate relationship of ends, means and consequences in scientific assessments of policy options.

More recent, promising pragmatic models

Fortunately, however, a few scholars in the philosophy of science (but also in Science and Technology Studies) actually more recently met the challenge of discussing how scientific expertise at the science-policy interface can become reliable and (to some extent) objective, despite the inevitable entanglement of facts and ethical or social value judgements in scientific research. Over the last two or three decades, they have sought to establish a third camp (Hands 2004, pp. 257f), in addition to the two camps described above, or at least to determine how the second camp could rescue the belief in objective scientific knowledge.[5] Although these attempts have not led to a new, widely accepted philosophy of science (Hands 2001), they have resulted in a few very interesting and elaborate specific proposals for a pragmatic science-policy model. Among these new pragmatic models are, to mention

[4] See Chaps. 8 and 9; Montuschi (2014); and Douglas (2014) for details.

[5] See, e.g., the influential work by Longino (2002) who argued that the social influence on scientific knowledge production helps to ensure scientific objectivity rather than making it impossible.

some outstanding examples, those by Heather Douglas (2009), Kevin C. Elliot (2011a) and Philip Kitcher (2001, 2011). Some further relevant approaches in the literature on science-policy models will be discussed in Sect. 6.4.2 with regard to some of their more specific claims (in direct comparison with specific elements of my own proposal).

Based on what was already explained in Sect. 5.2, Douglas' new ideal for the science-policy interface limits "all kinds of values to an indirect role when making judgments concerning the acceptability of data and theories" (2009, p. 133) – stating that the need for judgements under uncertainty is pervasive in all of scientific risk assessment (2009, Chap. 7). Transparency of the role of value judgements in policy advice is also key. Despite the value saturation of research, this new ideal still allows for scientific integrity and a "robust understanding of objectivity, with multiple aspects available for assessing the objectivity of a claim."[6] It also allows for justified disagreement among researchers (which does not automatically result in "junk science"). Moreover, Douglas points out that in democratic nations such as, for instance, the USA, formally "the federal agencies are legally responsible for final decisions" in policy (2009, p. 134). At the same time, she also assumes an ethical responsibility of the researchers for the social and ethical consequences of error in light of uncertainty (see Sect. 5.2.4), as well as of the public as a whole (2009, p. 158). Emphasising the value of public participation (given some conditions, see 2009, p. 166f) which ensures legitimacy to some extent, Douglas sees

> two general ways to assist scientists in making the necessary judgments: (1) one can help the scientists make those judgments as the need arises throughout a study, and (2) one can decide prior to such judgments which particular values should be used to shape the judgments. For both of these approaches, greater public involvement would be beneficial (2009, p. 157).

Douglas provides a rather differentiated answer to the question of who should be responsible for the practical consequences of policy decisions that are based on scientific expertise.[7] As already stated in Sect. 5.2.4, I agree with Douglas that there is a basic responsibility for consequences of error, and I agree with most other analyses and proposals in Douglas (2009). Only a few aspects did not convince me. *First*, as argued in Sect. 5.2.4, one may extend Douglas' ethical argument with regard to social and ethical consequences of scientific evaluations of policy ends or means, even if there is no uncertainty.[8] *Second*, Douglas' strict prohibition of any direct (epistemic) roles of non-epistemic value judgements in theory acceptance or rejection is questionable also with regard to empirical analyses in natural science. Douglas (2009) rightly states that there are many examples of a direct role of non-epistemic value judgements in the later stages of scientific research that are clearly undesirable; "wishful thinking" in the sciences as well as ignoring or manipulating

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[6] Douglas (2009, p. 133). See Sect. 5.2 above for such aspects of objectivity. For Douglas, the ideal of detached objectivity, rather than value-free objectivity, is key (2009, p. 149).

[7] Douglas (2009, Chap. 8) points out that her proposal has much in common with the approach developed in NRC (1996) which will be briefly discussed in Sect. 6.4.2 below.

[8] Elliot (2011b) also argues that not all examples fit Douglas' (2009) framing well.

evidence have to be avoided (see Sect. 6.3). Indeed, only evidence should count, as she argues. From Dewey's perspective (Sect. 6.2), however, the choice of data-sets, the characterisation of data and the interpretation of evidence themselves are also influenced by value judgements which are sometimes non-epistemic in character and which are related to the research purpose at stake. *Finally*, I do not share her enthusiasm about valuation consensus (conferences) (Douglas 2009, Chap. 8). The revision of value assumptions based on the positive and negative effects of the means for realising them may be the more reliable approach.[9]

Elliot (2011a) philosophically and critically examines the evidence for hormesis in particular, as a case study. In line with Douglas, he argues that social and ethical value judgements cannot and should not be excluded in scientific policy advice (rather, he argues for taking into account a broad range of societal values), and that value judgements play various roles at different stages of scientific research. As a conclusion for the possibility of objective, value-laden scientific advice on environmental policy issues, he presents

> three major suggestions: (1) safeguarding university research from powerful interest groups; (2) diagnosing deliberative forums in response to policy-relevant research; developing an ethics of expertise that helps scientists to communicate with the public (2011a, p. 199).

The first strategy goes beyond conflict-of-interest policies in five distinct ways (Elliot 2011a, p. 108). The second strategy aims at involving multiple stakeholders and advisory bodies to openly discuss and review the major social or ethical value judgements at stake in scientific knowledge production (again, similar to Douglas' proposal). Finally, the third strategy is about the appropriate communication of complex and value-laden scientific results to the broader public.

In his very clear argumentation, Elliot (2011a) focuses on a few aspects of objectivity (which is not the central theme of his work) and on the application of his philosophical thoughts. I largely agree with Elliot's proposals and regard them as interesting further developments of some of the core claims made by Douglas, although I do not agree with all details of his argumentation.

As a final example, there is Philipp Kitcher's variation of the pragmatic model (2001; 2011). Kitcher's work is perhaps most difficult to discuss here: *first*, because he presents a relatively complex and difficult philosophy of science which also slightly changes over time; *second*, because his work is mainly about the role of the sciences in democracies in general (rather than solely about scientific expertise in public policy); and *third*, because he (inter alia) builds on Dewey's philosophy – yet

[9] See Sect. 6.2. Douglas' three general methods for ethical thought experiments (2009, pp. 170f) are a useful amendment to her model, but still provide a too narrow perspective on methods for evaluating value judgements. Moreover, the practical example of Lomborg's "Copenhagen Consensus" (summarised, e.g., in Lomborg 2007) indicates how misguided consensus exercises can be due to their over-simplified choice between artificial alternatives, each based on questionable normative (intergenerational) assumptions. Lomborg inter alia underestimates all the interdependencies between economic development, poverty reduction and climate change mitigation in the long term. Again, this is why more elaborate, integrated assessments are so desperately needed (Sect. 2.2.4).

in a slightly different way than I do below. Doing full justice to Kitcher's philosophical work and important concepts in comparison with other approaches would require a separate book.

Like Elliot and Douglas, Kitcher is one of the outstanding philosophers who brings together the philosophy of science, political philosophy and ethical issues. While the focus of Kitcher (2001) was on ideal research agendas and the role of values in this regard, Kitcher (2011) also discusses the acceptance of scientific statements and their dissemination in light of democratic ideals and dissent. Kitcher's problem framing (in both books) regarding the role of scientific expertise in democracy is a useful introduction to the issues at stake, also leading to some crucial questions that the philosophy of science in policy should address. Like the other scholars mentioned above, he assumes a far-reaching and inevitable fact/value entanglement (to some extent also accepting Rudner's argument), while arguing that scientific objectivity is still possible. His systematic and compelling basic arguments in favour of deliberative democracy (as the "middle ground" division of labour between 'epistemic elitism' and 'epistemic equality') are inspired by John Dewey's philosophy. Kitcher follows Dewey's concept of democracy in terms of "expanding freedom through elaborating ways for satisfying mutual interaction" (Kitcher 2011, p. 12).

Although I agree with many assumptions underlying his concepts of a moderate realism (see Sect. 6.2 below) and well-ordered science,[10] I disagree with him in several more specific aspects. This will become clear in the following section where I present a slightly different interpretation of Dewey's philosophy. Kitcher emphasises interactive objectivity more than I do,[11] and I disagree with his highly idealised and sometimes rather static thought experiments (for instance, on ethical questions) under several ideal and partly questionable conditions. Nevertheless, Kitcher's work is a very interesting pragmatist philosophy that could serve as a basis for the development of a more specific science-policy model.

These and other approaches indicate that the above-mentioned weaknesses of large parts of the pragmatic model cluster may be overcome, particularly with regard to the possibility of sound science (objectivity) of scientific assessments. The weaknesses seem remediable through appropriate philosophical theories; the basic idea of the pragmatic model cluster thus remains as a promising avenue to realising the four general norms for scientific expertise in policy (Sect 2.1.3). Some refinement of the pragmatic model is nonetheless possible.

[10] Decisive for well-ordered science is the hypothetical endorsement by an ideal public conversation (e.g., Kitcher 2011, p. 106). Kitcher (2011) elaborates on this ideal (which is unlikely to obtain, as he admits) compared with Kitcher (2001), e.g. regarding the role of value judgements regarding scientific significance. Well-ordered science is extended in Kitcher (2011) and includes, e.g., well-ordered certification and ideal transparency at the stage of the acceptance of scientific statements where the public has a role to play as well.

[11] See Douglas (2009, p. 127) for an explanation of this term. I also disagree with Kitcher's rather Habermasian concept of ethics "for which there are no experts. There is only the possibility of conversation" (Kitcher 2011, p. 12), which is different from Dewey's and Putnam's standpoint (see Sect. 6.2 below).

In order to philosophically substantiate and underpin the assumed possibility of objective yet value-laden scientific knowledge in principle, pragmatist philosophy in the tradition of John Dewey and Hilary Putnam will now be introduced and discussed. Then (in Sect. 6.4), building on the intriguing approaches by Douglas, Elliot and Kitcher, and endorsing many of their conclusions regarding the science-policy interface, I will develop a refined pragmatic model that particularly aims to guide the (social-science) assessment of complex public policy options and their effects. This focus is different to the interests of Douglas, Elliot and Kitcher. This refined model is primarily based on Dewey's core thought that ends and means are interdependent in their evaluation through the practical implications of the means (see Sects. 6.2 and 6.4).

This crucial ends-means interdependency has largely been neglected in both the seminal literature on, and the practice of scientific expertise in, public policy. Although, for instance, the works by Douglas, Elliot and Kitcher more or less explicitly mention this idea of an ends-means interdependency (as do some other proposals for a science-policy model), they do not really elaborate on this Deweyan thought and do not systematically point out its various interesting implications for the science-policy interface.[12] A similar point can be made with regard to Habermas. The philosophical work and particular ideas by Habermas (1968) certainly paved the way for the development of the pragmatic model cluster. However, while he did take into account at least some elements of Dewey's philosophy in his version of the pragmatic model, he neither satisfactorily substantiated the possibility of scientific objectivity (he emphasised inter-subjectivity instead), nor did he draw the full conclusions from Dewey's ends-means rationality for a normative science-policy model.

6.2 Pragmatist Philosophy to Overcome the Weakness

As an amendment to Dewey's political philosophy (Sect. 2.1), the here presented philosophical pragmatism in the Deweyan-Putnamian tradition[13] is a fundamental philosophy of science, epistemology and meta-ethical theory, i.e. more than just a

[12] Also other seminal proposals for (more or less) pragmatic science-policy models – such as the post-normal science approach (Funtowicz and Ravetz 1991); the findings by the Harvard project on global assessments (summarised, e.g., in Cash et al. 2003); the more normative elements of Jasanoff's co-production model (2006); the "realist constructivist model" by Millstone (2005) that he termed a "co-dynamic model;" or Grunwald's pragmatic model that builds on both Habermas and Dewey in a convincing manner (2008) – do not fully elaborate on the ends-means interdependency. In Kitcher's work, for instance, one can at least find interesting examples of potential scientific policy assessments that seem guided by the idea of a Deweyan ends-means interdependency (e.g., 2011, p. 247, on the climate policy debate). Kuruvilla and Dorstewitz (2010) are among the noteworthy exceptions, calling for a Deweyan ends-means analysis in public policy assessments.

[13] This tradition ought to be distinguished from Richard Rorty's (e.g., 1987) most popular and (epistemologically) non-realist variation of pragmatism. The key elements of the Deweyan-

science-policy theory, for instance. This variation of pragmatism – which I find most convincing – combines anti-scepticism (first camp above) with fallibilism and fact/value entanglement (second camp). It holds that even though scientific statements always imply value judgements, they can be objective (although never absolutely true, see Sect. 6.2.3). In this sense, Deweyan-Putnamian pragmatism promises to safe us from the science-policy pessimism of the *radical* pragmatic model. Observers note that there has been a "recent revitalization of John Dewey" in philosophy (Khalil 2004, p. 1),[14] and

> [n]o single thinker in the history of political thought has explored the relationship between science and democracy as fully and thoughtfully as John Dewey (Brown 2009, p. 135).[15]

Although pragmatism is not a uniform movement, the central idea of pragmatism is to *trace and evaluate the practical consequences of hypotheses*: scientific statements should primarily be evaluated in terms of their practical utility as tentative hypotheses – but in a much broader sense than, for instance, suggested by utilitarianism (James 1978; Hookway 2010). The proof of the pudding is in the eating. More precisely, all kinds of scientific statements – be it complex physical theories, economic hypotheses, normative-ethical principles or statements of fact, for example – are regarded as potential means for resolving particular problematic situations that are practically relevant. From this perspective, the sciences are genuinely "applied sciences;" even what we call highly theoretical research has some practical relevance that also makes it so interesting to us.[16] The hypotheses are evaluated in light of their practical implications, that is to say, how well they solved the initial problematic situation. Since a pragmatist enquiry relies so heavily on human action and value-laden ends, a far-reaching fact/value conflation is even constitutive for pragmatist philosophy – rather than being regarded as a problem.

Putnamian variation of pragmatism, including the ends-means interdependency, are explained by Dewey (1986; 1988b) and H. Putnam (1995, 1999, 2004b), as well as R.A. Putnam (2010), Pihlström (2004) and Brown (2012). Although H. Putnam has contributed a lot to pragmatist theory, he does not call himself a pragmatist because he disagrees with the non-realist approaches of some pragmatists.

[14] See also Bernstein (2010) and Brown (2012).

[15] Accordingly, I am not the first who refers to Deweyan thoughts with regard to expertise in public policy; see, e.g., the many studies in environmental pragmatism (e.g., Parker 1996), Brown (2009), Kitcher (e.g., 2011), Grunwald (2008), Strand (2011); as well as Kuruvilla and Dorstewitz (2010).

[16] See also Dupré (2007) who argues in a similar direction. Pragmatism implies that the traditional philosophical understanding of epistemology as only dealing with theoretical philosophy (rather than with practical philosophy as well) is misleading.

6.2.1 Dewey's Pragmatist Theory of Enquiry

More precisely, Dewey's general idea of scientific enquiry consists of five major steps. Dewey describes these steps in several of his writings (e.g., Dewey 1986, pp. 105–122). In Dewey's opinion, they partly constitute a development and enlargement of the successful principle of empirical experimentation in the natural sciences. Yet, this "pattern of enquiry" is applicable to all kinds of enquiry.

1. The first step is to notice a problematic, undesirable situation where trouble, obfuscation or obstacles are perceived, be they intellectual, moral, material, etc. This situation then forms the point of departure for the scientific enquiry. An example is the assumed trade-off between dangerous climate change and the costs and risks of ambitious mitigation options. However, a problematic situation with practical relevance could also take less obvious forms, such as spiritual and philosophical problems or obfuscation concerning the astrophysical structure of the cosmos and, relatedly, the role (or identity) of human beings therein.
2. The next step in Dewey's enquiry – the first truly "scientific" and deeply intellectual one – is a precise and thorough analysis and framing of the problem, its causes, constituents and contexts.[17] According to Dewey, an enquiry is usually highly influenced by socio-cultural, historical and other contingent circumstances. A necessary part of a problem analysis is identifying the preliminary "ends-in-view," which denotes the possible and comprehensive problem-solving conditions (in contrast to the ends actually attained)[18]:

   > Inquiry, as the set of operations by which the situation is resolved (settled, or rendered determinate), has to discover and formulate the conditions that describe the problem in hand. For they are the conditions to be 'satisfied' and the determinants of 'success' (Dewey 1988a, p. 181).

   Concerning the above-mentioned example of a problematic situation, such an end-in-view, for instance, could be the 2 °C goal.
3. Next, it is necessary to develop tentative hypotheses (suggestions) for the means (i.e., proposals for a specific course of action) to reach the ends-in-view determined in Step 2. If the problem and its constituents – and particularly the ends-in-view – have been well scrutinised in the second step, the possible means can be conceived relatively easily. Then, the "possible solution presents itself […] as an idea" (Dewey 1986, p. 113). The means can, for instance, take the form of

[17] Similar ideas can be found in Latour (1999), also regarding the "transactional" character of enquiry, as described below. Another similar approach is the concept of "positional analysis" (e.g., Soederbaum 1982).

[18] Dewey distinguishes two different meanings of ends: First, an "end-in-view," which is the "anticipation of an existential consequence," and second, ends actually attained, i.e. "an end in the sense of a fulfilling close and termination. […] Unless the anticipation or end-in-view is an idle fantasy, it takes the form of an operation to be performed" (Dewey 1986, p. 168). Dewey allows a very broad and open understanding of what appropriate ends-in-view could be; they are usually informed by the results of previous enquires and experiences.

certain energy technologies as in the example of the 2 °C climate policy goal, but can also take the form of any scientific hypotheses in other enquiries.

4. A fourth and highly complex step is the evaluation of the possible ends-means combinations by critically, carefully and comprehensively considering the potential practical (direct or indirect) implications of these hypotheses for potential means, especially in terms of their many interrelations with other ends (side effects, etc.; see more detailed in Sect. 6.4). This Step 4 (and the following Step 5) may also require a revision or refinement of the analyses in Step 2. One might, for instance, identify additional ends-in-view for the problematic situation at stake.[19]
5. Finally, an evaluation is required after the actual implementation or application of the means that were chosen after Step 4. Did the proposed problem phrasing, ends-in-view and their means actually resolve the problematic situation (better than alternative ones)? What can be learned for next time?

These five steps[20] are not to be misunderstood as the only appropriate scientific method. They rather form a kind of meta-theory (i.e., a methodology) and an abstract pattern for all possible scientific enquiries. A colourful plurality of *specific* methods is conceivable from this pragmatist perspective.

Moreover, the process of the experimental enquiry developed by Dewey is to be regarded as a "transaction" instead of a mere contemplation of, or interaction with, the world[21]:

> action is integral to whatever we claim to know […, since] true inquiry cannot take place within an ivory tower, and inquirers cannot pretend to be above the fray of their own interests, beliefs, passions, and imagination. Dewey […] argued that humans gain knowledge by transacting with the environment, an environment that they partly constitute. Knowing is acting with imagination, interests, and beliefs (Khalil 2004, p. 2.).

Transaction takes place between the knower and the known (Khalil 2004, p. 2–6; Kuruvilla and Dorstewitz 2010); thus, these two are not completely separate entities, from a pragmatist perspective.

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[19] This can happen, e.g., when previously overlooked side effects of the means are revealed which imply valuable ends again in terms of, for instance, other policy fields affected by an action (due to the interdependencies between the policy fields).

[20] The number (five) is not fixed, as Dewey points out several times, but is rather only one possibility to describe the core idea (see also Ryan 2004, p. 18). Brown (2012) extensively discusses alternative views with regard to the five steps. My ambition is not to present a perfectly right interpretation of Dewey's work here (see Sect. 6.3).

[21] Dewey describes the transactive character of research, inter alia, in Dewey and Bentley (1989). See also Kuruvilla and Dorstewitz (2010, p. 267) and Ryan (2004).

6.2.2 The Need for a Rational and Participative Public Discourse

A crucial precondition for a successful Deweyan enquiry into more complex issues such as climate policy (in contrast to relatively simple enquiries such as: "Is there a chair in the room?") is an extensive dialogue between the sciences and the public as the essential *co-operative* aspect of a Deweyan enquiry (Dewey 1927), in addition to the just-discussed principle of experimentation.

The *first* reason why the co-operative aspect of a Deweyan enquiry is essential is that there are basically no original *scientific* methods. Rather, the methods employed in the sciences emanate from the rationalities and everyday "enquiries" of ordinary people; the pragmatist method itself is a mere reconstruction of the very practice of our (rather successful) everyday thinking as well as scientific thinking.[22] Nevertheless, *scientific* knowledge can be highly valuable due to the methods of scientific enquiry that are – ideally – stricter, more elaborate and more continuously employed than in everyday enquiries (see Sect. 2.2.4). However, the difference is only gradual, from the pragmatist perspective; therefore, the sciences should not lose touch with the public.

A *second* and highly important reason is that the problematic situations to which scientific enquiries respond are taken from everyday life or at least usually are practically relevant also to non-scientists. Steps 1 and 2 above can only be done well in more complex enquiries if those affected by the problem are sufficiently involved. Otherwise, relevant problematic aspects, contexts, conditions and ends-in-view may be missed by a scientific enquiry conducted in an academic ivory tower. The value saturation of scientific research shown in Chap. 5 makes particularly clear, why public participation is needed in scientific enquiries.

Third, the successful solutions to these problematic situations (Steps 3–5 above) can best be ascertained by those who are actually or potentially affected by the problem. This group, however, usually transcends the scientific community. They also may know much about relevant negative side effects or desirable co-benefits of the means employed to achieve the ends-in-view.[23]

Consequently, for a successful enquiry, public participation and stakeholder involvement are very useful and sometimes even necessary from Dewey's perspective. This, however, presupposes that ordinary citizens and the various stakeholders are in principle, to some considerable extent, capable of and interested in understanding, discussing and rationally criticising scientific inputs, for instance, to public policy processes (see also Sect. 2.1). Dewey aims to promote intelligence – i.e., the employment of the pragmatist scientific methodology described above – throughout the population with the help of the scientific community, since actively "to participate in the making of knowledge is the highest prerogative of man and the

[22] As argued, e.g., by the pragmatist philosopher Mead (Blum and Schubert 2009, p. 19f).

[23] In some cases, non-scientists may also have interesting ideas (or intuitions) for potential means for achieving the ends-in-view.

only warrant of his freedom."[24] Intelligence, however, is not a possession of individuals, but of society as a whole and requires training; "in fact, knowledge is a function of association and communication" (Dewey 1927, p. 158). This means that public debate needs to be actively and professionally promoted (although of course not dominated), particularly by the sciences and their methods (Dewey 1927; see also Sect. 6.4 below). Kuruvilla and Dorstewitz sum up:

> Dewey emphasized that pluralism is not only a reality, but also an intellectual resource on which societies should draw to resolve problematic situations […]. Dewey proposed two criteria for assessing 'social intelligence': (1) the level of pluralism in a society's intellectual resources and (2) the extent to which these pluralistic resources are freely available for inquiry to resolve problematic situations (Kuruvilla and Dorstewitz 2010, p. 271, referring to Dewey 1927).

6.2.3 Dewey and Putnam: Objectivity, Knowledge and Certainty

So, having introduced some core elements of Dewey's theory of scientific enquiry, how can value-laden scientific research that follows the proposed pragmatist pattern of enquiry, including public participation, generate *objective* knowledge? While Sect. 5.2 discussed the *predominant* understandings of objectivity and particularly its preconditions (value-free ideal, etc.), the present section will explain the more convincing Deweyan-Putnamian theory of objectivity.[25]

For this purpose, it is helpful to remember the distinction made in Sect. 5.2.1. The nuances that underlie the different predominant definitions and explanations of objectivity can be interpreted either (i) as disagreements only about the *bases* (e.g., methods or preconditions) on which objectivity can be achieved[26] (e.g., in its core, widely shared sense of reliability for everyone); or (ii) as different understandings of the essence and core meaning of objectivity itself. Chapter 5 primarily focused on the former, i.e. the bases of objectivity, and rejected the hypotheses of the traditional models in this regard. The pragmatist bases of objectivity will be discussed below. Let us first, however, think about what the core meaning of objectivity itself could reasonably be.

The proponents of the first camp tend to defend rather metaphysical definitions of objectivity. They sometimes argue that objective knowledge usually indicates absolutely *true* knowledge about the reality in itself (e.g., in terms of direct epistemic correspondence with reality). A "good deal of traditional philosophy has been motivated by a 'quest for certainty' – or […] a 'craving for absolutes'" (Bernstein

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[24] Dewey, quoted in Brown (2009, p. 135). This anthropological-ethical argument – if accepted – provides yet another reason why participatory research can be valuable.

[25] Particularly Putnam, in a more elaborate and analytic way than Dewey, developed such a theory of objectivity (e.g., 2004b).

[26] This seems to be the more appropriate interpretation in many cases (see Sect. 5.2.1).

2004, pp. 32f). Chapter 5, as well as philosophical pragmatism, show that this definition of objectivity is inappropriate, inter alia because its preconditions, i.e. that there is value-free scientific knowledge or at least a value consensus, are largely unattainable: social and ethical value judgements play a key role in scientific knowledge production, and there is hardly any de facto consensus with regard to value judgements. Moreover, Putnam rightly claims that the notions of objectivity and even truth cannot be so *radically non-epistemic* as assumed by parts of the first camp, particularly not since the Deweyan enquiry regards the "knower of the world as an agent in the world" (Putnam 2010, p. 34). We can never have direct epistemic access to reality that is free of value-laden perspectives and concepts (Putnam 1999, Part I). Accordingly, for pragmatism, it is impossible to produce infallible, everlasting, absolutely true and absolutely certain knowledge. Furthermore, problematic situations and consequences of human actions change continuously, as do our languages, values and worldviews. For these and other reasons, scientific judgements are always fallible in the pragmatist view. Putnam states that

> pragmatists have never believed in infallibility, either in perception or anywhere else. As Peirce once put it, in science we do not have or need a firm foundation; we are on swampy ground, but that is what keeps us moving (Putnam 2004b, p. 102).

In light of the numerous epistemological difficulties (see, e.g., Chap. 5), many proponents of the second camp, in contrast, usually define objective scientific claims more modestly – as far as the metaphysical and epistemic implications are concerned – in terms of a weaker reliability and trust based on meeting certain procedural or methodological criteria, without claiming that such (always fallible) scientific claims are also *true*. This definition often refers to, for instance, intersubjective consensus, coherence among theories and assumptions, Richard Rorty's 'solidarity,' or to similar concepts[27] as the necessary bases that render scientific statements objective. The main problem with this definition of scientific objectivity is that it is so modest in metaphysical and epistemic terms that one again may end up with the radical pragmatic model and science-policy pessimism.[28]

Fortunately, these two examples of definitions of objective scientific expertise are just two poles of a large range of possible definitions. Despite its anti-Cartesian assumption and despite its constructivist slant, Deweyan-Putnamian pragmatism defines objectivity in a manner that is, in epistemic terms, ambitious enough to render scientific expertise in policy highly credible and reliable (avoiding science-policy pessimism). This definition is situated somewhere between the two poles just described, as it combines fallibilism with anti-scepticism. It includes, but goes beyond, the understanding of objectivity in itself as "indicating a shared basis for trust in a claim" (Douglas 2009, p. 132). From the Deweyan-Putnamian perspective, scientific statements – as potential means for resolving problematic situations – are objective *if they can repeatedly transform a particular indeterminate problematic*

[27] See, e.g.,. Skodvin (1999, p. 7).

[28] Bunge humorously states, "philosophers are the only animals that, because they are protected by academic freedom, can afford to ignore or even deny reality" (1996, p. 358).

situation into a determined one in a manner that is reliable for everyone.[29] With it, they can resolve the (well-defined) problematic situation. Resolving a problematic situation means for effectively realising the ends-in-view (Step 2) without entailing severe side effects (including costs, risks, obstacles, etc., see Sect. 6.4 for more detail).

The indeterminate, problematic situations and their resolutions into determinate ones within a scientific enquiry are not so unique that the successful results of a certain enquiry could not also be applied to some other situations, or accepted by other people. Therefore, hypotheses that have turned out to be reliable in terms of their practical consequences regarding the solution to the problematic situation at stake can serve as premises for other enquiries. If these hypotheses, for instance on certain assumed laws of nature, are *repeatedly* useful and sufficiently reliable for everyone – as cumulative experience –, they can qualify as being objective and valid judgements, or as having "warranted assertability" in Dewey's terms.[30] With it, hypotheses can be developed into more general statements, although they were originally developed with regard to the very specific context of a given problematic situation.

In the end, it is the reality out there and its assumed causality that makes our best scientific theories so extraordinarily successful in terms of their repeated problem-solving, practical consequences in similar situations. Putnam calls this stance "natural realism," (1999, Part I), and also regards Austin and James as natural realists. Putnam argues that this natural realism recognises real-world objects *as they really are*, even though we can never have a view from outside our own. A Kantian 'thing-in-itself,' however, is a completely misleading concept, as Putnam rightly argues (1999, Part I; Ryan 2004, p. 18).

Having clarified what Dewey and Putnam mean by objective scientific knowledge, let us turn to the most decisive question for the purposes of this chapter as to how it can be achieved and what its bases or preconditions are. The five steps of the Deweyan enquiry, including public participation and stakeholder engagement, are the decisive means for achieving objective knowledge in the above, pragmatist sense. Objectivity can be achieved through a series of controlled and successful enquiries (as a set of transactions) – under good enough conditions for such enquiries, which include the possibility to identify and evaluate the practical implications of the means in a relatively clear and comprehensive manner; appropriate public participation; high transparency regarding the assumptions and arguments; absence of fraud; well educated researchers; etc. (Dewey 1986). This does not mean, however, that all scientific enquiries along the five Deweyan steps automatically result in objective knowledge.

[29] This presupposes that the problem definition (Step 2) is shared by everyone.

[30] See also Pihlström (2004, p. 43). Dewey uses the expression "warranted assertability" instead of "verification," inter alia also because of the above-mentioned idea of "transaction" during an enquiry.

Through successful, participatory pragmatist enquiries under good enough conditions, also highly value-laden scientific claims and even disputed, normative-ethical policy evaluations could, in theory, qualify as objective statements:

> Once knowledge is seen to be not only compatible with action but requiring action, it follows that the methods of inquiry that lead to knowledge in science are also the methods by which judgments of practice, and hence judgments of value, become known (Putnam 2010, p. 34).

Value judgements (e.g., in the form of ethical principles or climate change mitigation targets) can serve as ends-in-view and as means for resolving a problematic situation. For instance, internal consistency as an epistemic criterion seems to have helped us to cope with many problematic situations in epistemic terms, so this might be a candidate for being regarded as objective. Like other statements and hypotheses, ethical values, principles, etc. are not fixed once-and-for-all according to pragmatism, but instead are fallible hypotheses that can change due to new enquires, for instance as a result of a more thorough problem analysis. Normative-ethical analyses, for instance, are only *gradually* different from empirical research in natural science. Hence, the Deweyan pattern of enquiry can also be regarded as a kind of meta-ethical theory, as well as a theory of problem solving in public policy (Posner 2004, p. 171).[31]

Given the categories of objectivity described by Douglas (2009, Chap. 6; see Sect. 5.2.1 above), the pragmatist pattern of enquiry allows for a variety of bases and aspects of objectivity that "can work together to reinforce our sense of the trustworthiness of a claim," as also Douglas argues (2009, p. 132). All three major groups of bases play an important role for the pragmatist concept of objectivity.[32]

First, the emphasis on the pattern of enquiry indicates that the quality of the argumentation and thought processes (as the first group of bases) is an essential basis for pragmatist objectivity. However, the value-free ideal – as an additional possible aspect in this first group – is clearly dismissed as a basis, while the idea of being detached and disinterested (i.e., limiting non-epistemic value judgements to indirect roles in theory evaluation) is only reasonable if one considerably reinterprets this concept in terms of avoiding "wishful thinking" (i.e., replacing evidence by interests, etc.). For being detached in the full sense is neither feasible nor desirable from a pragmatist perspective (see above). Moreover, value-neutrality in the rather weak sense of not ignoring other important aspects of the problematic situation at stake, or assuming more extreme standpoints than defendable (Douglas

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[31] For an introduction to Dewey's thoughts on ethics, see Pappas (2008). Deweyan-Putnamian pragmatism implies, that value judgements should not be interpreted in the way suggested by emotivism (see Sect. 5.2.1), nor are values to be regarded as abstract entities, nor are they merely related to certain virtues or to Kantian duties. Rather, the ends and means of a Deweyan enquiry not only "*have* value as instrumental to satisfaction, but […] they *are* values" (Sleeper 1986, p. 141).

[32] In this sense, Deweyan-Putnamian pragmatism can serve as philosophical underpinning of the interesting analytic-deliberative science-policy approach by the National Research Council (NRC 1996) which also combines several aspects of objectivity (see also Douglas 2009, pp. 160f).

2009, pp. 123f), is accepted as a basis for objectivity by pragmatism. If one regards coherence and consistency with other, widely accepted theories and claims as another potential aspect within this first group of bases for objectivity, they only play a minor role in Deweyan-Putnamian philosophy.

The *second* group of bases – effective social processes – are clearly important for Deweyan-Putnamian pragmatism, as Sect. 6.2.2 argued, but mainly in the sense of interactive objectivity (Douglas 2009, pp. 127f). In this regard, there are similarities with the approaches by Longino (who emphasises self-corrective social mechanisms so much to avoid value bias etc. in scientific research), Douglas, Kitcher, Elliot and Habermas (see above). Simple agreement and consensus without a public deliberation process are hardly relevant to Deweyan-Putnamian pragmatism which offers a much more compelling criterion for approaching reality than such intersubjective consensus. Consensus can at most be seen as a – non-necessary – symptom (indicator) of objectivity, among other potential symptoms. Moreover, if interpreted less strictly, procedural objectivity (Douglas 2009, p. 125) can play a useful role in determining objectivity in the sense that an objective scientific statement has to be *repeatedly* successful in enquiries along Dewey's pattern, and reliable for everyone, as argued above.

Third, given the above sketch of Putnam's natural realism, the appropriate interactions with reality is absolutely key for the Deweyan-Putnamian understanding of objectivity. Pragmatist objectivity implies, roughly spoken, that "it works reliably in practice."[33] As summarised by Ralph Sleeper, also Dewey argues

> that 'warranted assertions' are the reliable means of obtaining desired results, that they function in controlled activity designed to resolve problematical situations and produce valued consequences. But he also takes pains to demonstrate that those valued consequences are reliable only when the means employed to obtain them are causally related to objective reality (Sleeper 1986, p. 141).

If understood rather broadly, both manipulable objectivity (scientific results can be used in practice to repeatedly and successfully manipulate the world) and convergent objectivity (different approaches lead to the same results), as Douglas (2009, Chap. 6) calls these aspects of the third group, are very much in line with Deweyan-Putnamian pragmatism and can substantiate the objectivity of a scientific claim.

[33] Brown (2012) adds, interpreting Dewey: "Facts capture the fixed conditions with which inquiry must cope. They provide the resources for locating and formulating the problem of inquiry. The facts also suggest certain hypotheses for solving the problem (e.g., determining that we have an oil fire rather than a wastepaper fire suggests a different method of solution be tried). Likewise, once a hypothesis has been suggested and elaborated, further examination and determination of the facts can help test the hypothesis and suggest acceptance, rejection, or further refinement."

6.3 Discussion and Some Implications of Pragmatism

To conclude, the failure of the traditional science-policy models does not force us to fall back upon the pessimist, radical pragmatic model, at least not as far as the philosophy of science is concerned. The Deweyan-Putnamian variation of pragmatism can serve to overcome the severe, yet remediable, weakness of those variations of the pragmatic model cluster that do not satisfactorily explain how reliable expertise in policy can be warranted. Part III will argue that the pragmatist idea of enquiry also works for the economics of climate change in integrated scientific assessments. Against the traditional models, each form of "expertocracy" (rule of experts) and infallible technocracy, which regards a serious and open public debate as dispensable or impossible, must be strictly rejected. Moreover, different degrees of certainty are possible from the pragmatist perspective between "purely subjective" and "highly objective" judgements; scientific judgements can be useful, although they are mere estimates or opinions rather than highly objective knowledge. In any case, their practical implications are always decisive. The general possibility of objective value judgements does not mean that objectivity is often achieved, nor does it imply cultural imperialism, since

> "recognizing that our judgments claim objective validity and recognizing that they are shaped by a particular culture and by a particular problematic situation are not incompatible," […and we shall] "investigate and discuss and try things out cooperatively, democratically, and above all *fallibilistically*" (Putnam 2004b, p. 45).

But, as pragmatists point out, doubt and scepticism also require good reasons in terms of the consequences of hypotheses, since doubt means that one has to identify an *indeterminate* problematic situation.

A further implication of the pragmatist understanding of objectivity is that pluralism of more specific scientific methods and standpoints is desirable. Pluralism is irreducible since pragmatism cannot lead to the determination of the one, absolutely true method or result. Additionally, pluralism increases the "hit rate" of scientific enquiries (Posner 2004, p. 170). According to Putnam (2004a, pp. 48f), theories need not be incompatible to claim pluralism. It is sufficient to argue that they are non-equivalent (but irreducible to each other). Putnam refers to the example of describing a room: (1) using concepts like particles and fields, as in physics and (2) using concepts like chair, bed and table. These two approaches are not incompatible, yet irreducible to each other.

The brief introduction to Deweyan-Putnamian philosophy above is certainly not a comprehensive account of Dewey's and Putnam's thoughts; it rather emphasises elements that I find most convincing and most relevant to the development of the refined pragmatic model. The main focus was pointing out *that* – and roughly *how* – even highly value-laden hypotheses, in principle, can qualify as objective statements. Ryan (2004, p. 16) lists some of the milestones of pragmatism: "doubt-belief and the pattern of inquiry; the pragmatic theory of truth; the ontology of primary experience; the fact-value relation; and transaction." Brown (2012) provides a far more detailed, excellent philosophical introduction to, and reflection on, Dewey's thoughts on scientific logic; he rightly states (as I also argued above) that these Deweyan thoughts are still under-researched and underestimated in the philosophy of science, including particularly the ends-means interdependency.

Critique of pragmatism

In contrast to a widespread yet mistaken criticism,[34] pragmatism does not equate objective knowledge with anything that is somehow "useful" for anybody, e.g., in terms of one's individual political benefits and expedience. Pragmatism also goes beyond the Western paradigm of utilitarian consequentialism – it is in line with, for instance, ancient Chinese philosophy (Chen 2010, p. 11ff). More generally, how does Dewey's pattern of enquiry avoid mere "wishful thinking" as one of the major epistemic concerns, for instance, by Lacey (1999) and Douglas (2009)? The decisive point is that all the methods, criteria, choice of data sets and other decisions within an enquiry must be aligned with the problem analysis from Step 2. Ideally, a problem analysis is acceptable for everyone and takes into account the whole range of values, interests, etc. that are affected by the situation at stake. Moreover, as was already said above, the ends-in-view (which are among the major determinants of pragmatist utility of a scientific claim) can take various shapes. But, as was already said, they a not determined a priori, nor is pragmatism developed a priori. Rather, pragmatism itself, as a philosophical hypothesis, has to be evaluated by means of a pragmatist enquiry:

> The discovery that inquiry that is to be successful in the long run requires both experimentation and public discussion of the results of that experimentation is not something a priori, but is itself something that we learned from observation and experimentation with different modes of conducting inquiry: from the failure of such methods as the method of tenacity, the method of authority, and the method of appeal to allegedly a priori reason (Putnam 2004b, p. 105).[35]

Another line of critique of Dewey's work concerns the relationship between experience and existence.

> A massed chorus of critics – Russell, Santayana, Cohen, Lovejoy, Rogers, Murphy, Kahn – stridently insisted Dewey had left the basic relationship between experience and existence unresolved, and thus had not settled the debate as to whether he was 'really' an idealist or a realist (Ryan 2004, p. 22).

Bernstein called this the "deep crack" in Dewey's metaphysics (Bernstein 1961) and regards this problem as unresolved – Dewey seems to be an idealist rather than a realist. However, as Ryan explains, Dewey's later writings better addressed these issues; particularly in terms of the previously mentioned idea of "transaction" (see Dewey and Bentley 1989 and Ryan 2004). Dewey himself admitted that the early concept of "experience" was intended to comprise "the whole range of transactions

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[34] Much criticism of pragmatism is based on misunderstandings and oversimplifications of the pragmatist approach.

[35] As it implicitly already presupposes the pragmatist perspective, this argument alone does not prove pragmatism to be right, but at least that there is no performative self-contradiction regarding the rationale for the method.

within which the needed distinctions have to be made" (Dewey, quoted in Ryan 2004, p. 22). In contrast, Dewey's later work assumes that the knower and the known are both part of the transaction during a successful, ideal enquiry. This stands in contrast to traditional philosophy, which strictly distinguishes between subject and object, mind and world, knower and known. All of these elements and steps of the transaction are seen as "real," but also as "experience," according to Dewey (Ryan 2004). Dewey and other "transactionalists" assume that "action does not stand outside reality" (Khalil 2004, p. 4): the ends-in-view and beliefs that guide action are not given as a *datum*, but are rather dependent on the available means.

> This entails that action cannot be fully explained in terms of ends and beliefs only, as if means and the environment in general do not matter, or in terms of the environment only, as if beliefs do not matter. (Khalil 2004, p. 4).

Critical discussions of Deweyan-Putnamian philosophy can be found, for example, in Cochran (2010), Ben-Menahem (2005) and Conant and Zeglen (2002).[36] A rather comprehensive list of secondary literature on Dewey is provided by Levine (2007). Some alternative approaches to pragmatism are briefly addressed in Chap. 9.

Appendix: Dewey's theory of enquiry applied to the structure of this book

As an appendix, let me briefly explain how Dewey's theory of enquiry is used to structure the argumentation in the present book. In this book that started with "noticing a problematic situation" (Dewey's Step 1) in the introductory sections, I attempt to employ Dewey's five steps of an enquiry in order to answer the guiding question of this book that seeks an appropriate framework for integrated economic assessments, for instance by the IPCC. Instead of, for instance, an a priori approach to a framework for the IPCC assessments, this book systematically and thoroughly, although not comprehensively, analyses important aspects of the "problematic situation" (and its diverse constituents) of integrated-economic assessment-making in climate policy. This relates to Step 2 in the pattern of enquiry which is so crucial for any enquiry. Chapters 2, 3, 4, 5, 6, 7, 8, 9 and 10 all contribute to the problem analysis (including ends-in-view) of the topic at stake, although on different levels, respectively. Next, Chap. 11 can be interpreted as Step 3, where potential means for achieving the ends-in-view from the problem analysis are proposed. The means, i.e. the envisaged framework, mainly consist of the elements of a guideline for the IPCC assessments. Moreover, Chap. 12 briefly explores possible (positive and negative) practical implications of the proposed means, as claimed by Step 4 of the Deweyan enquiry. Finally, Chap. 12 at the end provides an outlook on Step 5 – which, however, would require an almost complete realisation of my proposals in the practice of scientific assessments.

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[36] Many (e.g. Bunge 1996, pp. 317–320) have criticised pragmatism in terms of Rorty's (e.g., 1987) more radical constructivist approach. An interesting and extensive comparison of Dewey and Rorty's (quite different) views of pragmatism is provided by Pihlström (2004), who also provides an overview and discussion of the mutual attacks that Dewey and Rorty inflicted on each other.

More precisely, Dewey's Step 2, i.e. the problem analysis where major factors, ends-in-view, etc. are determined, often requires itself a series of preceding enquiries *along the five steps proposed by Dewey* in order to prepare the actual enquiry at stake in more complex cases. For sometimes, the gap between the ends-in-view and the envisaged more specific means can be rather huge and requires intermediate steps. This is also valid for the complex problematic situation addressed in this book. Therefore, as an intermediate step, the first and preparatory sub-enquiry within this book is conducted in the present Part II. It aims to identify means (that are appropriate in terms of their practical implications) for realising the general norms for expertise in policy (Sect. 2.1) – as the preliminary ends-in-view in light of the key challenge at the science-policy interface (Sect. 3.4). The second sub-enquiry within Step 2 for this book is the critical analysis of the more specific problems of the IPCC's economics in Part III which considerably deepens and specifies the problem analysis provided by Part I. This will be heavily based on Part II (mainly Sect. 6.4) that, in Dewey's terms, *refined* our understanding of the ends-in-view for the IPCC's integrated economic assessments.

This illustrates both that a Deweyan enquiry is essentially an iterative process and that there is a continuum of ends and means. For Dewey, everything can be an end-in-view or a means depending on the situation (a similar view is taken by Bunge 1996, p. 221). As a result, this book actually presents three major levels of guidance for the IPCC's integrated economic assessments: (1) the rather abstract general norms in Sect. 2.1, as the ends-in-view for the book project; (2) the refined pragmatic model developed in Sect. 6.4 below (as a more abstract element of the envisaged framework); (3) and its translation into some more specific recommendations for the IPCC's integrated economic assessments in Part IV (based on the more specific problem analysis in Part III). However, although the form and language of my proposals and recommendations for the IPCC assessments made in this book may perhaps wrongly suggest that they are intended to be "universally valid and true," they are in fact merely *tentative* (but well-grounded) claims, according to pragmatism. These claims are only valid if – and as long as – their practical consequences truly turn out to resolve the problematic situation at stake.

6.4 Refining Dewey's Philosophy: A Novel Science-Policy Model

While the above argumentation suggests that scientific distrust and science-policy pessimism could be avoided through the Deweyan-Putnamian methodology for achieving objective, reliable and sound scientific knowledge, the question remains as to how a *normative, pragmatic model* for scientific policy evaluation in assessments could look more concretely based on this general, philosophical theory of enquiry by the pragmatists. In particular, how can we avoid authoritarian, ideological argument in normative scientific evaluations of policy options – which would endanger the legitimacy of any scientific assessment?

6.4.1 Key Characteristics of the Refined Pragmatic Model

The most important implication of the Deweyan theory of enquiry for a normative science-policy model of such a kind is the ends-means interdependency and the resulting methodology for scientific policy evaluation. Ends-in-view do not justify the means. Instead of simply exploring the possible means for given ends-in-view (decisionist model), one should critically reflect on both the means and the ends-in-view and consider their interrelations via the practical implications. *Both* the ends-in-view and the means should be evaluated in light of the practical implications of the means (Step 4 in Dewey's enquiry). For instance, assume some given policy objectives as ends-in-view in the sense that they are necessarily normative valuations, i.e. as something that *should* be achieved. A critical scientific assessment of these policy objectives may reveal, for instance, possible adverse side effects of the best available means; this may result in a substantial revision or abandonment (i.e., delegitimisation) of the policy objectives at stake. Consequently, policy ends-in-view and means are interdependent (via the practical means-implications) in their evaluation and cannot be evaluated separately. The types of practical implications (including consequences, outputs, outcomes, etc.) of means for achieving policy objectives are: (1) direct effects of the means, which are related to the explicitly given policy objectives[37]; (2) unwanted side effects,[38] referring to *other*, additional policy objectives or societal values (in terms of trade-offs); and (3) desirable co-benefits, again referring to other, additional policy objectives or societal values (in terms of synergies).

As already said at the end of Sect. 6.1, very few publications endorse or explain this ends-means interdependency regarding policy analysis and policy assessments. Additionally, the practical implications of the means sometimes seem to be discussed rather "ad hoc" and in an ill founded manner with regard to science-policy models. This may be due to a misguided view of value judgements, if one regards (policy) ends as valuable, by definition.

> "The common, perhaps prevailing, assumption is that there are objects which are ends-in-themselves; that these ends are arranged in a hierarchy from the less to the more ultimate and have corresponding authority over conduct. It follows from this view that moral 'judgment' consists simply in direct apprehension of an end-in-itself in its proper place in the scheme of fixed values" (Dewey 1986, p. 169). "Classic theory transformed ends attained into ends-in-themselves. It did so by ignoring the concrete conditions and operations by means of which the fulfillments in question are brought about" (Dewey 1986, p. 179).[39]

[37] Also secondary, later effects of an action (such as, e.g., rebound effects in environmental regulations) belong to these direct effects as long as they affect the given ends-in-view directly.

[38] Broadly understood, these may include different kinds of costs or resources required; externalities; risks; obstacles; difficult preconditions; etc.

[39] See also, for instance, the Tinbergen rule in macroeconomics, which relates objectives and means, but regards the objectives as given.

Dewey also states that the idea that ends-in-view could justify the means

> rests upon the postulate that some end is already so fixedly given that it is outside the scope of inquiry […]. The hypothetical and directive function of ends-in-view as procedural means is thus ignored and a fundamental logical condition of inquiry is violated (Dewey 1986, p. 490).

The mistake here is to regard general values or more specific societal or policy ends-in-view as something fixed or as panaceas so that they almost become ideologies. More generally, the rationalistic view of ideas (including valuations) as independent from facts and factual consequences is misleading (Dewey 1986, Chap. VI) and partly tied to the dichotomies rejected in Sect. 5.2.[40] In contrast to the value fundamentalism described above, pragmatism suggests that a critical enquiry into all consequences of the means may change our previous (e)valuations dramatically. Moreover, "changing one's values is […] frequently the only way of solving a problem" (Putnam 2004b, p. 98). An end-in-view cannot be evaluated by simply referring to a priori given, abstract and general values, but only by regarding the concrete, expected or actual, practical implications of the related means. In light of such implications, the policy end-in-view is to be evaluated and, if necessary, adapted or abandoned when compared with alternative policy ends-in-view.

Let me illustrate this ends-means issue with the example of climate change mitigation goals. Let us assume a hypothetical 1.5 °C goal as a climate policy end-in-view, requiring a high share of biofuels as a means for achieving this end. What if this indeed helped achieve the 1.5 °C goal, but implied severe side effects of the extensive use of biomass, particularly regarding food prices and land-use change including deforestation? And what if, hypothetically, the positive as well as negative practical implications of all the policy means (e.g., biofuels, geo-engineering, etc.) to achieve the 1.5 °C goal were, from a societal perspective, worse on balance than those of less ambitious mitigation objectives? This would clearly necessitate a revision of the given policy objective.

In general, the evaluation of practical implications of means can lead, for instance, to the insight that a particular set of means is better than another, or to the conclusion that the ends-in-view need to be revised (or abandoned), or that the entire problem framing has been inappropriate and requires revision. Sometimes, even the general moral values – for instance, normative assumptions about distributional justice – underlying the policy ends-in-view have to be revised in light of adverse ramifications of policy means.

For the envisaged, refined science-policy model, this ends-means interdependency means that it is absolutely crucial to carefully analyse and evaluate a broad range of practical implications of policy means in scientific assessments, be they potential or actual, quantitative or qualitative, direct effects or co-effects, positive or negative ones. In light of such practical ramifications of policy means, not only the proposed policy means, but also the given policy objectives (as preliminary ends-in-

[40] Dewey (according to Hands 2004, p. 258) provides a rather polemic historical explanation for this misguided, passive "spectator theory" of knowledge, ideas and ends, arguing that this view is rooted in the Ancient Greek slave society where the masters dedicated themselves to 'theoria' while the slaves had to implement the ideas of their masters.

view) can and have to be critically evaluated in scientific assessments. Under good enough conditions (see Sect. 6.2.3), such a scientific policy evaluation can even result in objective knowledge; from the perspective of the philosophy of science, epistemology and meta-ethical theory, the pragmatist approach seems the *most reasonable methodology* for achieving sound, relatively objective and credible scientific knowledge with regard to the critical evaluation of public policy goals and options. Due to the multi-faceted real-world problems addressed, a successful ends-means analysis in policy assessments requires close, transdisciplinary cooperation as well as the pluralism of more specific methods and disciplines, including the largely underrepresented social sciences and the humanities.[41]

The crucial pragmatist ends-means interdependency has some further implications for a refined science-policy model that particular focuses on the scientific evaluation of policy options: (i) the need for an adequate problem framing; (ii) the need for a critical exploration of the implications of *different* possible sets of ends-in-view and *different* sets of means for achieving them; (iii) the need for participatory knowledge production at all stages of the assessment process; and finally (iv) the need for high transparency, an adequate division of labour between experts and decision-makers as well as well-defined roles for social and ethical value judgements in scientific assessment processes in order to ensure their legitimacy.

Thorough problem analysis

A thorough, comprehensive problem analysis is also crucial for successful assessment-making, it refers to Dewey's Step 2. An old proverb expresses Dewey's seminal thought very well: "a problem well-put is half-solved." This is valid because understanding the different drivers, control levers and conditions of a problematic situation makes the identification of the possible means for overcoming the problem easier. In spite of several decades of discussion on this topic, the problem framing (including also the "policy narratives," see also Sect. 11.3) of *climate* policy is still highly disputed (Hulme 2009). For instance, should climate change policy primarily be about an environmental issue in terms of hazard risk management and insurance policy, or rather primarily about economics, resource conflicts and 'green growth'? For the problem framing for integrated scientific assessments of climate policy *solution options*, the appropriate identification of the various economic, social, cultural, etc. things that are highly valued by different human beings (and, with it, should be covered by appropriate social welfare functions) and that are potentially affected by climate change response options would be the most important point, rather than questions of climate change physics. Chapter 8 will critically analyse whether or not the ends-in-view (i.e., normative assumptions in terms of social welfare, etc.) assumed in some economic studies on climate policy succeed in analysing the problematic situation of climate policy comprehensively enough.

[41] For instance, my impression is that relatively few economists have been involved in most global environmental assessments, compared with natural scientists.

Exploring *different* policy pathways in light of their practical implications

For more general theoretical reasons, in order to reliably identify the *best* set of ends-in-view and means, a thorough and sound scientific evaluation and comparison of all the different possible, relevant ends-means combinations would be required in terms of their practical implications, because there is no a priori method according to pragmatism. For scientific assessments of disputed and complex public policy options, there are some further reasons why alternative policy pathways – i.e. different sets of policy objectives and related, specific policy means[42] – as well as the practical implications of the means should be explored *and presented* in scientific assessment reports, as I have already argued elsewhere.[43] Among these reasons is that in the very complex and heated case of climate policy options, for instance, fully objective judgements in the pragmatist sense are only achieved rarely; nevertheless, assessment findings can still be highly valuable for policy-making processes. Therefore, different relevant policy pathways, the related uncertainties and the practical implications should be presented in assessments in order to promote a public deliberation about the full policy solution space. Additionally, presenting alternative policy pathways would help to avoid illegitimate policy-prescriptions as well as mitigate the risk of misusing scientific assessments for political reasons, etc. (Sect. 3.2). In this sense, according to the refined pragmatic model, scientific consensus should at most play a role with regard to the epistemic quality (e.g., internal consistency) of the scientific statements on the policy alternatives. A full scientific consensus about what the most appropriate policy pathway is, however, neither realistic nor necessary in climate policy assessments such as the IPCC's in light of the general norms for expertise in policy from Sect. 2.1 (see below and Chap. 12 for more details).

However, the scope of possible future policy pathways must be narrowed because of the vast range of climate policy options, the many possible future developments and consequences, and the many uncertainties in the natural and socio-economic systems. This complexity must be reduced to make assessments feasible (Dunn 1994). To be highly relevant for policymakers, the selected scenarios[44] about alter-

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[42] Note that this understanding of the term 'policy pathway' combines (i) the trajectories towards the realisation of the policy objectives (e.g., the IPCC scenarios of natural, socio-economic and technological developments under different policy assumptions) and (ii) the specific policy instruments and measures (i.e., policy options) to facilitate these trajectories.

[43] The following core reasons for presenting alternatives were already listed in Edenhofer and Kowarsch (2015). This short paper – based on a brief summary of the pragmatist ends-means-interdependency without discussing it – further develops the work presented here to the "pragmatic-enlightened model" of scientific expertise in policy by employing the metaphor of policy assessments as "scientific cartography" of the solution space (for this metaphor, see, e.g., also Kitcher 2001, Chap. 5). It adds procedural and other details to the refined pragmatic model and focuses on large-scale scientific assessments in general, while the present book rather is about integrated economic assessments and the treatment of value judgements therein more specifically.

[44] There are different understandings of the term "scenario." In this volume, "scenario" refers to a set of assumptions that form a "storyline" about a consistent future pathway (not only including policy options, but also trends and dynamics in the natural or social system), leading to a range of changes and practical consequences. This rather broad definition of a scenario, thus, comprises

native and viable future pathways should be (theoretically) viable and consistent. Moreover, in order not to be too biased, these policy scenarios ought to reflect several politically important, disputed normative-ethical viewpoints which may result in very different policy pathways. Also major scientific uncertainties and other aspects that are highly relevant to many stakeholders may underpin the scenario choice in assessment processes. While exploring the *full* policy solution space is infeasible, assessments should assess a broad range of alternative policy pathways.[45]

In complex and disputed cases, the idea of presenting alternative policy options seems acceptable for some other scholars as well who prefer the pragmatic model cluster (e.g., Doubleday and Wilsdon 2013), although this often lacks a consistent philosophical rationale in their work and although not many emphasise the need to also analyse the related practical implications. In the practice of assessment-making, alternative policy pathways – in the above sense of also including more specific policy instruments, etc., rather than mere abstract scenarios for societal changes or other outcomes – are hardly ever explored and presented yet.

Deliberative public debate

Additionally, as claimed by all variations of the pragmatic model cluster, public participation is required in policy-relevant scientific assessments. The epistemological justifications for a rational public discourse[46] presented above (Sect. 6.2.2) go beyond the widespread rationales that mostly focus on the salience and impact of the sciences in the policy arena, or on improved communication of results; in keeping with Dewey (1927), I regard a serious and open dialogue with the public as indispensable in scientific assessments for the more fundamental reasons. Dewey states, "to participate in the making of knowledge is the highest prerogative of man and the only warrant of his freedom."[47] This implies that the input by diverse stakeholders – here in the broadest possible sense of everyone who is somehow affected by climate policy – to scientific assessment processes should be quite substantive (see Sect. 6.2.2). This must not, however, undermine scientific rigor in terms of methodologies, quality of argumentation etc., and must not replace evidence by wishful thinking and political expedience.

The main role of stakeholders and the public is to clearly point out their stakes, interests, concerns and values so as to facilitate a more comprehensive scientific

both model inputs and outputs. The main purpose of a scenario should not be to prescribe a specific policy, but to learn about certain aspects of viable policy pathways. Due to the many uncertainties of the scenario assumptions (they are not "predictions"), scenarios are not suitable as *direct* policy proposals, anyway.

[45] This does not necessarily mean that policymakers will ultimately choose one of the policy options presented in an assessment, although such an option may, nonetheless, function as a useful benchmark in public policy debates.

[46] The envisaged public discourse should not be regarded as something separate from the work of academia or policymakers, but rather as a conceptual framing of the co-operation between academia, policymakers and the remainder of the public.

[47] Dewey, quoted in Brown (2009, p. 135).

analysis of both the problem at stake and potential solution options. It is imperative, however, that this role of the public is *integrated* into the scientific explorations of problems and policy options from the very beginning on (instead of prociding lists of abstract, fixed interests, etc.), and that the representatives of the public are provided with the opportunity to critically reflect on the problem analysis, the selection of alternative scenarios, and their scientific evaluation.

While the technocratic model suggests that the complexity and multitude of possible scenarios can only be handled by the sciences, in fact, a public discourse is required even more since there are so many uncertainties and controversial value judgements involved, which – due to their high political relevance – ought not to be left to scientists only. A deliberative discourse is required to narrow down the scope of the pathways and to co-operatively explore the implications of the selected pathways. "The definition of the alternatives is the supreme instrument of power" (Schattschneider 1960, p. 66), which requires the involvement of diverse decision-makers for the selection of alternatives in assessments. Scientific assessments without unambiguous policy recommendations can still help society form opinions on the policy options at stake. Inversely, new arguments or aspects brought forward in the public discourse can be used to improve assessments.

Although "the public" generally comprises every citizen, regarding science-policy interactions, it is to be formed depending on the functional requirements of the respective situation (Dewey 1927). Public discourse does not require the full participation of everyone in each case, since this would be inefficient and unpractical. For most cases, however, the Deweyan stance clearly implies that the group of relevant stakeholders in assessments includes also non-governmental stakeholders (again, in the broadest sense of the term). Moreover, the relevant stakeholders representing the public should be seriously involved at *all* stages of a scientific assessment process, including the problem analysis which entails disputable, often opaque social and ethical judgements.[48] Most scientific assessment processes usually do not invest much time in cooperative problem framing (see also Blum and Schubert 2009, p. 108). But the active participation of the people affected by a given problem is required here because it may be extremely difficult to achieve a common solution if there are unresolved controversies concerning the appropriate formulation of the problem already. Involving diverse stakeholders at all stages of an assessment process, however, does not mean that the scientific experts never work on their own. Rather, there should be an iteration between the work of the scientific experts and the broader public debate (see also Douglas 2009, p. 161; NRC 1996).

Particularly with regard to highly value-laden assessments of disputed policy issues, this participatory, deliberative approach offers an appealing middle ground between empty liberal proceduralism (science-policy pessimism, or "epistemic equality") on the one hand, and ethicised republicanism (technocracy, or "epistemic elitism") on the other in the policy realm.[49] Dewey's philosophy of science, episte-

[48] The value saturation of problem analysis (including risk definition) as well as the need for public participation therein are explained, e.g., by NRC (1996).

[49] This is argued inter alia by Putnam (1995), Brown (2009), and Kitcher (2011).

mology and political philosophy are closely and systematically interconnected (Posner 2004, p. 171; Brown 2009). His understanding of democracy as a public deliberation about the indirect consequences of human action (Sect. 2.1) is inter alia based on his theory of enquiry (and possibly also the other way round). Much more could be said about the realisation of public participation in a global assessment process such as the IPCC's; huge challenges have to be mitigated for a successful stakeholder engagement and public participation in large-scale scientific assessments (see, e.g., Rayner 2003; Maasen and Weingart 2005). Yet, this volume will not further discuss stakeholder engagement in assessments because it focuses on other aspects of assessment-making.[50] The body of literature on participatory research could already fill entire libraries.

How to ensure legitimacy?

In scientific assessments of policy pathways, legitimacy presupposes an appropriate treatment of the many disputed social and ethical value judgements involved. Ideology, illegitimate bias and authoritarianism at the science-policy interface are to be avoided. The previous section explained the envisaged division of labour between experts and diverse stakeholders in scientific assessments. According to the refined pragmatic model, the main task of experts is to scientifically explore different policy pathways and their implications, including important conditions and (normative or other) premises under which these policy options are viable and reasonable. Representatives of the public are involved at all stages and play a substantial role both in the problem definition including the identification of the ends-in-view and in selecting the major normative assumptions on which the alternative policy scenarios are based. At the end, ideally based on a broader public debate once the assessment report is available, policymakers make the policy decisions, rather than the experts. Consequently, although scientific researchers do not have privileged access to ethical wisdom, and although they should not decide themselves which of the most disputed value judgements to prefer in scientific assessments, they could contribute a lot to the discussions about disputed normative issues through the pragmatist method of enquiry; they can help understand the decisive practical implications of such normative assumptions in integrated, participatory scientific assessments. This may facilitate a valuable learning process about highly disputed issues (Sect. 12.1).

Building on Douglas' (2009) work, value judgements of all kinds should only play those roles in scientific assessments that are in line with the theory of enquiry sketched above (adequate ends-in-view, etc.); in particular, value judgements must never replace evidence, although evidence itself is value-laden. This also helps avoid "wishful thinking" in assessments. Rather than only making random value judgements and conflicts in assessments transparent, the refined pragmatic model gives disputed social and ethical assumptions a much more central role to play. Ideally, the policy scenarios explored in assessments essentially represent and

[50] I am planning to address the issues of public discourse in assessments in other publications (see also Sect. 12.4.3).

explore (inter alia) precisely such societally or politically highly relevant normative judgements in order to learn about them through their practical implications revealed in an assessment. The normative judgements which are more deeply explored are chosen based on a participatory deliberation process; they are typically highly disputed ones and central assumptions of a given policy pathway.

In line with what most other science-policy models are claiming, transparency regarding central normative assumptions and major uncertainties in scientific assessments is nonetheless decisive for achieving legitimacy. This is also a crucial precondition for the envisaged public participation in scientific assessments.

As several, partly opposing policy standpoints are taken into account and high transparency of disputed value judgements is claimed, the refined pragmatic model is not policy-prescriptive – despite its assumption that objective scientific judgements are possible in principle also with regard to disputed value-laden policy issues. Like other models, this refined pragmatic model can of course not avoid *any* misguided use of academic authority (Sect. 3.2); but, it promises to significantly reduce these risks. Due to the presentation of opposing viable policy options, politicians can no longer legitimate their interests through an alleged "inherent necessity" of a policy option based on a mistaken or mistakenly assumed scientific consensus, or uncertainties and disagreements in the sciences. The refined pragmatic model does not close down policy debates, but rather, opens them up. In contrast to the traditional science-policy models, the refined pragmatic model allows for a *rational*, legitimate and constructive discussion about disputed, highly value-laden issues, assuming that even normative-ethical assumptions, for instance climate policy objectives, can be scientifically scrutinised in a pragmatist enquiry. In light of this possibility of a legitimate exploration of disputed policy issues, it seems almost absurd for the sciences not to contribute their expertise to the public discussions about policy goals and objectives (as, e.g., claimed by the decisionist model) – a discussion that has so many impacts for so many lives.

Summary of the refined pragmatic model

Figure 6.1 summarises the refined pragmatic model.

With regard to policy evaluation, I argued that the pragmatic science-policy model should be refined by employing the Deweyan-Putnamian theory of enquiry which is based on the key assumption of an ends-means interdependency via the practical implications of the means. Value-laden policy research can become objective and sound through this methodology which presupposes highly interdisciplinary work and a thorough problem analysis that results in an adequate problem definition, including the ends-in-view. Another crucial implication is the serious involvement of stakeholders and the public at all stages of an enquiry in scientific assessments for the different reasons given above, including political legitimacy (as explained in Sect. 2.1). Legitimacy is furthermore ensured by exploring and presenting different policy pathways and their implications if these alternative scenarios represent disputed, highly relevant normative assumptions. Transparency of major disputed value judgements is another important precondition for a legitimate assessment process. The refined pragmatic model essentially aims at an iterative

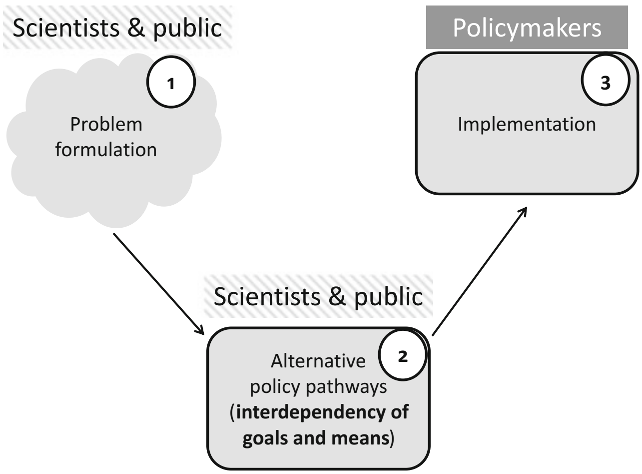

Fig. 6.1 The refined pragmatic model of scientific expertise in policy emphasises the ends-means interdependency; experts, jointly with stakeholders and the public, explore alternative policy pathways and their practical implications

learning process on policy objectives and means through the exploration of the practical implications of the policy means.

The refined pragmatic model can be regarded as a means for mitigating the related key challenge (Sect. 3.4). With it, we can translate the general norms of expertise in policy (Sect. 2.1) into slightly more specific guidelines for scientific assessments of complex and disputed policy issues.[51]

1. Sound, reliable and objective scientific knowledge – even on highly value-laden issues – can be achieved through the pragmatist pattern of enquiry including public participation. Researchers are now free to admit that there is no such thing as absolute, infallible truth and they may be more aware of the limitations and fallibility of their own knowledge production. The envisaged pluralism of scientific methods may also help better understand the uncertainty related to specific scientific claims.
2. A scientific assessment is highly policy-relevant if it (i) thoroughly analyses and defines a problematic policy situation or (ii) engages in the scientific exploration of policy pathways and their practical implications, based on the problem analysis that identified the ends-in-view. The degree to which these goals are achieved (or one of it) in assessments constitutes their level of policy-relevance.[52] With its focus on concrete policy pathways and their practical implications, building on

[51] Simultaneously, in terms of refined ends-in-view (compared with the major results of Part I), this also specifies the key challenge faced by scientific assessments as Part III will make clear (policy pathway assessment of the proposed kind may entail new challenges and require new methodologies, e.g. with regard to the integrated ethics in policy assessments).

[52] Compare the more formal and perceptual understanding of policy-relevance in Cash et al. (2003).

what diverse stakeholders regard as most important and disputed assumptions, the refined pragmatic model promises to lead to highly policy-relevant assessments.

3. Instead of through the value-free ideal, political legitimacy can be achieved by exploring *alternative* policy pathways and their (socially and politically relevant) implications, and by doing this jointly with stakeholders and the public as described above. This presupposes a high transparency of disputed value judgements.
4. Good communication can be promoted through the envisaged high transparency regarding major normative assumptions. Most importantly, however, the serious involvement of the public and different kinds of stakeholders could significantly improve communication between academia, the public and policymakers, compared with the traditional science-policy models. The pragmatic model brings together the rationalities of academia and policy – "theoretical explanation" versus "political measures/practical solutions" (Grundmann and Stehr 2011, p. 27).

Consequently, the refined pragmatic model is well in line with, and promotes, the ideals of Deweyan democracy (Sect. 2.1), which is essentially "the pooling of different ideas and approaches and the selection of the best through debate and discussion" (Posner 2004, p. 171).

6.4.2 Comparison with Similar Approaches

The idea of scientifically exploring the practical implications of policy options jointly with stakeholders and the public is similar to, but not identical with, some other approaches. Cost-benefit analysis, for instance, also emphasises the comparison of policy alternatives via their practical implications. However, at least as far as the classical variations of cost-benefit analysis are concerned, they only take a rather narrow range of consequences into account (quantitative, usually monetary ones), and the underlying ends-in-view ("utility") are considered to be fixed concepts. This is clearly different from pragmatism. A similar point can be made regarding "regulatory impact assessment." The literature and political documents on regulatory impact assessment argue for an exploration of alternative policy options and their costs and benefits, but they usually do not emphasise the ends-means interdependency, nor a comprehensive assessments of all kinds of relevant practical consequences.[53] Almost the same is true for the differences between the refined pragmatic model and the concept of evidence-based policy (which is interpreted quite differently).[54]

[53] Moreover, in political "practice," ends-in-view and means are often disconnected (or only rhetorically connected), since explicit policy goals are sometimes merely a symbolic resource for politics (Blum and Schubert 2009, pp. 114f; Beck 2009, p. 38).

[54] Cartwright and Hardie (2012) provide a very insightful and clear concept of evidence-based policy; Munro (2014) also presents some interesting critical points with regard to evidence-based policy.

In contrast to Pielke's honest broker (see Sect. 4.2.5), the above pragmatist proposal for the role of experts in policy does not subscribe to the idea of being a broker and does not aim to negotiate or bargain conflicting interests etc., but rather, to provide a map of the policy solution space in order to provide decision-makers with accurate knowledge about alternative transition paths and to facilitate an open public, democratic deliberation process.[55] Moreover, also Pielke (2007) largely ignores the ends-means interdependency and does not emphasise the need to explore all kinds of relevant practical consequences of the policy means. Another difference to Pielke's model (which also lacks any philosophical underpinning) is that he does not adequately consider potential feedback loops from stakeholders and the public to the scientific experts at later stages of scientific policy advice (he does not highlight the need for assessments in complex cases).

Finally, the refined pragmatic model certainly shares some elements with the NRC's (1996) analytic-deliberative process as a model for scientific expertise in public policy. In contrast to earlier guidelines by the NRC (e.g., 1983), it emphasises the need for public participation already at the stage of problem definition in risk assessments, and it combines several bases for objectivity (see above). According to Douglas (2009, Chap. 8), it has been very influential in getting scientists to move past the technocratic science-policy model and helped to overcome the boundary between risk assessment and risk management that often implied a strict demarcation between scientific research and public policy. One of the differences to the refined pragmatic model is that also the NRC proposal does not draw the full conclusions from the ends-means interdependency for assessment-making. Moreover, the refined pragmatic model suggests to turn away from risk assessment and rather focus on "policy pathway assessment," i.e., the integrated scientific assessment of alternative policy pathways and their practical implications in order to revalue policy ends-in-view in light of their positive and negative practical implications.

6.4.3 Concluding Part II: The Refined Pragmatic Model as Guidance

In terms of their practical implications, the present Part II evaluated different science-policy models which are supposed to be means for achieving the general norms for expertise in policy (Sect. 2.1). Some refinements of the core idea of the pragmatic model cluster were proposed, as implications of the Deweyan-Putnamian theory of enquiry. Figure 6.2 provides an overview of the traditional and pragmatic science-policy models discussed above.

[55] Exploring the political solution space may help overcome political conflicts by making the pros and cons and other implications of alternative options transparent. Yet, this is rather hypothetical and requires further research (see Chap. 12).

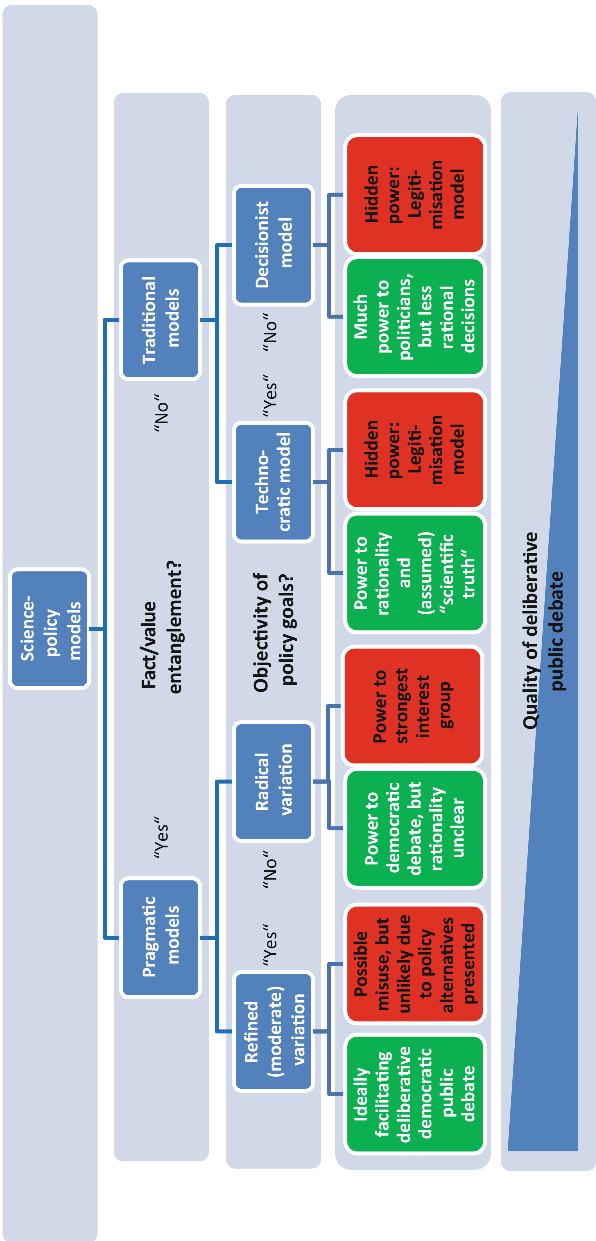

Fig. 6.2 Overview of science-policy models. This figure provides an overview of the major characteristics, strengths and weaknesses of the science-policy models discussed in Part II

The science-policy models inter alia differ in their responses to the questions about (1) the fact-value relationship and (2) the possibility of objectively evaluating policy goals (as ends-in-view). The dotted white boxes in the fourth row of Fig. 6.2 indicate the "best case" scenarios of the possible practical implications of a particular science-policy model, while the boxes in light grey in the same row indicate the respective "worst case" scenarios.

The technocratic model assumes that policy ends-in-view can be determined by experts objectively, while the decisionist model vehemently rejects this assumption. The fact/value conflation (Sect. 5.2) ruled out the traditional models based on their flawed epistemological assumptions, which easily lead to the misuse of scientific expertise in policy, e.g., in terms of the legitimisation model.[56] In contrast to the radical pragmatic model, as well as other variations of the pragmatic model, the refined pragmatic model provides a theory of objective, yet value-laden scientific expertise regarding both policy ends-in-view and means. This variation of the pragmatic model thus clarifies the objectivity issue, claims the ends-means interdependency and points out the necessity of exploring the practical implications of alternative future policy pathways. The refined pragmatic model particularly focuses on cases of highly disputed and very complex, large-scale policy assessments.

The last row in the figure about the respective quality of the deliberative public discourse might be misleading at first sight since the traditional models do not claim such a public discourse. Instead, they want to be isolated from the "dangerous realms" of policy and politics (Chap. 4). However, there is always some form of public discourse. The point is that rudimentary public debate in the case of the traditional models is low in quality, compared with the ideal public debate outlined in Sects. 6.2 and 6.4.1. Since the decisionist model rejects any possibility of a rational discussion of (value-laden) policy ends, there is no theoretical basis for a fruitful public debate.

The refined pragmatic model certainly does not resolve all the problems and trade-offs at the science-policy interface (Sect. 3.2). But it provides a proposal on how value judgements can play a legitimate role in scientific assessments of different policy pathways without undermining scientific objectivity (and without the need for consensus). The crucial point of this proposal is that one should evaluate and perhaps revise the policy ends-in-view in light of the practical implications of the policy means; value issues can be discussed through a comparative evaluation of their expected practical implications. From this feedback loop between ends and means follow all the other elements of the refined pragmatic model. One should not overestimate what the sciences can deliver – as does the technocratic model with its belief in infallible policy recommendations without any need for serious public participation. Underestimating the sciences, however, as does the decisionist model, is also mistaken; reasonable and reliable scientific evaluations of policy goals, means and their implications are possible – and highly policy-relevant.

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[56] In this figure, the legitimisation model only appears as a "worst case scenario" regarding the traditional science-policy models.

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Part III
A Critical Look at the IPCC's Economics

Chapter 7
Understanding and Evaluating the IAM-Based Economics

Abstract Deepening the problem analysis of the previous parts, Part III analyses both the Working Group (WG) III contribution to the Assessment Reports (ARs) of the Intergovernmental Panel on Climate Change (IPCC) (in Chap. 10) and the underlying economics of climate change (in this chapter, 8 and 9). This chapter will introduce: (1) the economics of climate change (Sect. 7.1), while pointing out the diversity of possible problem framings (and methods) in the economics of climate change; (2) the integrated assessment models (IAMs) as its main methodical tools in the IPCC WG III AR4 and AR5 (Sect. 7.2); and (3) three evaluation criteria for the critical reflection on the IAM-based literature (Sect. 7.3), including a framework for identifying normative assumptions in economics to make them more transparent. The evaluation criteria will mainly build on the refined pragmatic model of scientific expertise in policy from Chap. 6, as the tentative ends-in-view for Part III. (4) Finally, the policy-relevance of the IAM-based literature will be briefly discussed (Sect. 7.4). IAMs can contribute a lot to the important topic of the costs, risks and benefits of global mitigation goals.

With the better understanding of what roles scientific expertise in public policy should and should not play in general (Part II), we are prepared to specifically evaluate the integrated economic assessments by the IPCC. In the past, the literature reflecting on large-scale scientific assessments mainly focused on IPCC Working Group (WG) I, which represents the physical science basis of climate change. There are also a few reflections specifically about WG II, which focuses on vulnerability and adaptation (e.g., Beck 2011). Compared with the other WGs, the literature does not pay much attention to WG III, which concerns mitigation options (see Chap. 1). Since the IPCC WG I AR4 and AR5 stated, however, that there is rather high agreement among scientists about the assumption of anthropogenic and dangerous climate change, mitigation options and the economics of climate change became more important. The success of the Stern Review (Stern 2007) – in terms of its relatively high political impact (Sect. 3.1.3) – has further increased attention on the economic issues of climate change. The WG III was the focus of public attention when the IPCC AR5 was published (2013–2014); whether or not the 2 °C climate change mitigation goal is still achievable, and under which conditions, was one of the key

M. Kowarsch, *A Pragmatist Orientation for the Social Sciences in Climate Policy*, Boston Studies in the Philosophy and History of Science 323,
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topics.[1] Most interesting about WG III is that it is – more directly than the other WGs – about policy options; therefore, its work can be more delicate compared with the other WGs. Politically relevant ethical value judgements, but also uncertainty, play a much bigger role in WG III. It has to deal directly with political lines of conflict (see Sect. 10.3).

Separating the more general (Parts I and II) from the more specific (Part III) analysis of the problematic situation at stake regarding the IPCC's integrated economic assessments seems reasonable also given the tremendous complexity of this topic: Part III itself has to analyse and evaluate (which is unfortunately rarely done in the literature) both the WG III contribution to the IPCC ARs itself (in Chap. 10) *and* the economic literature underlying the IPCC assessment (in this chapter, 8 and 9) in terms of its potential, challenges and limitations. This will help to more precisely understand the specific challenges for WG III ARs, including the challenges for realising the ideas from Part II. For both of these analyses in Part III, the results of Part II are now "applied" as a tentative evaluation viewpoint (ends-in-view). The evaluation criteria will mainly build on the refined pragmatic model of scientific expertise in policy from Chap. 6. Furthermore, also the understanding of the traditional science-policy models is useful for the evaluation of the specific integrated economic assessments (see introduction to Chap. 4).

It is not difficult to imagine why a reflection on the economics underlying the WG III ARs is necessary to develop a guideline for the IPCC's assessments. One needs to understand whether, and to what extent, the economic literature can actually deliver what is needed in light of the refined pragmatic science-policy model, and assessment processes have to deal with these limitations. If, for instance, the studies based on the integrated assessment models (IAMs) contain opaque, politically relevant value bias, the authors of an IPCC AR should make this transparent; it would also be important to know whether these studies actually are relevant and reliable material for multi-scenario analyses as claimed by the refined pragmatic model (Chap. 6). As one aspect, Part III assumes that, metaphorically speaking, the performance of the cook (the IPCC) is dependent on the quality of the ingredients (the publications of the scientific community); "good" economics is a necessary, yet insufficient, precondition for "good" economic policy assessment.[2]

The analysis of the economics underlying the WG III ARs is structured as follows: this chapter provides necessary general background information on the economics of climate change (i.e., climate economics), and presents three evaluation criteria in light of Chap. 6: relevance for the exploration of policy pathways, transparency and diversity of value judgements, and scientific and epistemic quality. So

[1] See also Nature (2013), arguing that "attention will turn to the second and third groups, which focus on impacts and mitigation." A rough media analysis undertaken by the WG III AR5 Technical Support Unit revealed a relatively high coverage of WG III issues in the mass media this time (source: personal conversation with WG III Technical Support Unit).

[2] The evaluation of IAM economics undertaken herein will, however, not only be preparatory work for the evaluation (Chap. 10) and improvement (Chap. 11) of IPCC assessments, but also for the evaluation and improvement of the work of the IAM-community itself for which the IPCC could at least provide some incentives (see Sect. 11.5).

many aspects of the economics of climate change could be analysed, but I have to limit myself to these few central, philosophically interesting aspects. While policy-relevance is briefly evaluated at the end of this chapter, the treatment of value judgements in economics (in Chap. 8), and the scientific and epistemic quality (in Chap. 9) are discussed more extensively. These are the two topics which the literature typically focuses on when discussing the science-policy interface.

More precisely, to prepare the ground for this criteria-guided analysis of climate economics, this chapter will introduce: (1) major issues of the economics of climate change in general (Sect. 7.1), while highlighting the diversity of problem framings and approaches in the economics of climate change; (2) IAMs as the main methodical tools for climate economics in the IPCC WG III ARs (Sect. 7.2); and (3) the three evaluation criteria for the critical reflection on the IAM-based literature (Sect. 7.3), including inter alia a new framework for identifying normative assumptions in economics. (4) Finally, the policy-relevance of the IAM-based literature will be briefly discussed in Sect. 7.4.

7.1 The Economics of Climate Change: Topics and Debates

The economics of climate change is an extensive, but relatively new sub-discipline of economics that emerged around the 1980s. Not only is the philosophical reflection on integrated economic assessments for climate policy a highly interdisciplinary (and, ideally, transdisciplinary) work, but so is the economics of climate change itself, which comprises, beside "classical" economic issues, technology, energy policy, social aspects, demography, etc.

7.1.1 What Is Economics About in General?

To begin, it seems helpful to clarify the main research goals, scope and methods of economics in general.[3] In philosophy, there is no consensus on what the discipline is precisely about; this has been disputed since the very beginning of philosophy. Quite interestingly, there is a similar problem in economics, although the controversies are not as obvious as in philosophy. Many famous economic scholars have begun their economic studies by determining the task of economics and the limits of its subject (Giersch 1993, p. 16).

For example, Adam Smith's the "Wealth of Nations" (Smith 2008) is often regarded as the starting point of economics, which is typically called "Political Economy" in the context of the classical economists. Smith's focus was on the policy goal of safeguarding and augmenting material wealth with the help of market

[3] The most successful introductory textbook on economics was written by Samuelson and Nordhaus (e.g., the 19th edition Samuelson and Nordhaus 2010).

mechanisms. Later, Ricardo and Mill – together with Smith, they are among the most important classical economists – kept to this, in principle (Giersch 1993, p. 17). The neo-classical economists Marshall and Pigou agreed with Smith in that regard, to some extent. An important amendment was the concept of marginal utility. It highlights gains or losses from consuming an additional unit of particular goods or services, rather than focusing on the aggregated utility of consumption.[4]

A substantially new determination of economics in general was inter alia brought forward by Robbins (1945; see also Giersch 1993, pp. 17f, and Sect. 8.1 below). Robbins contributed to the development of neoclassical economics; he argued that the discipline of economics should focus on ends-means rationality as such, rather than on substantive subject matter. Moreover, he argued that economics should only focus on ordinal utility rather than cardinal utility. Ordinal utility means that one can only *rank* different preferences (relative to each other) on an ordinal scale, rather than measuring their absolute utility as claimed by the concept of cardinal utility (Sect. 8.1 will provide more details).

This led to the distinction between the "material-welfare school" and the "ordinal-welfare school" (Giersch 1993, p. 27). The material-welfare school focuses on economic goods and certain "objective" basic needs, as well as wealth (always quantifiable in monetary terms) and positive-empirical research (because wealth, goods, etc. can be measured and explored empirically, as this school assumes). In contrast to the physical-level school, the material-welfare school prefers a broader concept of goods, integrating, among other things, marginal and subjective utility. According to the ordinal-welfare school, however, economics does not merely deal with economic goods, but with decision problems in general. The scarcity[5] of means for a set of given ends is decisive here (Robbins 1945, Rodriguez-Sickert 2009, p. 224).[6] In this view, economics is "end-neutral."

In addition to these two major economic schools, there were also other influential definitions of economics. They include, but are not limited to (Dutt and Wilber 2010, p. 6): (1) Marshall's (1842–1924) activity-related definition of economics as a study of business, which could be understood as "consuming, producing, working, buying and selling, saving, investing […], and holding assets such as financial assets" (Dutt and Wilber 2010, p. 6); (2) Samuelson's (1915–2009) system-related definition (Dutt and Wilber 2010, p. 6) according to which economics examines the economic system through three decisive questions: What shall be produced, how and for whom? (Samuelson and Nordhaus 2010, pp. 7f); and (3) another definition by Samuelson and Nordhaus, stating "the study of how societies use scarce resources

[4] This led to a split into physical-level approaches (focus on "objective" human labour) and subjective-level (focus on "subjective" marginal utility) approaches (Giersch 1993, p. 17).

[5] Scarcity can be understood as "the finiteness of the space of consequences; that is to say, the actions homo economicus can choose do not exhaust all conceivable experiences in the world" (Rodriguez-Sickert 2009, p. 224).

[6] See also Caldwell (1994, Chap. 6). Robbins (1945, p. 16) defines economics as follows: "Economics is the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses." This was very influential for economics (Dutt and Wilber 2010, p. 235). It slightly reminds one about the decisionist science-policy model.

to produce valuable goods and services and distribute them among different individuals" (Samuelson and Nordhaus 2010, p. 4). The latter definition sounds like a compromise between the activity-related and system-related definitions of economics, while drawing on Robbins' definition mentioned above. It is, however, an improvement on Robbins' narrower definition, which neglected distributional and other issues (see also Dutt and Wilber 2010, p. 235). There is thus a variety of definitions that determine what economics is about. The definition offered by Robbins and the ordinal-welfare school, as well as its modification by Samuelson and Nordhaus, currently seems to be the most widely accepted one.

As the thoughts on the definition of economics already imply, there is a clear mainstream in economics that defines the state-of-the-art: "Most economists and introductory texts follow what is called the neoclassical approach"[7] (Dutt and Wilber 2010, p. 5; see also Blaug 1992, p. 138) which I already mentioned and which was mainly developed by Walras (Brodbeck 2011, p. 45), Robbins and others. The main methodical instruments of mainstream economics are the mathematical-formal descriptions often used within an economic model framework.

7.1.2 Different Problem Framings in Climate Economics

Climate change policy is largely an economic issue (Sect. 2.2). The economic problems of climate change (impacts, adaptation and mitigation) can be framed quite differently, however; one can emphasise different aspects of this complex issue. For instance, a traditional problem framing is to regard climate change as an externality – i.e., as a negative consequence of economic activity affecting inter alia those who were not directly involved in these economic transactions. The standard instruments of environmental economics (such as the "Pigovian tax") can come to bear here (Endres 2011).

In contrast, the introduction to the climate change problem and its crucial economic aspects (Sect. 2.2) provided a different, far more complex understanding of what the economics of climate change (particularly mitigation) is about. It regards climate economics as dealing with the scarce and common resource of the atmosphere as a dumpsite for greenhouse gases, especially CO_2, which can imply redistribution or even some kind of dispossession of the owners of fossil resources (Edenhofer et al. 2013). In this sense, this standpoint frames climate policy as a complex global common-goods problem[8] instead of a "(global) public good" problem (Kaul et al. 1999), which latter focuses on financing of the goods. As argued in Sect. 2.2, this conceptual construction of a new, scarce resource (the atmosphere as a dumpsite) does not necessarily lead to an unsolvable zero-sum game (given the

[7] The core ideas of neoclassical economics are explained in most introductory textbooks to (history of) economics. See also Sect. 8.1.2 below.

[8] As do Nordhaus and Boyer (2000, p. 3), for instance.

distributional conflicts over the scare resource), nor to a costly reduction of the use of fossil fuels in international climate policy, since there is the possibility of transforming the world's energy system ('decarbonisation').

While I find this "commons" problem framing of climate economics most convincing, different economic framings of the problem in this context could theoretically be based on one or more of the following aspects: (1) (global, regional or national) costs, the (co-)benefits or risks of adaptation and climate impacts (economic vulnerability, etc.) or mitigation, the economics of risk, uncertainty and possible catastrophic events; (2) the alleged scarcity of fossil resources ("peak oil" etc.)[9] and the need to implement new energy technologies that are almost independent from environmental aspects; (3) bottom-up, individual consumption-related[10] or local/regional approaches instead of binding, global, long-term mitigation targets; (4) a behavioural approach via public choice theory (e.g., game theory) and the dynamics of political negotiations and related rationalities, or making use of alternative approaches such as Actor-Network Theory (Sect. 3.1.1); (5) integration into the debate about "sustainable development (goals)," or issue linkage in general, e.g. climate change and development (Edenhofer et al. 2012), or alleged trade-offs between such policy fields (Lomborg 2007); and (6) the economic implications of policy instruments.

This list is not comprehensive, nor are the aspects listed here to be categorised on the same level, systematically. Yet, this list points out the diversity of possibilities to emphasise different aspects in the economics of climate change. Virtually all of these aspects have some importance. The need for a reflection on problem framing regarding the economics of climate change becomes evident, because these different problem framings could have a substantial impact on policy proposals based on the respective economic research.[11] Indeed, climate economics raises new questions beyond standard economics, requires new economic methods and models, and increasingly goes beyond neoclassical frameworks.[12]

[9] But, ambitious climate change mitigation cannot wait until the combustion of fossil resources stops because so much fossil fuels are still in the ground (IPCC 2014). Although there are still uncertainties, there are already – in principle – sufficient technological possibilities for a drastic reduction of GHG emissions and for creating energy security (IPCC 2007, 2014).

[10] This view has been held by, e.g., large parts of the American public in recent years (Pooley 2010, pp. x and 6).

[11] A good example of the possible impact of a particular problem framing is the Stern Review (Stern 2007). Stern argued that in the case of unabated emissions of GHGs in the twenty-first century, climate change impacts will cause considerable economic costs that exceed the global costs of ambitious climate change mitigation by a factor of roughly ten. This problem framing had a significant political impact (see Sect. 3.1.3 and Edenhofer 2006); it pointed out that there is no simple trade-off between economic development and climate change mitigation (as also argued, e.g., in Edenhofer et al. 2012). Moreover, Stern's report made clear that climate policy is largely a moral problem, particularly in terms of intergenerational justice.

[12] See, e.g., Siegmeier et al. (2015). Detailed introductions to the economics of climate change mitigation can be found in Nordhaus (2008; 2013a), Stern (2007; 2008), Edenhofer et al. (2012; 2013), Touffut (2009), and Heal (2009), for instance.

7.2 Role of IAM-Based Studies in IPCC Assessments

IAMs are the central scientific tool for economists dealing with climate policy. There are also other types of formal models used in the economics of climate change, as well as more empirical methods and also qualitative methods. As IAMs played such an important role in IPCC assessments, however, I will focus on them and their contribution to the debates about climate change mitigation. Nonetheless, the more specific proposals for future WG III ARs discussed in Chap. 11 will point out the need for a greater diversity of economic-interdisciplinary methods and for some improvements of IAMs and IAM-based studies.

This section will briefly explain the roles of IAMs in the IPCC WG III AR4 and AR5, and will provide some examples of IAMs. IAMs were key for the IPCC WG III AR4 (Hope 2005, pp. 94ff), and the AR5 drew even more on IAM-based literature, as many new IAM-based results had been produced after the AR4.

> As the debate over climate policy shifts from scientific uncertainty to economic feasibility, the results of IAMs grow in importance. Interpreting IAMs properly is critical for scientists and others who support a proactive response to the climate problem (Ackerman et al. 2009, p. 298).

7.2.1 What Are IAMs? In What Sense Do They Integrate?

What are IAMs and what is their central purpose? IAMs can be broadly defined as "any model which combines scientific and socio-economic aspects of climate change primarily for the purpose of assessing policy options for climate change control" (Kelly and Kolstad 1998, p. 3).[13]

As the name implies, *integrated* assessments (IAs) of long-range, long-term environmental issues, such as the IPCC ARs, integrate different disciplines and approaches. The problems to be assessed not only affect one, but several (natural and social) domains. Perfect "integration" within an IA means that the different disciplines are combined within a single, consistent framework (but not necessarily the same metric, at least in qualitative IA). Integrated *assessment* is not only an interdisciplinary, integrated approach, but is ideally "trans-disciplinary," i.e. IAs usually provide relevant information to policy and decision-makers based on a dialogue with them. IAs are needed for analysing policy paths, as a bridge between the sciences and decision-makers (Füssel and Mastrandrea 2009; Beck 2009, p. 118). In addition to evaluations or optimisations of policy pathways, IAs can also provide information about important uncertainties, linkages, feedback and critical points in broad systems (Parson and Fisher-Vanden 1997).

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[13] A more recent, great introduction to climate-related IAMs and their history is provided by Nordhaus (2013b). See also Weyant (2009) as well as Füssel and Mastrandrea (2009) for the historical and future development of IAMs.

An IA can be conducted using a variety of instruments, such as expert panels, literature synthesis, new research, and so on. In the context of global climate change, formal, numerical computer models – i.e., IAMs – are the main instrument. Within those IAMs, several sub-system models are combined to take into account their respective feedbacks.[14] The WG III SAR (IPCC 1996, pp. 374f; see also Kelly and Kolstad 1998, p. 3) describes three purposes for IAMs and IAs in general: (1) IAMs help assess different climate policies; (2) they can help force the multiple dimensions of climate change and climate policy into one single framework; and (3) they enable issue linkages by comparing the climate problem with other policy issues. In the last two or three decades, IAMs have become a standard approach for environmental and economic problems:

> IAMs were used extensively to examine energy policy in the 1970s and the acid-rain issue in the 1980s. IAMs of climate change first emerged in the late 1970s, and have multiplied dramatically since the early 1990s under the twin stimuli of the […] IPCC, which first reported in 1990, and the Framework Convention on Climate Change (FCCC) signed at Rio in 1992 (Hope 2005, p. 77).

IAMs are so important for the economics of climate change because they can address long-term issues (particularly social costs and benefits of alternative climate policy options) within an integrated framework.

7.2.2 Diversity of IAMs in the IPCC Assessments

In the 1990s, the climate change related IA community split into two groups. One group attempted to improve modelling of regional climate impacts and other disaggregated issues,[15] while the other focused on more simple and much more aggregated climate-economy models on a global level.

The IAMs[16] discussed in the following chapters solely belong to the second group. Frequently, relatively simple climate models are combined (integrated) with an energy system model and a macroeconomic model as simple representations of the subsystems relevant to the policy context. The IAMs discussed in this volume are global, regionalised energy-environment-economy models that are usually multi-equation computer models. According to Beck (2009, pp. 80), these IAMs build on the tradition of energy and emissions models for future predictions developed by the International Institute for Applied Systems Analysis (IIASA) in the 1970s. Moreover, Beck argues that such IAMs can also be understood as an attempt to compensate policymakers for their disappointment with the overly complicated and hardly policy-relevant climate models developed by other scientific communities. These IAMs, in contrast, attempt to translate "science" into "policy." Their

[14] See also Shackley and Wynne (1995); IPCC (2007, Chap. 3); Füssel and Mastrandrea (2009).

[15] E.g. the scientific community dealing with impacts, adaptation and vulnerability.

[16] It would be more precise, but too laborious, to talk about IAM families herein.

central, although not only, purpose is to answer the question of how the world economy or regional economies are affected (mainly in terms of social costs and benefits) by alternative, future climate policy paths, under various opportunities and constraints (Edenhofer et al. 2006b, p. 61). The IA models within the second group just mentioned, however, also differ greatly from each other, "reflecting the diversity of information needs of climate policymakers and of scientific approaches to the problem" (Füssel and Mastrandrea 2009).

> Different modeling frameworks were created for different problems, with each model design tailored to address a specific set of questions. The characteristics of the modeling framework as well as the primary questions that guided its designs must be kept in mind when comparing the model results (Edenhofer et al. 2006b, p. 67).[17]

Edenhofer et al. (2006b, p. 61) distinguish between four kinds of IAMs (although, the authors point out the limited applicability of these categories regarding the great variety of IAMs): (1) optimal growth models that maximise social welfare intertemporally; (2) energy system models that minimise costs in the energy sector; (3) simulation models that solve initial value or boundary condition problems, including econometric models; and (4) general equilibrium market models that balance demand and supply among multiple actors.

One can further distinguish between the following *dimensions* of IAMs: (1) top-down and bottom-up IAMs (Edenhofer et al. 2006b, p. 62); (2) policy evaluation versus policy optimisation[18] versus policy guidance models (usually in the form of a guardrail analysis) (Füssel and Mastrandrea 2009); and (3) deterministic versus probabilistic versus adaptive IAMs (Füssel and Mastrandrea 2009). Furthermore, IAMs can be "partial" or "full-scale" (Hope 2005, p. 83). Some IAM teams conduct cost-benefit analyses (CBA, e.g. DICE/RICE, see below), the traditional economic instrument for policy evaluation, while most current ones conduct cost-effectiveness analysis (e.g., ReMIND). In contrast to CBA, cost-effectiveness analysis explores the best way to achieve a given policy target in economic terms (i.e., cost-efficiency, welfare maximisation, maximisation of consumption, etc.).

According to Schneider (1997 p. 232), there are several generations of IAMs. For instance, much progress has been achieved since the publication of the AR4 in 2007 regarding uncertainty analyses, consideration of large-scale climate instabilities, multi-gas assessments (not only CO_2), endogenous (instead of exogenous)

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[17] A helpful systematic overview of different types of models can be found in Edenhofer et al. (2006b) who take into account only those models that "incorporate technological change in innovative ways and allow an assessment of costs of global carbon dioxide mitigation." This limitation, however, is not a severe restriction; both of the aspects are crucial for answering crucial questions of climate policy. It should always be kept in mind that there are many other kinds of IAMs not discussed in the present volume. Further publications providing an IAM overview include, e.g., IPCC (1996, Chap. 10); IPCC (2007, Sect. 3.6.2 and Chap. 11); Hope (2005); Kelly and Kolstad (1998); Parson and Fisher-Vanden (1997); and Füssel and Mastrandrea (2009).

[18] These models can be cost-benefit models or target-based models on the one hand, or uncertainty-based models on the other hand, according to Hope (2005, p. 82).

technological change,[19] consideration of future learning, application of game theory, second-best worlds, modular IAMs and so on (Füssel and Mastrandrea 2009).

The IAMs have been substantially developed since the IPCC AR4. They cover more aspects now, their results are partially more robust than before and their structure has become even more complicated in recent years. A major role for the development of IAMs play the many pertinent model inter-comparison projects, particularly by the Stanford Energy Modeling Forum.[20]

As examples of the economics of climate change underlying the WG III ARs, three IAMs (or more precisely: their basic economic structure) are selected here: (1) PAGE2002 (underlying the Stern Review), (2) DICE/RICE (one of the most important IAMs for previous IPCC WG III ARs, including the AR4) and (3) (Re)MIND (as a decisive IAM in the WG III AR5).

IAM-based studies played an important role in Chaps. 3 and 11 of the WG III AR4, as inter alia the reference lists in these two chapters reveal. In the AR4 (as well as for climate economics in general around 2007), two of the most influential IAM-based studies were the already mentioned Stern Review[21] as well as the model comparison presented in Edenhofer et al. (2006b).[22] Both publications supported the view that even ambitious mitigation targets could be achieved at relatively low costs (compared with business as usual). The IAM underlying the Stern Review is "PAGE2002." PAGE2002

> is a stochastic IAM of climate change that uses a number of simplified formulas to replicate the complex environmental and economic interactions as presented in the literature. Furthermore, the coefficients and data ranges used often come directly from the Third [IPCC AR] (Alberth and Hope 2006, p. 13).[23]

Among the IAMs analysed in Edenhofer et al. (2006b) is MIND, which also played a crucial role in Chaps. 3 and 11 of the WG III AR4. Since this IAM (or more precisely, its updated version called ReMIND) also underlies some model comparison projects (including Edenhofer et al. 2010) that played a central role in the IPCC WG III AR5 (IPCC 2014, see particularly Chap. 6), this IAM is chosen as another example of the economics of climate change. MIND

> is an intertemporal optimization model with a macroeconomic sector and four different energy sectors: resource extraction, fossil-fuel based energy generation, a renewable energy source, and carbon-capturing and sequestration (CCS). The growth engine in the macroeconomic sector is fueled by R&D investments in labor productivity and energy efficiency. There is no autonomous total factor productivity improvement. The investments in the

[19] See Edenhofer et al. (2006b), also for an explanation of "endogenous" versus "induced" technological change.

[20] See http://emf.stanford.edu/, accessed 30 Mar 2015.

[21] Stern (2007). Citations in IPCC (2007): Chap. 3 (pp. 206, 226, 232, 233) and Chap. 11 (pp. 649, 651, 657, 659).

[22] Citations in IPCC (2007): Chap. 3 (pp. 197, 201, 205, 223, 224, 238) and Chap. 11 (pp. 636, 648, 651, 653, 654, 656–659, 661).

[23] PAGE2002 is explained in detail by Hope (2006) and partly by the Stern Review (2007).

> different energy sectors are determined according to an intertemporal optimal investment time path. MIND derives a first-best social optimum (Edenhofer et al. 2006b, p. 65).[24]

Finally, among the oldest and highly influential IAMs are DICE and its regionalised variant, RICE (Nordhaus and Boyer 2000; Nordhaus 2008) as well as another variant, ENTICE, which includes endogenous technological change (Popp 2004). They are taken into account, for instance, in Chap. 3 (p. 205) and 11 (pp. 649, 654, 655) of the WG III AR4. In contrast to studies based on PAGE and MIND, DICE/RICE-based studies often suggested more moderate mitigation activities (Nordhaus and Boyer 2000; Ackerman et al. 2009, p. 299). This, however, changed more recently (e.g. Nordhaus 2013a). The relatively high simplicity and transparency are specific characteristics of the DICE/RICE model. In DICE/RICE, as a policy-optimisation model,

> policies are chosen to maximize a social welfare function that is the discounted sum of the population-weighted utility of per capita consumption (Nordhaus 2008, p. 39).

Because of their importance for the IPCC, the following sections will focus on these three IAMs: PAGE2002, (Re-)MIND and DICE/RICE. These models were chosen as specific examples because a comprehensive analysis of IAMs relevant to the IPCC, let alone all of their interesting aspects concerning the science-policy interface, would be impossible here.

7.3 How to Evaluate IAM-Based Literature on Mitigation Options

For critically evaluating selected aspects of the IAM-based economics of climate change – as the core material on which the IPCC WG III assessments are based –, specific evaluation criteria for the economics underlying the IPCC assessments are required. Given the purposes of this volume, it is sufficient to focus on some basic economic assumptions of the selected IAMs (rather than discussing these particular, complex IAMs comprehensively).[25] As the IAM-studies considered herein are highly interdisciplinary in nature, technological, social and other kinds of assumptions will also play a role in their evaluation.

[24] MIND is described in detail by Edenhofer et al. (2005) and 2006a, and has since been developed into ReMIND-R and other variants (Leimbach et al. 2010).

[25] A further, already mentioned limitation of Part III is that the economic models and scenarios as well as the IPCC assessment sections analysed herein have mainly to do with issues related to long-term global climate change mitigation. Moreover, understanding the reasons why IAM-based literature in some cases does not fulfil these selected evaluation criteria is yet another question. Although it will be addressed to some extent in the following chapters and in Sect. 11.5, it is not the key focus of the present volume.

7.3.1 Main Aspects of the IAM Evaluation

So, what do we want from climate economics? The evaluative viewpoint developed in Part II, particularly the refined pragmatic model, helps us identify the crucial aspects to be evaluated regarding IAM-based economics. This presupposes that the statements in Part II on scientific knowledge production in general (on value judgements implied, objectivity, the pragmatist pattern of enquiry, etc.) are also valid for policy-related economic research in particular.

In light of the philosophical discussions, Sect. 6.4.1 translated the general norms for expertise in policy (Sect. 2.1) into more specific, refined ends-in-view for the integrated economic assessments by the IPCC. Based on that, one can easily derive a first interesting evaluative aspect. Can IAMs actually deliver *policy-relevant* knowledge, in the sense of (i) directly discussing (aspects of) problem definitions regarding climate policy, or (ii) analysing sets of climate policy objectives, policy means and particularly their practical implications? Do IAMs help us better understand possible future climate policy pathways and their various ramifications? The extent to which IAMs can contribute to this will be evaluated in Sect. 7.4. While one cannot reasonably expect from individual IAM-based economic publications that they cover a huge number of aspects of particular climate policy problem definitions, pathways and their practical implications, they could at least *directly contribute* to their more comprehensive exploration in large-scale assessments that necessarily build on these individual economic publications.

Moreover, what do IAM-based studies have to deliver to support the political legitimacy of assessments that have to rely on these publications? Building on the claim to primarily explore the implications of policy pathways, the second candidate for evaluation is the degree to which the IAM-based literature incorporates, and explores the practical implications of, *different, alternative* and disputed ethical viewpoints (including different policy objectives). In this context, transparency regarding the disputed ethical viewpoints and judgements is a crucial requirement for all kinds of scientific assessments, as argued in Sect. 6.4.1. Thus, the individual economic studies *underlying* an assessment should also make disputed ethical judgements transparent as far as possible. The burden of identifying the value judgements themselves in the underlying studies would otherwise be too high for assessment authors. Furthermore, although one cannot reasonably expect that individual economic studies explore a wide range of alternative ethical value judgements and their implications, there should be some diversity (i.e., a lack of a strong ethical bias) in this regard in the body of IAM-based economic literature *as a whole*. To examine these things, Chap. 8 will identify several, often highly disputed ethical value judgements (i.e., ethically relevant, normative assumptions) in the IAM-based economics of climate change (particularly regarding welfare economics), and analyse whether they are made transparent and are balanced overall. This will be based on the framework developed in the subsequent Sect. 7.3.2.

Finally, the third evaluative aspect is about the scientific and epistemic quality of IAM-based results, addressed in Chap. 9. High scientific and epistemic quality of the underlying scientific material is a key precondition for a credible, reliable scientific assessment. This is related to, but not exclusively about, the treatment of uncertainty in scientific publications. Can value-laden IAM-based economic studies provide reliable, sound, objective (or at least relatively plausible) hypotheses in light of the philosophical findings from Part II? The "sound science versus junk science" war (Douglas 2009, Chap. 1) perfectly illustrates the relevance of this question. IAM-based economic studies are certainly in danger of being regarded as junk science, i.e. making spurious or fraudulent policy recommendations driven, for instance, by ideological motives rather than by evidence. This issue also has a lot to do with the treatment of value judgements in economics. In general, as pointed out by Douglas (2014), policy-relevant research by the social sciences is criticised for not being objective more often than natural scientific analyses, also because the research objects of the social sciences – highly complex social systems and human behaviour – make it much harder to come to reliable predictions.

The issues of value judgements in economics (Chap. 8) and the treatment of uncertainty (Chap. 9) are the most discussed issues in the literature critically examining economic policy advice.[26] According to Schneider, it is important to

> present many examples of the dangers that analytic methods with limited capabilities bring to the public debate given that not all potential users of IAM results will be aware of hidden values or assumptions that are inherent in all such tools – now and for the foreseeable future (Schneider 1997, p. 230).

Although value judgements and uncertainty at the science-policy interface are widely discussed, it should become clear below that the more specific evaluation criteria used here are rather special. They are heavily based on the refined pragmatic model from Chap. 6. Moreover, in this volume, I do not primarily intend to contribute to a criticism of climate economics.[27] The main underlying aim of the analyses in Part III is, rather, to contribute to a better understanding and awareness of the critical aspects of climate economics from a science-policy perspective, in order to improve economic policy assessments and to make more efficient use of economics in climate policy-making processes.

7.3.2 A Framework for Identifying Value Judgements in Economics

In order to prepare the ground for the analysis of the treatment of ethical aspects in IAM-based economics (Chap. 8), this special section needs to develop a framework for identifying relevant and disputable ethical value judgements in economics,

[26] See Betz (2006); Dutt and Wilber (2010); Hausman and McPherson (2006); and the extensive debate after the Stern Review explained below.

[27] According to Beckerman (2011, p. 3), many philosophers in the past mainly criticised economic assumptions, rather than constructively contributing to economic theory.

based on the insights from Sects. 5.2 and 5.3, and from Chap. 6 on pragmatism. Developing such a novel framework here is necessary because, in contrast to the issues of policy-relevance (Sect. 7.4) and uncertainty (Chap. 9), there is no well-established framework in the literature (at least no one in line with Deweyan-Putnamian pragmatism). Rather, the definition and identification of value judgements are disputed non-trivial issues, as Chap. 5 demonstrated.

Although there is no "universal agreement among philosophers about the precise definition of terms such as 'value judgement'" (Beckerman 2011, p. 17), Chap. 1 (footnote 2) explained the term 'ethical value judgement' – or 'normative-ethical assumption' –, with some specifications added in Chap. 5. In the following sections, I am primarily referring to normative assumptions about how to shape our socio-economic institutions and interactions, which have much to do with philosophical justice,[28] and which are the most disputed ones in political debates.

Elaborating on this explanation, the term 'value' is old and was primarily used in mathematics and economics before it became an important concept used in philosophy in the nineteenth century (Krijnen 2011). A value judgement in the sciences provides some kind of normative orientation (meaning, direction, etc.) for human action, thinking or attitude towards something.[29] This does not mean that value judgements are always prescriptive *in a narrow sense*, i.e., in the sense of a strict imperative towards someone (Putnam 2004, Chap. 4, discussing Amartya Sen's view). However, they are always at least normative in a weak sense, i.e., in the sense of providing the aforementioned kind of orientation. Policy ends-in-view (i.e., goals, objectives) are always and necessarily normative and value-laden (or interest-laden, if one wants to distinguish values and interests) from an ethical perspective, because they imply that the attainment of the suggested policy goal is a desirable thing. For instance, the 2 °C goal implies that one should act in a way that leads to the attainment of the 2 °C goal.

There are at least two main aspects that together provide the reason why such ethical judgements in scientific policy advice are particularly feared.[30] *First*, ethical judgements are often regarded as purely subjective (see Sect. 5.2), endangering the objectivity of scientific findings. *Second*, ethical assumptions implied in political decisions can have a considerable impact on millions of lives; also the normative assumptions implied in scientific scenarios that explore policy options can indirectly have such an impact. Ethical values (such as liberty, basic needs fulfilment, etc., or, in general, principles that provide guidance for private life or policy-making)

[28] To avoid a misunderstanding sometimes occurring in economic texts, ethically reflecting on actions does not mean to simply introduce an additional and competitive aspect beside economic or other reasons when assessing a situation, but rather, it means to weigh all of the economic, socio-cultural, environmental and further aspects.

[29] See Krijnen (2011). In contrast, Weber's influential definition focuses on satisfaction: "By 'VALUE JUDGMENTS' are to be understood […] practical evaluations of the unsatisfactory or satisfactory character of phenomena subject to our influence" (Weber 1949, p. 1).

[30] See also the German "Werturteilsstreit," i.e., the controversies about values in sociology and other social sciences in the twentieth century, in order to better understand the importance and complexity of this issue.

are about the most essential things in our lives. Therefore, when value judgements occur, there is usually a heated controversy and a great deal of caution – because it is usually about something relevant. In this regard, it can be said that policymakers and many other stakeholders do not trust scientific results if the underlying normative-ethical assumptions are undesirable to them.

As a result, many mistakenly argue that normative assumptions should be a taboo in economics (see Sect. 5.2 and Fullbrook 2009, p. 124). While Dewey – and I agree with him – thinks that it is right not to use "moral condemnation or approbation," this is unfortunately "often converted into the notion that all evaluations should be excluded" (Dewey 1986, p. 489). In Chap. 5, I argued that it is impossible to avoid normative-ethical assumptions in scientific knowledge production, but that scientific statements can still become objective under some conditions. Ethical assumptions could also be used proactively in integrated assessments in a very constructive, highly policy-relevant and legitimate way by exploring alternative policy pathways inter alia building on different, disputed ethical assumptions. The deliberate and transparent inclusion of selected ethical judgements can be regarded as part of the mission and task of scientific assessments, according to the refined pragmatic model. Exploring the practical implications of alternative, disputed normative assumptions is a vital element of *policy-relevant* scientific assessments.

Different types of ethical value judgements in IAM-based studies

Value judgements can occur in a very general (e.g., general principles of distributive justice) or in a rather specific sense (e.g., the specific evaluation of a particular policy outcome). Ethical assumptions in economic models and scenarios occur in all phases of scientific knowledge production (see Sect. 5.2) and on several levels of the economic modelling process. The model output highly depends on the kind of data that is chosen to serve as the model input, as well as on the structure of the model itself (model equations, etc.). In addition, model outputs require interpretation. All these levels – input, structure, output and interpretation – can be ethically relevant (if used for policy advice), or may even directly imply normative-ethical judgements. Based on these presuppositions, what are the major types of disputable ethical assumptions in IAMs and IAM-based studies?[31]

First, the academic discussion about value judgements in economics mainly focuses on obvious, directly implied[32] ethical value judgements, mostly related to welfare economics (be it explicitly or implicitly). This concerns the goals of economic and political activity and evaluation, and is, therefore, naturally related to ethical questions and values. As widely accepted, every economic study that aims to

[31] In Biewald et al. (2015), a similar account – in terms of three different types of normative-ethical assumptions in economic models – was already presented, yet in a highly condensed form. The following sections refine, elaborate on and partly underpin the brief statements made by Biewald et al. (2015).

[32] An ethical value judgement is 'implied' when an economic statement or model assumption cannot be fully understood without such a normative assumption. There is, however, always space for interpretation.

evaluate or optimise policy options necessarily has to somehow address ethical questions, particularly regarding their understanding of social welfare (at least through an axiomatic or "if-then" approach). More difficult to identify are ethical value judgements that suggest particular policy objectives yet are not expressed in the optimisation functions in IAMs, but instead opaque in terms of certain implicit value-laden assumptions or thick ethical concepts (such as development, rational behaviour, etc.). An important treasure trove for such directly implied value judgements is the problem analysis (i.e., the framing of an economic study) that is sometimes explicit in economic studies, but is usually only implicit. As Chaps. 5 and 6 above explained, defining a situation as (ethically, politically or socially) "problematic" already implies a bundle of normative assumptions. Directly implied value judgements can thus mainly, but not only, be found in the "objective functions" (i.e. explicit functions stating the modelling goals) in economic models.

In addition to such directly implied ethical value judgements that can be explicit or implicit in IAMs and IAM-based studies, there are further – less often discussed – types of ethical assumptions in economics: a *second* type are normative assumptions in IAM-based studies that discuss policy means (such as technologies or policy instruments) and their practical implications. The normative assumptions then are about the appropriateness of policy means themselves – or, indirectly, also about policy objectives. The latter can occur through the (sometimes only implicit) identification and evaluation, or disputable omission, of practical implications of technological, economic, political and other policy means. Remember that the refined pragmatic model (Sect. 6.4.1) argued for a thorough analysis of these practical implications of policy means when assessing them, since neither policy goals nor policy means can be reasonably determined a priori, but only through the evaluation of such implications. Economic studies underlying an IPCC assessment thus have to make these implications of means explicit. For policymakers and other users of economic assessments, the evaluative scientific statement that there will be, for example, a lot of unwanted side effects and hardly any synergies if a certain set of policy means is implemented, will certainly have an influence on their decisions on a given set of policy means.

Scientific studies can also imply opaque ethical value judgements regarding the evaluation of policy objectives and the means of achieving them, through not making particular, relevant implications (e.g. co-effects) of the means transparent, or exaggerating the relevance and magnitude of particular implications of the means. This may result in an opaque bias towards a certain policy option due to the one-sided, biased evaluation of such implications. Hence, even if a scientific study – as soon as used for policy advice and assessments – does not explicitly address the implications of means at all, but only identifies and explains means of achieving given policy goals, this may imply ethical value judgements. It indirectly, mistakenly and usually unintentionally implies that there are no negative side effects worth mentioning; the direct effectiveness of means with regard to the policy objectives is not the only decision criterion that matters. The scientific study can unintentionally imply the alleged goodness of the given policy goal if a scientific study argues that there are effective and feasible policy means without however exploring their various practical implications.

Most economic studies are about policy means. As such, they are often deemed value-free; but they are not. This is also due to the fact that they usually imply a certain problem analysis and (a set of) policy goals. Dewey concludes

> that evaluations as judgments of practice are […] an inherent part of judgment itself. In some cases, the immediate problem may so directly concern appraisal of existences in their capacity as means, positive-negative (resources and obstacles), and so directly concern appraisal of the relative importance of possible consequences that offer themselves as ends-in-view, that the evaluative aspect is the dominant one. [… T]he valuation operation is inherent in judgment as such. The more problematic the situation and the more thorough the inquiry that has to be engaged in, the more explicit becomes the valuational phase (Dewey 1986, pp. 180f).

One of the difficulties of identifying means-related value judgements in IAM-based studies lies in their great number – in contrast to the number of directly implied ethical judgements in the IAM objective functions, etc. Virtually every model-related or scenario-related assumption has an impact on the results of the economic study, if they are about policy means. Some economic studies, however, actually make sufficiently transparent that they are *only* exploring a very narrow set of effects of policy means and do not suggest that the set of policy means in question is appropriate for public policy.

The *third* type is about implied ethical assumptions in the treatment of model simplifications, uncertainty and ambiguities regarding statements on policy objectives, policy means or their practical implications. Rudner's and Douglas' argumentation presented in Sect. 5.2.4 underpins and explains this type of ethical judgement in IAM-based economics and its potential high relevance from a social and ethical perspective. This type of value judgement is a cross-cutting one, as it can concern statements on problem definition, policy goals, policy means and the positive or negative practical implications of these policy means.

These three types are certainly not a comprehensive typology of value judgements implied in economics (see, e.g., Sect. 5.2).[33] Moreover, it is not always possible to clearly allocate an ethical assumption to one of the three types of normative judgements. Nonetheless, this approach to identifying ethically relevant assumptions in models can be very useful and lead to more clarity on the ethical issues of the economics of climate change.

[33] Section 8.4.5 will furthermore discuss ethical gaps as another cross-cutting type of ethical assumptions in IAM-based economic research.

7.4 Do IAMs Answer the Questions Most Relevant to Policy?

Having introduced climate economics, IAMs and the evaluation criteria for them, this section briefly evaluates IAM-based economics in terms of the first evaluation criterion, i.e. policy-relevance. Can it contribute to the exploration of policy pathways and their implications in integrated scientific assessments?

First, in terms of better understanding the problematic situation underlying climate policy, IAMs can contribute a lot. The main thing about problem analysis is to appropriately determine the scope of the valuable, relevant aspects (e.g., climate change is not only an environmental, but also an economic and social problem). IAMs could contribute to that, and actually do so, by providing quantitative analyses of so-called business-as-usual scenarios and some of their practical implications. This helps better understand to what extent particular aspects of the assumed problematic situation actually matter. This again illustrates how closely the problem definition and the ends-means analysis are related, since problem definition is mainly about determining the ends-in-view (i.e., goals; see Sect. 6.2.1).

Second, to an increasing extent in recent years, IAM-based studies also provided valuable insights on the relationship between different sets of policy objectives, policy means and future implications. A key and highly disputed question addressed by the climate-IAM community is related to the costs, risks and benefits of global climate change mitigation goals.[34] A few years ago, the result of IAMs in this regard was as follows:

> Probably the most striking result is that our current understanding of climate change costs, damages, etc. does not justify more than modest emissions control (Kelly and Kolstad 1998, p. 26).

More than a decade later, in contrast, economists came to different results (at least concerning the mitigation costs) that are extensively discussed in the WG III AR5 (IPCC 2014, Chap. 6; see also Sect. 10.2 below):

> low stabilization of CO_2 emissions is found to be achievable, at moderate costs, in all models used if the full suite of technologies is available, all regions participate […] and effective policy instruments are applied (Edenhofer et al. 2010, p. 43).

However, what ambitious mitigation policies would really mean in economic terms for particular regions is still highly uncertain (IPCC 2007, 2014).

[34] Such “costs” can be defined very differently: “In general, four different types of mitigation costs can be distinguished […]: direct engineering costs, economic costs for a specific sector, macroeconomic costs and welfare costs” (Edenhofer et al. 2010, p. 29). See also IPCC (2007, Sect. 2.4 and pp. 203ff) and Edenhofer et al. (2006b, Sect. 3). The WG III AR5 provides an explanation of the term ‘mitigation cost’ (IPCC 2014, Box TS.9). E.g., the regional economic costs of ambitious mitigation targets – under the assumption of a global carbon market – would consist of at least three elements: (1) the devaluation of fossil resources in the region, (2) the costs of transforming the regional energy system and (3) the allocation of emissions rights insofar as the region would have to buy emissions permits (Knopf et al. 2012). However, currently hardly anybody believes in a global emission trading system given the political reservations.

The costs (as well as risks and benefits) of mitigation options played a central role in the WG III AR4, since exploring these costs is one of the core tasks of WG III.[35] While in the WG III AR4, the IAMs were mainly used to explore aggregated mitigation costs, the IAM-based studies underlying the WG III AR5 focussed on a broader range of aspects (well explained in Tavoni et al. 2015, e.g.): emissions reduction pathways; technological and sectoral requirements; mitigation costs. Among other things, IAM model comparisons (see Sect. 7.2.2) explored the economic and other future implications over time of (i) limited availability of mitigation technologies, (ii) delayed participation of particular countries in global mitigation efforts, or alternative timings of mitigation (overshoot or not, etc.), and (iii) alternative ambition levels of climate change mitigation, including particularly the 2 °C goal (also in terms of technological and policy requirements) compared with current national pledges. IAM model comparisons found, for instance, that current national CO_2 emission reduction pledges for 2020 are not in line with the 2 °C goal and that considerably delayed mitigation action, or more ambitious mitigation goals than the 2 °C goal, would lead to a huge increase of economic costs and perhaps the infeasibility of these mitigation goals. Moreover, limited availability of certain low-carbon technologies (particularly carbon capture and storage combined with an extensive use of bioenergy) would also tremendously raise the costs.

All of this more recent IAM-based research is clearly policy-relevant in the sense described above, particularly because it goes beyond the modelling of idealistic "first best worlds" and because it addresses the tremendous role of technologies. Before the IAM community explored these policy-relevant second-best (i.e., non-ideal) world and governance aspects more recently, some stakeholders and researchers had been criticising that the IAM-based studies – perhaps too much driven by their methods rather than the policy questions – are too much focussing on unrealistic, idealistic scenarios and perfect markets far away from political reality, and that the results are too aggregated to be useful for policy processes.

There are still many interesting research questions that are not yet fully addressed by the IAM community, including, for instance, regarding the 2 °C goal[36]: (i) transformation requirements in the near-term future and in a national or regional context; (ii) technology issues and diffusion; (iii) various side effects and co-benefits, including distributional implications (political economy); (iv) institutional barriers; (v) various interactions with other policy fields and scenario types.[37]

To defend the IAM community, the system complexity covered by IAMs is incredibly high, and the academic system only provides limited incentives for researchers to (further) develop the complex and impressive IAMs (both in terms of

[35] See IPCC (2007, pp. ix, 12, 18, Sect. 2.4, 203–214, and Chap. 11).

[36] I mainly learned about such research gaps in a conversation with Dr. Gunnar Luderer, a distinguished expert on, and practitioner of, IAM modelling.

[37] A highly interesting study that discusses both under-researched second-best world aspects and their potential integration into IAMs is provided by Staub-Kaminski et al. (2014). Another major research gap related to IAMs is the possible climate change impacts and damages. The uncertainty is still so high that most IAMs follow the cost-effectiveness approach.

funds and the possibility to publish the results in the most high-ranking journals). The IAM community has made a tremendous and successful effort in the past two decades to inform the international community about climate policy pathways, more than any other research community perhaps. Nonetheless, IAMs are perhaps close to their maximum potential currently; they have become extremely complex and face several limitations with regard to some of the interesting research gaps. Overcoming these research gaps would therefore benefit from other methods and model types in addition to IAMs (see also Sect. 9.4). IAMs are thus very helpful but limited and not sufficient regarding the policy-relevant questions at stake, also because they can only integrate societal values that are transformed into commensurable quantitative values. Furthermore, IAM results are uncertain in many regards (see Chap. 9) – which is, however, mainly due to the difficulty and complexity of the research object itself, and not significantly different from other scientific methods in this context.

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Chapter 8
Ethics in Climate Economics: Balance or Bias?

Abstract This chapter aims to analyse the normative-ethical assumptions implied in the structure and scenarios of integrated assessment models (IAMs), as well as the IAM-based studies used in the recent assessments by the Intergovernmental Panel on Climate Change (IPCC). This will be done according to the framework developed in Sect. 7.3 which claims transparency and balance. I focus particularly on aspects related to objective functions in IAMs, i.e., on welfare economic issues. Section 8.1 discusses the predominant views of the relationship between welfare economics, ethics and values. Since these views have a considerable impact on the welfare economic assumptions of IAMs, one should be aware of them. Then, some fundamental assumptions of mainstream economics underlying welfare economics – i.e., the assumed rationality of agents in markets – are examined (Sect. 8.2). Based on that, the more specific analysis of IAMs regarding welfare issues can be undertaken (Sect. 8.3). Moreover, Sect. 8.4 briefly discusses other ethically interesting aspects of IAMs that serve as additional examples of the value-laden IAM economics of climate change. It is concluded that at least some disputable ethical value judgements in IAM-based studies are still relatively opaque and one-sided – which makes life more difficult for the authors of assessment reports (Sect. 8.5).

We can now evaluate the degree to which the IAM-based economic literature that informs IPCC assessments incorporates, and explores the practical implications of, *alternative* ethical viewpoints and policy objectives in a *transparent* manner. For this purpose, employing the framework from Sect. 7.3.2, this chapter will identify several ethical value judgements (i.e., normative assumptions) in the IAM-based economics of climate change. It will be analysed whether these often disputed judgements are made transparent and are balanced overall.

> In a global climate policy debate fraught with differing understandings of right and wrong, the importance of making transparent the ethical assumptions used in climate-economics models cannot be overestimated (Stanton 2011, p. 418).

If the scientific studies that make it into assessments contain only a one-sided range of politically relevant values and interests, they can become policy-prescriptive and “ethically biased.” This is particularly problematic if these normative assumptions are usually disputed, but not made transparent in a particular scientific

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study (be it deliberately or unknowingly). Analysing value judgements in economics should thus not be regarded as a secondary issue with low priority, interesting only for philosophers. Rather, conflicting values and interests are at the core of political decisions regarding climate change (see also Sect. 2.2).

I will primarily (not exclusively) analyse directly implied value judgements, i.e. the first type of value judgements (see Sect. 7.3.2). These are typically the most far-reaching and obvious normative assumptions. They will be analysed in Sect. 8.2 in terms of the fundamental assumptions on the rationality of (market) agents, and in Sect. 8.3 in terms of the specific objective functions of IAMs. Section 8.4 will discuss other ethically interesting aspects of IAMs that serve as additional examples of the value-laden economics of climate change. Section 8.5 will conclude.

To prepare this analysis of specific normative assumptions in economic studies, however, a discussion of some more fundamental economic assumptions is needed first. The predominant views of the relationship between (welfare) economics and ethics will be discussed in Sect. 8.1, because these views considerably determine the degrees of transparency, and the choices, of the more specific normative assumptions in economic studies. One should thus be well aware of these views.

8.1 Welfare Economics and Ethics: A Strained Partnership

The considerations of value judgements in economics give rise to the question of how they affect the delicate relationship between economics and (philosophical) ethics.[1] The role and treatment of value judgements in the economic literature is considerably determined by the particular viewpoints held by economists regarding this relationship between (welfare) economics and ethics. For instance, economists believing in the value-free ideal, i.e. clear boundaries between economics and ethics, would not take great pains to identify value judgements in their analyses, and to make these value judgements transparent.

8.1.1 General Viewpoints of Economics and Ethics

Facts and values are inevitably entangled in scientific studies, and the value-free ideal is misguided, as Chap. 5 concluded. Nonetheless, some economists have defended the value-free ideal, despite its absurdity. As Sect. 7.1 indicated, some regard economics as a purely empirical-logical science, or as engineering – in both

[1] As a philosophical discipline, ethics reflects on the moral beliefs of people and societies. The often-used term 'equity' can be understood in a narrow sense as addressing principles of fairness that apply to economic activities (often regarding distributive issues). Meanwhile, a huge body of literature on economics and ethics exists, pioneered by distinguished scholars such as Ian M.D. Little, Amartya Sen, Partha Dasgupta, John Broome and Peter Ulrich, among many others.

cases as a value-free enterprise to explore the means of achieving given targets (Sayer 2011, p. 30). According to these views, economics and ethics are two strictly separate disciplines that do not necessarily have to get along with each other. “It is widely believed by economists and non-economists alike that knowing about and ‘doing’ economics does not involve ethical and moral issues” (Dutt and Wilber 2010, p. 3). Some assume that economists “are not entitled to make any value judgment, and as citizens, they are no more qualified than any other citizen in making value judgments” (Ng 1972, p. 1015). Dupré states more generally: “Nowhere is the tradition of dividing the factual from the evaluative more deeply ingrained than in economics” (Dupré 2007, p. 35). Menger, Walras and others have argued that economics must primarily be positive economics because *the* scientific method, in their opinion, can be applied to both natural and social phenomena (Brodbeck 2011, p. 43f). Positive economics originated in the nineteenth century and follows the successful natural-science approach to reality (Brodbeck 2011, p. 43), only analysing the means to given targets (Weston 1994, p. 4). In contrast, normative economics, being as old as economics itself, traditionally comprises welfare economics and the theory of economic policy.

These examples suggest that many economic studies are produced in the spirit of the value-free ideal, and thus probably do not ensure transparency of the value judgements involved. Other economists, however, have acknowledged the close relationship between economics and ethical issues; “[i]nquiring involves action, and action is driven by values” (Hausman and McPherson 2006, p. 296).

> Whatever the approach taken, the consequences of economics require an ethical stance, or at least a stance toward ethics, by the economist. The raw material that motivates economics and the practical consequences of economics place economics in a normative context (Weston 1994, p. 7).

With regard to climate economics, Broome argues that there cannot be an objective, value-free economic optimum due to the diversity of moral values that are relevant to this issue (Broome 1992, p. 19). Another connection between economics and ethics is that “[e]thical commitments are among the causal factors that influence people’s economic behavior” (Hausman and McPherson 2006, p. 300). Fullbrook even suggests that the great discord between the different economic traditions is mainly due to the fact that “in economics different epistemological choices suggest different ethical/political choices” (Fullbrook 2009, p. 125).

Considering such examples, many publications on the economics-ethics relationship[2] rightly criticise the lack of ethical reflection in economics, and the lack of awareness that economics has much to do with ethics. All of the founding fathers of economics – Aristotle, Smith, Bentham, Mill, among others – were both economists and moral philosophers. Their interests in the ethical issues of economics was often greater than many believe (Wallacher 2011, e.g. Chap. 1).

[2] E.g., Streeten (1950), Anderson (1993), Beckerman (2011), Dutt and Wilber (2010), Hausman and McPherson (2006), Peil and Staveren (2009), Sen (1988), Putnam and Walsh (2012), Wallacher (2011), Dietz et al. (2009).

8.1.2 Welfare Economics and Ethical Values

Let us have a closer look at the relationship between *welfare* economics and ethical issues.[3] The main task of welfare economics is to evaluate economic situations (or social situations in general) and their changes. Political measures leading to these situations can be evaluated – be it compared with a normative standard, to another situation or measured absolutely (Kleinewefers 2008, pp. 11 and 20). This implies that welfare economics is a key economic sub-discipline underlying IAM-based studies on climate policy. For instance, the objective functions of IAMs are based on different welfare assumptions; these objective functions have rather obvious normative (often disputed) implications, and a huge influence on model results. Understanding the welfare economics underlying IAM-based economic studies thus facilitates the identification and evaluation of specific value judgements in these studies (see particularly Sects. 8.2 and 8.3).

Increasing welfare (or development, as an alternative or complementary concept used since the 1960s) should be the core goal of an economy from a societal perspective. Yet, welfare economists disagree over the right approach to 'welfare.' Despite the rather obvious normative implications of any approach to welfare economics, many welfare economists (since about the 1930s) see themselves as doing positive, value-free economics (Kleinewefers 2008, pp. 24–30; Sen 1970, pp. 56f). This is because they generally refer to welfare definitions and criteria merely as axioms or as unquestioned hypotheses, and draw analytic conclusions from them. In economic history, this issue has been disputed extensively, as will be explained in the following paragraphs. It took a very long time before the majority of economists rightly admitted that even the Paretian approach (see below) is not value-free, but also implies normative elements (Kleinewefers 2008, p. 36).

Welfare economics has a long history, reaching back to classical utilitarianism. The moral and political philosophers, Bentham (1748–1832) and Mill (1806–1873), have provided a basis for the 'older' welfare economics, but also to a certain extent, for the 'newer' (Pareto-based) welfare economics (Kleinewefers 2008, pp. 35f). The older welfare economics developed by Pigou (1877–1959), Marshall (1842–1924) and Edgeworth (1845–1926) was much more explicitly normative than today's prevailing Pareto welfare economics (Kleinewefers 2008, p. 36). The core elements of the older welfare economics are: (1) normative individualism, which means that everyone is assumed to be capable of deciding what is good for herself or himself and that, in principle, each person's utility is equally important for social welfare; (2) a concept of utility that can be cardinally measured, which allows for the interpersonal comparison of utilities (assuming that everyone has the same perception of what utility is in principle); (3) a strong belief in competitive markets that allegedly lead to greater benefits for society; (4) no interrelation between two individuals' welfare, which allows for a rather simple aggregation of social welfare by adding up individual welfare; (5) the idea that economic welfare – i.e., the utility associated

[3] Little (1957) and Sen (1988) have provided seminal works on this relationship.

with consumption of economic goods – is closely connected, if not identical with human well-being in general (Kleinewefers 2008, pp. 36f; Giersch 1993, p. 24); and (6) the idea that only the consequences of policies (in terms of changes in aggregated utility) are ethically important (Sen 1999). Based on these assumptions, older welfare economics aimed to maximise aggregated utility in order to reach maximum welfare, for which competitive markets were deemed crucial (Kleinewefers 2008, p. 37).

Some concepts of the older welfare theory (based on classical utilitarianism, or later on different kinds of welfarism[4]) imply that the actual distribution of welfare to individuals does not matter for social welfare as a whole (Kleinewefers 2008, p. 38). Yet, Menger's later idea of diminishing marginal utility influenced welfare economics; it means that the marginal utility for the poor is higher than for the rich. As a result, the redistribution of wealth from the rich to the poor now matters for social welfare. Moreover, the strong belief in competitive markets inter alia resulted from the assumption that people are *equal* regarding their opportunities, which renders competition ethically acceptable (Kleinewefers 2008, p. 38). Mill changed this idea into the conditional: only *if* people are equal, competitive markets are good (Kleinewefers 2008, p. 38). This led to discussions about distributive justice in terms of the (still disputed, but obvious) need *to achieve* equality of opportunity for maximising welfare (Kleinewefers 2008, p. 38; Pigou 2002).

Newer welfare economics attempted to avoid ethical assumptions

While even more normative claims had been added (e.g. redistribution of wealth) between Bentham and Pigou's time, the subsequent development of the newer welfare economics led to a reduction of *explicit* normative assumptions and to a more analytical, descriptive approach (Sen 1970, pp. 56–58; Robbins 1945, p. vii). The decisive difference between the older and newer welfare economics is the dropping of the disputed, allegedly paternalistic idea of cardinally measurable utility in favour of a merely *ordinally* measurable, allegedly value-free (but in fact again highly normative), more "subjective" concept of individual utility based on revealed preferences (Sect. 7.1.1; Giersch 1993, pp. 9f, 16; Robbins 1945). A related modern, formal definition of utility is "the value of a function that represents a person's preferences" (Broome 1999, p. 21). Broome adds (ibid.) that this is now "the official definition of utility in economics."

Pareto (1848–1923) is the most important thinker on newer welfare economics. A situation is 'Pareto-optimal' if no one's situation could be improved (according to his or her subjective preferences regarding bundles of goods and marginal rates of substitution) without making someone else's situation worse, i.e., a situation without losers.[5] "In simple terms, Pareto optimality is just about not wasting scarce

[4] Welfarism is consequentialism in terms of individual utility, disregarding non-utility features.

[5] Sen (1970, p. 21) states, interpreting Pareto's approach, "the two following rules are used: (a) if everyone in the society is indifferent between two alternative social situations x and y, then the society should be indifferent, too; and (b) if at least one individual strictly prefers x to y, and every individual regards x to be at least as good as y, then the society should prefer x to y." He goes on to

resources" (Beckerman 2011, pp. 52f). The appeal of the Pareto criterion is that no interpersonal comparison of utility is required between someone who gains and someone who loses (since no one loses). The only thing that is required here is some form of benevolence (Hausman and McPherson 2006, p. 65) regarding others who benefit, while one's own situation does not get worse. However, there is no criterion to decide which Pareto optimal situation (there are several ones at the "utility possibility frontier") is the best in terms of welfare. There is also nothing to say about situations with winners and losers, even when losses appear trivial compared with gains. This is why one has to distinguish between actual Pareto improvement and potential Pareto improvement. The latter implies compensation for losers, but this is almost impossible in practice since in more complex projects it is impossible to determine exactly who gains and who loses how much and to compensate all the losers[6] (Beckerman 2011, p. 54).

The only thing newer welfare economics can do is identify situations of optimal allocative efficiency (both regarding the maximisation of production and of *individual* utility); however, there are usually several welfare optimal situations and no criteria for identifying the maximum welfare among these Pareto optimal situations (Sen 1970, p. 22). Due to this, Paretian welfare cannot be empirically operationalised (Kleinewefers 2008, p. 44). In addition, ordinal utility makes interpersonal comparisons or aggregations almost impossible (Robbins 1945; Giersch 1993, pp. 16–18). As a result, distributional questions can no longer be addressed (Giersch 1993, pp. 17f; Kleinewefers 2008, p. 43).[7]

Later developments struggle with aggregation of individual preferences

To address these issues, newer welfare economics was further developed by Robbins, Hicks, Bergson, Kaldor, Samuelson, Arrow and others. In the 1930s, there was an increasing need for criteria to compare alternative situations where there are winners *and* losers. The idea that ideal free markets lead to an optimum was abandoned due to existing market imperfections and more convincing second-best theories. Popular criteria beyond Pareto, designed as "compensation criteria" to compare alternative situations, were developed by Kaldor and Hicks, Scitovsky, Little, and

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point out with some literature examples that "the Pareto principle has been often taken to be free from value judgments" (p. 57).

[6]As Little pointed out ('Little Criterion'), there is only a Pareto improvement if (1) "expected social benefits are greater than expected social costs" and if (2) "the effects of the project on the distribution of income does not violate society's distributional values" (Beckerman 2011, p. 54). Pareto optimality has "a built-in bias in favour of the status quo" (Beckerman 2011, p. 55). "In short, a society […] can be Pareto optimal but be perfectly disgusting" (Sen 1970, p. 22).

[7]The two fundamental theorems of welfare economics based on Walras and Pareto are: (1) equilibrium of a (perfectly) competitive market is always Pareto efficient, and (2) any Pareto-efficient allocation in a competitive market is a market equilibrium (if indifference curves and isoquants are strictly convex). Since these theorems are very theoretical and presuppose perfectly competitive markets, they cannot play an important role in practice (Kleinewefers 2008, p. 104). Paretian theory has been used in political debates to argue for free, competitive markets until more differentiated economic theories, and new empirical findings, made it more or less obsolete – although it is still a very influential theory (Kleinewefers 2008, pp. 44; 193; Chap. 10).

Coase. The basic idea was to show that – different from the Paretian approach – even alternative situations where there are winners and losers can be better in terms of welfare than the original situation due to fictious and voluntary compensation payments between the winners and losers. Typically, however, these compensation approaches are not empirically measurable; they remain as abstract, theoretical and "empty" as the Pareto optimality. These compensation criteria can only be used for comparison between two or a few alternative situations.[8]

The core problem of welfare economics thus remained: how to go from individual welfare (based on the popular assumption of normative individualism) to the determination of *social* welfare? Binmore illustrates this problem well.

> Traditional economists suffer from a severe case of schizophrenia on the subject of *interpersonal* comparisons of utility. In classes on welfare economics, the idea that we can compare how much utility different people are getting is so taken for granted that nobody feels the need to explain how this is possible. But in the class next door, students of microeconomics are simultaneously being taught that interpersonal comparison of utility is so obviously a laughable impossibility that nobody need give the reasons why (Binmore 2005, p. 116).

Arrow's famous "impossibility theorem" (Arrow 1970) shows that under certain premises,[9] there is no democratic voting system that goes from individual, ordinal rankings of preferences to a social ranking of preferences, i.e., to a social welfare function. Among Arrow's (1970) core assumptions are: normative individualism and welfarism, ordinal individual utility (independent from the situation of other people), nondictatorship (Sen 1970, p. 38), a weak Pareto principle and unanimity for social choice about welfare, consistently and comprehensively ranked individual preferences, as well as consistent and comprehensive social preference rankings. Consistency and completeness are in general crucial criteria for concepts of rationality and preferences in welfare economics (see Sect. 8.2).

As a result, any social welfare function requires both cardinality and interpersonal comparison of utility (Beckerman 2011). Both cardinality and interpersonal comparison of utility, however, had been criticised regarding the older welfare economics. Hence, Arrow's theorem led to intensive discussions on "social choice theories"[10] in order to better understand collective choice, particularly if ordinal utility measures are assumed (Kleinewefers 2008, p. 48f). Most previous approaches to welfare referred to social utility as a function of individual utility, while social choice functions (in the tradition of Arrow) denote a procedure of community-wide, social decision-making (Kleinewefers 2008, p. 50). The perception of the welfare problem thus changed from an individualistic system dominated by the market to a democratic-collective system governed by politics; hence, decision procedures (social/public choice) gained importance.

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[8] For this paragraph, see particularly Kleinewefers (2008, pp. 45–47; Chap. 11).

[9] For a criticism of these premises see Sen (1970), Touffut (2009) or Arrow et al. (2002).

[10] An example of a social choice is a majority decision. Although social choice theory developed out of welfare economics, it is still a research field of its own (Kleinewefers 2008, p. 56; Sen 1970, p. vii). For an introduction see Arrow et al. (2002), especially Part 3.

However, many economists did not want to give up the idea of a substantial social welfare function. The *ordinal* individual utility functions are the main reasons for the impossibility of social choice in Arrow's theorem.[11] Many economists, therefore, came back to the idea of more "objective," and with it, equal individual utility functions that are similar to the approach in older welfare economics and utilitarianism (Giersch 1993, p. 11; Kleinewefers 2008, pp. 53f), not because the problems of cardinal utility were solved, but because the practical problems with ordinal utility were even bigger and many thought that welfare functions were necessary for welfare economics (Giersch 1993, p. 11).[12] Consequently, the concept of welfare *functions*, as first developed by Bergson (1938) and Samuelson (1947, 1950), became popular again. Such real-valued welfare functions are mathematical maximisations of social welfare under certain conditions and restrictions, usually based on ordinal individual utility, rather than social choice (Giersch 1993, pp. 10 and 30; Sen 1970, pp. 34f). With these functions, which are crucial for most IAMs, one can compare a greater amount of alternative social scenarios or social states by directly determining the social welfare maximum or ordering the social states. Such approaches to individual choice theory are mostly based on "neoclassical"[13] *homo economicus* theory (maximising expected individual utility under certain conditions; see Sect. 8.2), while attempting to further develop the issues of aggregation, inter-personal comparison and measurement of utility (Kleinewefers 2008, p. 49). Beckerman interprets social welfare functions as representing attitudes to equality and

[11] Giersch (1993, p. 10) and Kleinewefers (2008, p. 53). Sen (1986) provides an overview of the literature on Arrow's theorem.

[12] As Giersch (1993) explains, a societal welfare function of the original Bergson type is possible despite Arrow's theorem, because it does not refer – as Arrow suggested with his ordinal utilitarianism – to ordinal *utility* in interpersonal comparison. In contrast, it demands a general weighing of ordinally ranked preferences, which does not necessarily mean "utility." The interesting question is, then: are interpersonal comparisons of utility necessary for determining social welfare? Obviously, this is not an economic but an ethical question.

[13] The neoclassical approach is sometimes used synonymously with economics itself (Dutt and Wilber 2010, p. 10). Two different definitions are common. The first one "relates to method:" neoclassics "analyzes the economy by examining the behavior of individual, self-interested, optimizing agents and how they interact with each other. The second is a narrower definition related to how the economy operates which, in addition to the assumption made in the first definition, assumes that the economic agents interact with each other in smoothly functioning markets in which all resources are being fully utilized and in which there are no distortions such as imperfect competition" (Dutt and Wilber 2010, p. 10). Dutt and Wilber (2010, pp. 10–12) identify four main characteristics of neoclassical economics: (i) the rationality of maximising individual utility; (ii) competitive markets, which work perfectly, or where market distortions have to be removed; (iii) under certain conditions these things lead to efficiency; (iv) but do not (necessarily) lead to fair distribution since there is a trade-off between fairness and efficiency. The first definition above does not say "that free markets will result in efficient outcomes" (Dutt and Wilber 2010, p. 12), but it also implicitly values efficiency; therefore, policies that "move the economy closer to the perfectly competitive distortion-free situation" are preferred. The second definition above prefers laissez-faire policies, apart from distributional issues in order to create fairness. The appeal of neoclassical theory – after surviving so many attacks – is that it provides a methodological tool to answer almost every political question.

distributional issues and, therefore, as the possibility to "escape from the distributional neutrality of the Pareto criterion" (Beckerman 2011, p. 57). Today, such welfare functions primarily contain – directly or indirectly – consumed goods and employed factors of production (Kleinewefers 2008, p. 47). These welfare functions imply an even greater number of substantial normative assumptions than the older welfare theory: a complete set of goals for a given society (Sen 1970, p. 33). The wheel of welfare economics history turns full circle.

In line with the criticism of older welfare economics, however, these welfare functions were never operationalised or stated *more precisely* by Bergson and Samuelson (Kleinewefers 2008, p. 47, 49), because there is no consensus about the appropriate welfare function.[14] There has been an extensive debate about more concrete welfare functions over the last 50 years, without much practical impact (Kleinewefers 2008, pp. 35, 52, 179).

Another proposal to solve Arrow's impossibility theorem was, based on Rawls (1971), to drop the idea of individual *utility* (i.e., welfarism) and interpersonal utility comparisons altogether, and replace them with a focus on resource endowment, happiness, opportunities or "capabilities" (Sen 1999) for all members of society. This makes the determination and aggregation of individual utility unnecessary (Kleinewefers 2008, p. 54; Giersch 1993, pp. 12f), or, in the case of happiness, perhaps more feasible. While such approaches might better reflect the predominant debates in political philosophy, they are not widely accepted by economists.

To conclude, the goal here was not to discuss what the best approach to welfare economics is, but rather to introduce and explain the predominant approaches. Inter alia, it became clear that every approach to welfare economics, and all economic schools, presuppose far-reaching normative assumptions, explicitly or implicitly. Little even regards welfare economics as "a branch of applied ethics" (2002, p. 140). Besides understanding that all of these approaches to welfare economics (in contrast to their self-evaluation) are value-laden, also better understanding their major assumptions more precisely helps identify the related value judgements in IAM-based studies (see the subsequent sections). Additionally, knowing about the weaknesses and ethically relevant gaps of each approach to welfare economics (e.g. neglecting distributive aspects, or neglecting the diversity of cultural understandings of utility or welfare), as analysed above, can also considerably help facilitate the identification of value judgements in such studies.

[14] An interesting recent report provided by the Stiglitz-Sen-Fitoussi commission on the measurement of economic performance and social progress states that there are three major current strands regarding welfare measurement: (1) happiness research, (2) the capability approach and (3) gross domestic product (GDP), or resourcism. See http://www.stiglitz-sen-fitoussi.fr/en/index.htm, accessed 2 Mar 2015.

8.2 Economic Assumptions on the Rationality of Agents

IAM (welfare) economics often builds on the neoclassical theory of rationality (see Sect. 8.1.2), although many IAMs go far beyond neoclassical assumptions. This rationality, allegedly, also determines actual human behaviour in markets. It is, inter alia, key for rational choice (e.g. game theory) approaches to describing economic phenomena and climate policy. A closer look at this theory of rationality, with the concept of *homo economicus*[15] as its main element, reveals a bundle of ethically relevant assumptions underlying IAM-based economic statements.

8.2.1 Homo Economicus *in IAMs*

One of the basic (and very old) assumptions of the concept of *homo economicus* is methodological individualism, which means that the rationality of individuals (rather than of collective players) is decisive for the explanation of economic phenomena, but also that an individual's preferences are independent from other people, e.g., relationships, envy, role models, etc. (Brodbeck 2011, p. 47). Closely related to this point is the important auxiliary assumption of "exogeneity of preferences," meaning that preferences do not change in different (institutional, social, etc.) environments or times (Rodriguez-Sickert 2009, p. 225). These are rather unrealistic, and ethically perhaps questionable, assumptions, although perhaps being necessary simplifications when modelling reality.[16] For example, compassion is largely excluded then, which is empirically absurd and ethically problematic.

Moreover, the "essence of rational choice" and of *homo economicus* is "consistency" (Rodriguez-Sickert 2009, p. 225) along with related assumptions such as completeness, transitivity and so on. Consistency is, roughly speaking, the assumption "that people – except lunatics and children – rationally pursue their […] interests. But […] most people *are* either lunatics or children" (Beckerman 2011, p. 43). It is obviously not true, nor ethically demanded, that people always behave rationally in the *formal-logical* sense claimed by the neoclassical theory (see Offer 2006, especially Chaps. 3, 4, 5, and Beckerman 2011, pp. 40–43).

A further *homo economicus* assumption is the "self-regardfulness of preferences" (Rodriguez-Sickert 2009, p. 225): all human preferences are guided by self-interest and instrumental rationality. Yet, people clearly are not always selfish (see, e.g., the meta-study by Dutt and Wilber 2010, p. 78). Ostrom et al. (1992) show that some players actually punish uncooperative agents and spend resources on this, beyond what the individual would directly benefit from it. Smith stated,

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[15] Many publications discuss the concept of *homo economicus*, its diverse assumptions, strengths and limitations. See, e.g., Sen (1999); Kirchgässner (2000); Rodriguez-Sickert (2009); Davis (2009); Wallacher (2011); Bowles and Polania-Reyes (2012). The different logical axioms and assumptions of the rationality theory are explained, e.g., by Endres and Martiensen (2007).

[16] See, e.g., Kleinewefers (2008, p. 278); Dewey (1927, 1988).

> How selfish soever man may be supposed, there are evidently some principles in his nature which interest him in the fortune of others, and render their happiness necessary to him though he derives nothing from it except the pleasure of feeling it (Smith 1759, Part I, Sect. I, Chap. 1).

Being strictly guided by self-interest and external incentives only, as neoclassical rationality assumes, means that people are incapable of communicating and learning (Brodbeck 2011, p. 48; Hands 2001, p. 324), which is also untrue and might also imply that such a rationality is "inconsistent with freedom of choice" (Fullbrook 2009, p. 126). Regarding climate policy, this also implies that many IAMs do not cover the possibility of lifestyle changes (e.g., changes of consumption patterns), despite their potential effects (Edenhofer et al. 2012). A related problem of neoclassical theory is that the revealed preferences[17] (as interpreted based on the observable behaviour of agents, guided by the assumption that people are the best judges of their interests) are not always our real preferences (see also Broome 1999, p. 4) due to, for example: (1) political structures such as oppression (see Sen 1999) or (2) our sometimes bounded rationality (we do not always know immediately, what is good for us) and limited availability of information. Odd and unrealistic assumptions of neoclassical economics include:

> individuals do not follow rules of thumb, they are not creatures of habit, do not care about anyone but themselves, and always prefer to consume more to less (Dutt and Wilber 2010, p. 28).

These brief remarks on the neoclassical theory of rationality point out what has been accepted for a long time in the economic community: simplifications and even counter-factual assumptions for the sake of methodology (see Chap. 9). As a defence of *homo economicus* and in spite of its problems, one could primarily argue that firstly, many cases that look like irrational behaviour are actually cases of limited information (or high transaction costs, in this regard) rather than "bounded rationality;" secondly, the generalisation that economic agents in markets follow their self-interest in the above manner is not a fully mistaken description of reality; and thirdly, *homo economicus* is *per se* only a formal model of rationality that would also allow for altruistic behaviour (Endres and Martiensen 2007). Nevertheless, *homo economicus* clearly has ethically relevant and disputable implications.

Another interpretation of the neoclassical theory of rationality demands even more caution and scrutiny regarding economic assessments; it is more directly about normative-ethical assumptions. It states that *homo economicus* is not only an attempt to objectively describe reality, but also *per se* a normative idea, i.e., it intentionally implies that we *ought to* behave according to this formal theory of rationality

[17] Referring to revealed preferences is typical for newer welfare economics (Sect. 8.1.2): "The modern theory […] *disowns* its Benthamite origins and cannot be properly understood if these trappings of its childhood are not entirely discarded […] A rational individual is only said to behave as though he were satisfying preferences or maximising a utility function and nothing is claimed at all about the internal mental processes that may have led him to do so. A utility function, in the modern sense, is nothing more than a mathematically tractable means of expressing the fact that an individual's choice behaviour is consistent" (Binmore 1974, pp. 50f).

and the typically-related assumptions, such as following self-interest (Dutt and Wilber 2010; Kleinewefers 2008, p. 52). According to Brodbeck (2011, p. 50), the origins of the "dogma" of neoclassical theory of rationality can partly be understood as a normative statement (Mises, Hayek, etc.) against the feared and hated theory and practice of the communism of the 1920s and 1930s. Choosing *revealed* preferences (i.e., actual market behaviour, instead of assumed preferences) as the starting point for determining welfare can also be regarded as a normative idea that aims to avoid paternalism (Beckerman 2011, p. 48).

Regardless of whether or not economists consider it to be a normative theory, there is another reason to be wary of using this theory of rationality in IAMs. The reason is that there is only a very thin line between using such a theory-laden concept (with all the problems mentioned above) to describe real human behaviour and subliminally suggesting that this is "normal" behaviour, which immediately has normative connotations. Much depends on the context of the respective economic statement (Caldwell 1994). A good example of such a condemnatory connotation could be stating that altruistic behaviour or non-profit behaviour is "irrational" according to neoclassical theory (not, however, according to the more fundamental, formal concept of *homo economicus*, as stated above). Some studies show that economic theory has a considerable impact on students of economics as they begin accepting the worldview underlying this theory (individualism, a specific understanding of rationality, consumerism, etc.) as their own worldview.[18]

Alternative approaches to the neoclassical theory of rationality include (see Dutt and Wilber 2010, p. 13): (1) focussing not on individuals but on groups (as Marx did, i.e., workers vs. capitalists); (2) focussing on institutions; (3) abandoning the idea that people are always rational and self-interested and accepting that there is a variety of rationalities (as claimed by behavioural economics or feminist economics); (4) due to the lack of information, the prevailing theories of rational behaviour both of individuals and institutions are unrealistic, therefore one should make much more use of "rules of thumb" (as claimed, e.g., by some post-Keynesian approaches). There are at least three possibilities – all of which cause severe problems – to deal with the fact that there is not only self-interest in maximising personal utility, but also ethical norms guiding human action (Dutt and Wilber 2010, pp. 71f): (1) one can integrate the latter into the former, i.e., into the concept and mathematical function of individual rationality; (2) one can drop the assumption that people have a unique preference or utility function; and (3) one can regard ethical issues as constraints on rationality.

Although the limitations of *homo economicus* are not new, and although some more recent economic modelling is based on more sophisticated rationalities, such rationality assumptions are still predominant at the interface between economics and policy. As shown, they imply normative assumptions, largely belonging to the first kind of value judgements, i.e. directly implied ones (Sect. 7.3.2). These judgements are, as was argued, largely disputable. In most IAM-based studies, these assumptions are not extensively made transparent, if at all.

[18] Oral presentation by Dieter Birnbacher, Bucharest, Nov. 2011; Fullbrook (2009, p. 125).

8.2.2 Markets and Ethics

The neoclassical theory of rationality mainly focuses on *markets*. Related to this fundamental concept of (free) markets[19] are ethically interesting assumptions. Although, the interpretation of these assumptions as "ethical" depends on the context of the respective economic statement and, to some extent, on the intention of the modellers. The concept of 'market' is used both descriptively and normatively in economics (and economic policy), mostly without reflection, and a "distorted market" seems to be something that is morally unacceptable (Fullbrook 2009, p. 127), which economic policy should tackle. I will not go into detail here, but will only list a few value judgements involved regarding the free market idea.

1. The first moral implication is liberalism (or even libertarianism) in the sense that everyone should have an equal right to be a free player in markets, i.e., to produce, sell and buy everything that she or he likes (at least as long as it does not endanger the basic rights of other people), which also implies that "bad" products offered on markets can only be sanctioned by not buying them (Anderson 1990). This seems to be not only a descriptive idea, but also a normative one, since *de facto* markets are not often "free" in this sense.
2. Besides the direct normative intention, claiming the need for free markets can also have an instrumental, but still normative function. The neoclassical assumption is that free competitive markets lead to Pareto-efficiency and to higher welfare than distorted markets. Efficiency and welfare are underlying normative goals then. Moreover, why favour markets as an instrument, rather than, say, an exchange organised by a democratically elected government, or communism, or mixed forms, or local co-operatives? All of these alternative means might have – value-laden – disadvantages compared with free markets, but these aspects are rarely made explicit when favouring the free market assumption (Dutt and Wilber 2010, Chap. 7). These are value judgements of the second type (Sect. 7.3.2).
3. An ethically important assumption of the second type is related to the consequences of markets. Sen showed that in some cases of poverty and inequality, free (international) markets should not be the choice (Sen 1981) because this would severely harm the poor; protectionism might be better for a short period, under certain circumstances.[20] In addition, there are many other decisive conditions for a "free market" that are rarely met, such as the previously discussed availability of information or the internalisation of externalities, such as global warming through the industrial combustion of fossil fuels. The implications of second-best markets or measures to overcome market distortions were rarely

[19] See, e.g., Endres and Martiensen (2007) for a precise and comprehensive definition of the '(free) market.' A briefer explanation could be the following: "In a market economy goods are produced for, distributed by and subject to contractual forms of exchange in which money and property rights are transferred between agents" (O'Neill 2009, p. 317).

[20] For value-laden judgements related to the idea of economic globalisation and globally free markets see DeMartino (2009) and Müller and Wallacher (2005).

made transparent in the IAM-based studies that were relevant to the IPCC AR4; only in the AR5 these conditions and implications were addressed more explicitly.

4. A free, competitive market presupposes the mutual ethical acceptance of property rights and of other basic rights (O'Neill 2009). Law and punishment without this acceptance would be insufficient (Dutt and Wilber 2010, p. 99).
5. Trust is also essential to markets (O'Neill 2009, p. 317) because control is not possible everywhere.[21] Markets can disappear when information is too asymmetrical between buyers and sellers (Dutt and Wilber 2010, p. 100). This has to do with trust and sincerity, which are ethical values. Neoclassical free markets only work if the agents accept some ethical values outside the market system (Brodbeck 2011, pp. 50f). Economists discuss these issues as "transaction costs."
6. Another less obvious ethically relevant aspect could be that the markets modelled in some economic studies[22] usually do not include the minimum wages of labour markets. Different viewpoints of equity concerning working conditions and wages can considerably impact market dynamics.
7. In more general terms, the way that individual goods and services are valued in markets also implies a set of ethical values. In line with the neoclassical model of rationality, concepts like "consequences," "utility" and "libertarianism" are decisive for the theory of market-based valuations. Neoclassical economists often regard the outcome of free markets as something that is ethically good, based on their libertarian perspective. In reality, however, market outcomes (or wages for workers) are always determined by numerous other factors as well. Anderson (1990) points out that the market-based (usually monetary) valuation theory is impersonal and neglects other typical forms of valuations in human life, for instance, valuations based on personal relationships.
8. Finally, Brodbeck argues that participation in markets forms our ethical values and worldviews. Possibly, market participation (i) makes us accept property rights and fairness; (ii) helps being more tolerant and peaceful towards other cultures and nationalities due to international trade relations and (iii) leads to more self-interested behaviour and materialism (Brodbeck 2011, pp. 50f).

The complex and rarely transparent relationship between values and the free market can be summarised as follows (see Dutt and Wilber 2010, pp. 103f): (a) participation in markets influences our values; (b) free markets are dependent on the ethical values accepted by market agents; and (c) following values *other* than the "neoclassical ones" can have a significant impact on the theory of how markets work and what outcomes they produce and should produce. Again, it should be made clear that identifying such often opaque value judgements is not intended to criticise IAM assumptions *per se*, because these ethical and other assumptions can

[21] For further reading and literature on "trust" see Nooteboom (2009).

[22] However, the three IAMs introduced in Chap. 7 are "social planner" models and do not model markets as such.

possibly be well justified. Instead, the idea here is to make them more explicit and transparent, for the reasons provided above.

8.3 Welfare Economics and Goals in IAMs

The following sections will analyse the more specific ideas of welfare implied in IAMs, which are always related to value judgements, as Sect. 8.1.2 pointed out.

8.3.1 Welfare-Related IAM Functions and Results

In the MIND model (Edenhofer et al. 2005), an intertemporal, aggregated social welfare function is maximised[23]:

$$W = \int_{t1}^{t2} e^{-\rho(t-t_1)} L(t) 1n \frac{C(t)}{L(t)} dt \tag{8.1}$$

$$max W \,!$$

DICE-2007 (Nordhaus 2008, p. 205) uses the following objective function W[24]:

$$W = \sum_{t=1}^{T_{max}} U\left[c(t), L(t)\right] R(t) \tag{8.2}$$

with

$$R(t) = (1+\rho)^{-t}$$

$$U\left[c(t), L(t)\right] = L(t)\left[c(t)^{1-\alpha} / (1-\alpha)\right]$$

$$\mathrm{c(t) = C(t) / L(t)}$$

Although the welfare functions look different in MIND and DICE, they follow exactly the same understanding of welfare (as does the PAGE2002 model). Both models attempt to maximise welfare understood as a globally and intertemporally

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[23] With W = objective function, t = time, C(t) = consumption of goods and services within a period of time, L(t) = labour within a period of time (labour is equivalent to population, at least in the ReMIND variant, Bauer et al. 2011) and ρ = pure time preference (see Sect. 8.4).

[24] With α = elasticity of marginal utility of consumption and L(t) = population, proportional to labour inputs. The model variant, RICE (region-based Dice), uses a similar approach.

aggregated utility (discounted over time, see Sect. 8.4). Utility is understood as per capita consumption, C(t)/L(t), with diminishing marginal utility of consumption per capita. Thus, according to (Re)MIND and DICE/RICE, welfare rises with total per capita consumption. Bringing this together with what was said about welfare economics in Sect. 8.1.2, it becomes clear that this is a utilitarian welfare function that more or less follows the older welfare economics. Through these welfare functions, the IAMs clearly imply (disputable) normative-ethical judgements.

Since both MIND and DICE are general equilibrium models, the result of the model runs is always Pareto efficient (if climate change impacts as externalities are internalised in the scenarios), following the theorem of newer welfare economics as presented in Sect. 8.1.2. The model results are thus about efficiency.

A typical category of IAM model results is "costs" (see Sect. 7.4 on this term). Costs are usually reported in comparison to a baseline (the "business as usual" path). In addition to welfare costs, macroeconomic and abatement costs (global or regional costs of mitigating CO_2 emissions) can also be provided by the IAMs mentioned above; therefore, one has to be careful when providing policy advice, because different studies report different kinds of costs (Edenhofer et al. 2010). The unit used for costs is usually the losses of Gross Domestic Product (GDP). Criticisms of GDP as an indicator can be categorised as follows (Brümmerhoff 2007, p. 276): (1) GDP comprises also elements that *diminish* welfare; (2) GDP comprises other elements that only compensate for diminutions of welfare; and (3) GDP does not comprise certain other elements that have an effect on welfare. Moreover, the value of increasing welfare, and particularly the quality of growth, are presently the subjects of heated debates.[25]

8.3.2 Further Comments on Welfare Issues in IAMs

Three major criticisms of utilitarian approaches, such as the above IAM welfare functions, are (1) the inter-personal utility comparison, (2) the disregard of distributional aspects (due to aggregation) and (3) the disregard of procedural issues (see Sen 1999 and Giersch 1993, pp. 146–180). Note, however – and this is also true for libertarianism and related ethical standpoints in mainstream economics – that, from a historical perspective, such standpoints are (sometimes coarse) attempts to draw attention to ethically important aspects and, therefore, should not only be criticised, but also appreciated in this regard. For instance, utilitarianism has its strength in overcoming poverty and misery, while the strength of libertarianism lies in fighting tyranny and paternalism. In addition, the partly normative and crucial idea of

[25] There is much literature critically discussing GDP (even though GDP, as a flow variable, originally was not developed to provide information on welfare, see Brümmerhoff 2007, p. 276). Collections of arguments against GDP include Kleinewefers (2008, pp. 245f), Nordhaus and Tobin (1973), Beckerman (2011, Chap. 9) and Dutt and Wilber (2010, Chap. 9).

efficiency can be justified by arguing that nowadays, the waste of resources is ethically unacceptable in most cases.

Yet, from an ethical perspective, it becomes particularly clear how disputable the social welfare functions employed in IAMs are when one compares them with hypothetical alternative approaches to welfare measurement and operationalisation, which reflect a larger set of societal targets. This is relevant because

> [t]here are innumerable ways that a person's welfare can be promoted, such as better personal relationships, increased knowledge and skill, relief of poverty, improved health, and improvements in the society around him or her, such as greater peace or tolerance (Beckerman 2011, p. 3).

Even Bentham had a broader understanding of welfare than most of modern economics (Bentham 1907, Chap. III). Without stating that they would be better choices, alternative approaches could theoretically be based on: aggregated wealth, distributional justice (e.g., equality or distribution according to Rawls 1971), balance of payment adjustments, sustainability, stability of prices, growth and full employment, etc. (Kleinewefers 2008, pp. 180f; 240f). An operationalisation via the "Human Development Index" of the World Bank, which includes the aspects of health, education and material wealth, might also be an option. An example of an attempt to incorporate a larger set of societal targets are the OECD social indicators (OECD 2011). Some recent approaches, such as the anti-paternalistic happiness approach already mentioned in Sect. 8.1.2, attempt to combine micro- and macroeconomic perspectives by directly asking people about their preferences regarding social welfare indicators (Kleinewefers 2008, p. 58).

Since all of these alternatives also may have severe downsides and would be difficult (or impossible) to operationalise for IAM calculations, the point is not necessarily that every modeller must implement many different concepts of welfare in IAMs (which is infeasible). Rather, the strengths and limitations of welfare functions, and especially the implied value judgements, should be made transparent. Fortunately, the transparency of major normative assumptions related to welfare economic has much improved in recent years in IAM-based publications.[26]

Furthermore, also the application of the welfare functions in IAMs is associated with the huge difficulties of operationalisation, and of determining total interdependencies of economies (i.e. general instead of merely partial equilibrium) (Kleinewefers 2008, pp. 56, 61). This operationalisation as well as the determination of interdependencies are also always value-laden (see Sect. 8.4 for examples).

Moreover, it is unclear how the results of a "social planner," as is assumed in the IAMs analysed here, can be implemented in practice, since we (fortunately) do not have a unitary global social planner. One may criticise such social-planner assumptions in IAMs for indirectly suggesting that a real-world social planner, i.e. a dictator, would be the best solution regarding global climate policy.

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[26] The model comparison study by Edenhofer et al. (2010, p. 30) is an example of a case where at least some basic, ethically relevant limitations are made transparent.

To conclude, welfare-related assumptions in IAMs are highly value-laden and require transparency because they are disputable and sometimes problematic.[27]

8.4 Further Ethical Aspects of IAMs

There are many other ethically relevant assumptions in IAMs and in the studies that report IAM-based results. Meanwhile, there is a considerable body of literature that is reporting and discussing such value-laden assumptions in IAMs (however, sometimes without employing a consistent theory of value judgements).[28] Without fully discussing them, I will mention some critical IAM aspects that can be found in the literature in order to get a better impression of the diversity of value(−related) judgements in IAM-based studies, including those that belong to the second and third type of value judgements (see Sect. 7.3.2).

8.4.1 Global Justice

At first sight, the utilitarian objective functions of MIND and DICE suggest that the distribution of consumption or utility does not matter for welfare. Rather, only aggregated consumption, utility, GDP, etc. seem decisive. Large parts of modern political philosophy would criticise IAM-based studies for neglecting distributive issues, for instance by defending the normative idea of equality (Kymlicka 2002). Questionable normative assumptions concerning distribution are, however, sometimes just *opaque* and merely implicit in IAM-based studies.

One example is the variable L in DICE. This variable (see Sect. 8.3.1) does not merely reflect population numbers, but also the different labour inputs of people (Nordhaus 2008, p. 207). This means, roughly speaking, that the value of the

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[27] Many more examples are discussed in the literature. Kleinewefers (Table 3.1, 2008, p. 59) provides a helpful overview of normative judgements found in different approaches to welfare economics. Box 2.1 concerning welfare functions in the Stern Review (Stern 2007, p. 30) is also helpful. Here, Stern acknowledges that his approach is "not always consistent with ethical perspectives based on rights and freedoms. But the approach has the virtue of clarity and simplicity, making it easy to test the sensitivity of the policy choice that emerges to the value judgements made. It is fairly standard in the economics of applied policy problems and allows for a consistent treatment of aggregation within and across generations and for uncertainty." For a broader discussion on the ethical aspects of neoclassical consumer choice theory, see Hodgson (2001). Sen (1982, p. 328) offers a critique on welfarism – i.e., on the idea that individual utilities are ethically decisive for evaluating social states – as well as a critique on Pareto's welfare economics (Sen 1970). The ethical anthropocentrism in welfare economics has rarely been criticised yet.

[28] See Schneider (1997) for one of the best articles on this topic, as well as Schneider (2005), Sanstad and Greening (1998), Broome (1992), DeCanio (2003), Nelson (2008), Füssel (2007), Ackerman et al. (2009), Stanton (2011), Weyant (2009), Heal (2009), Hope (2005), Hof et al. (2008), Sluijs (2002), Tavoni and Tol (2010) or Edenhofer et al. (2010).

well-being of a person in Bangladesh is much smaller than that of a US citizen, due to the focus on productivity. Consequently, climate change damages to poor people are less "important" than those to wealthy people.

A similar effect from an ethical perspective is produced by the so-called "Negishi welfare weights." These are technical tools employed in some IAMs to avoid any income redistribution across (model) regions. Negishi weights only play a role in regionally disaggregated IAMs, such as ReMIND, for instance. IAM modellers using Negishi weights in IAMs regard income redistribution as a policy issue that should not be addressed by economic studies on climate policy issues.[29] Yet, due to the inconspicuous IAM assumption of diminishing marginal utility, which makes utilitarianism a bit more egalitarian in the long run, the global social planner assumed in these IAMs tends to (given some conditions) redistribute wealth from wealthier to poorer regions over time. This is due to the fact that the marginal utility of a further unit of consumption is higher for people in poorer regions than in wealthier countries. The use of Negishi weights aims to counteract this tendency of these IAMs.

> Negishi weights freeze the current distribution of income between world regions; without this constraint, IAMs that maximize global welfare would recommend an equalization of income across regions as part of their policy advice. With Negishi weights in place, these models instead recommend a course of action that would be optimal only in a world in which global income redistribution cannot and will not take place […;] if consumption is assumed to have diminishing returns to utility, the only way to achieve the Negishi result – such that a dollar has the same impact on utility regardless of the region's income per capita – is to weigh the welfare of richer regions more heavily than that of poorer regions (Stanton 2011).

Implicitly, both the variable *L* in DICE and the Negishi weights (e.g. in ReMIND) do not only accept the (problematic) status quo concerning the distribution of wealth, but also, to some extent, the conditions under which commodities are produced in certain regions (child labour, discrimination of women, etc.; see Beckerman 2011, p. 229).

The "big trade-off," as it is often called, between efficiency and equality is thus not only crucial to the ethics of economics in general, but also for IAM results. "Basic economic models tend to ignore the importance of the initial endowments in determining the pattern of relative prices" (Beckerman 2011, p. 56). Initial endowments include the factors of production. "In a general equilibrium model different distributions of initial endowments will influence market prices and outputs in many ways," and this "would lead to different utility possibility frontiers" that are Pareto-optimal (Beckerman 2011, p. 55). Moreover, "some policy measures designed to improve equality […] will tend to improve economic 'efficiency' rather than reduce it. But it is generally assumed that there is a conflict between equality and efficiency" (Beckerman 2011, p. 27). The neoclassical assumptions on the relationship between efficiency, allocation and distribution – the classical Ramsey model

[29] See Stanton (2011) for a detailed technical explanation of Negishi weights in IAMs as well as a critique on them.

assumes a clear separability of allocation and distribution – are increasingly criticised regarding the modelling of climate policy options (e.g., Siegmeier et al. 2015). Defending the status quo can also be based on the idea that the wealth of regions is a function of effort. However, on an individual (micro) level, luck and birth are among the *main* reasons why people become rich, instead of through effort and right choices (Dutt and Wilber 2010, p. 180). All of these issues are frequently not made fully transparent in IAM-based studies.

8.4.2 Equity Weights and Discounting the Future

"Perhaps no issue in economic modeling of climate policy is more controversial than 'discounting'" say Sanstad and Greening (1998). Indeed, no other topic is more discussed in the literature on IAMs in recent years than discount rates. The Stern Review (2007) in particular triggered an interesting debate between leading economists on how to deal with such value-laden assumptions.[30] Discount rates are assumptions in economic models to calculate the present value of benefits or costs that accrue in the distant future (e.g. in 2100). There is a variety of reasons why the costs and benefits faced by future generations are discounted in economic models. Among the most important reasons are (Beckerman 2011, pp. 195f): (1) impatience (pure time preference, which is merely selfishness); (2) assumed higher consumption and wealth in the future due to the assumed (but highly uncertain) economic growth, which would mean less marginal utility for future generations (while they could also be worse-off, inter alia due to climate change impacts); and (3) the general uncertainty about future events – expressed also by some proverbs, such as "A bird in the hand is worth two in the bush" (Beckerman 2011, p. 196).

In the Stern Review, the discount rate plays a central role, is made explicit and discussed there. Stern chose a relatively low discount rate, which had a huge impact on the results of his influential IAM-based study. The discount rate in general has an enormous impact on IAM results concerning mitigation costs (Nordhaus 2008; Beckerman 2011, pp. 8f). Why is discounting normative, and thus ethically relevant? IAM-based climate policy scenarios often analyse policy outcomes in the distant future (2100 and beyond). This involves *inter*-generational ethical questions that can be addressed by discounting. Should we care about future persons (i.e., those not yet existing today)? If we do, should we care about them *less* than about our contemporaries, because there are also huge problems at present, such as world poverty, and because climate change impacts in the distant future are highly uncertain? PAGE2002, MIND, DICE and other IAMs make use of the so-called Ramsey equation to address these intergenerational ethical issues:

$$r = \delta + \eta g \tag{8.3}$$

[30] Dasgupta (2007); Weitzman (2007); Nordhaus (2007); Dietz et al. (2009); etc.

where g = expected future growth rate of per capita consumption, δ = pure time preference (in terms of a discount rate for welfare or utility), η = elasticity of utility with respect to consumption and r = the social rate of discount (Stern 2007; Beckerman 2011, p. 201).

While Stern and others (e.g. Parfit 1984, Appendix F) argued that uncertainty is the only acceptable reason for discounting, if at all, others have criticised Stern heavily, arguing that market interest rates are much higher than Stern's social discount rate. The difficulties associated with using a real-world "descriptive" market interest rate instead of *r* are numerous. As Broome argues (1992, pp. 67–77),[31] "there is not one, unique, market rate of interest;" different actors have different rates. Apart from this, as Broome explains, (1) market prices and interest rates came into being through processes and states (e.g., unfair initial endowments/distribution) that can be criticised normatively; (2) the market price cannot be taken as the aspired shadow price due to many market distortions; (3) "[s]ocial risk is invariably much less than an individual's risk" due to aggregation, which can lead to higher discount rates (less saving) for individuals compared with the social optimum; (4) market actors take into account taxes when discounting, but society should not, since taxes are merely redistributions; (5) differences between (i) one's own (individual) and (ii) the societal risk assessment due to the so called "isolation paradox" of rational choice; (6) market rates of interest only reflect short-term valuations; and (7) ethically, the expected preferences of future people, which are *not* expressed in current market rates of interest, should be decisive *rather than our individual preferences today*. Since future persons cannot state their preferences, economists, however, usually assume them to be the same as ours today. For these and other reasons, market rates of interests are usually considerably higher than societal discount rates in IAMs. This makes discounting a perfect example of how IAM economists are inevitably confronted with normative questions, both with the ethics of δ and η.[32]

The issue of discounting is much more complicated than what can be discussed here. To sum up this topic, it is both an example of unavoidable value judgements in economics and of how certain model assumptions cause complex ethical problems simply due to their mathematical structures. Different from what Dasgupta, Stern and others suggest, it is misleading to seek one single discount rate, i.e., to search for the "appropriate" δ and η that can be fully justified ethically, for there are too many purposes in IAMs that discounting has to fulfil simultaneously. Yet, rejecting the normative idea of *pure* time preference, with δ being zero, does not necessarily imply that discounting *as a whole* is wrong (Broome 1999, p. 44).

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[31] Similar arguments can be found in Kleinewefers (2008, p. 225), but he argues that the social discount rate should not be too far away from the market rate of interest, otherwise there are incentives for sub-optimal investments reducing economic growth. Without growth it might be more difficult for future people to overcome their societal problems (Beckerman 2011, p. 206).

[32] Montuschi (2014, pp. 130–134) clearly points out several normative-ethical issues of Stern's discounting. For an ethical discussion of discounting, see Caney (2009); Meyer (2010); and Kowarsch and Gösele (2012). Some scholars have proposed alternatives, such as a variety of discount rates, e.g. a higher one for Africa to overcome poverty (Beckerman 2011, p. 206).

8.4.3 Evaluating Practical Implications of Policy Means

As the second type of ethical assumptions in IAM-based studies (Sect. 7.3.2), it is crucial to make (the evaluation of) the practical implications of policy means transparent in scientific studies and assessments. This allows for an appropriate evaluation of policy means and objectives. However, the implications, especially the side effects and co-benefits of the technological means (e.g. bioenergy, geo-engineering, etc.) of achieving ambitious climate policy goals, or of particular economic and policy instruments (e.g., carbon taxation), are still under-researched and, therefore, cannot easily be made transparent in IAM-based studies (von Stechow et al. 2016). These co-effects of the policy means are, however, highly relevant from an ethical-societal perspective. The transformation of the world energy system towards a carbon-free economy might imply many social and other conflicts (e.g. the reaction of economic losers to this transformation), but also co-benefits such as improved air quality through reduced fossil-fuel deployment, that have been largely neglected by many IAM-based studies. IAMs do not have to address all of these issues; but the lack of doing so (i.e., the limitations of the IAM) should be made transparent due to the potential normative implications (Sect. 7.3.2). Fortunately, more recent IAM-based studies explored some practical implications of technological options and policy instruments to achieve climate change mitigation goals, without claiming comprehensiveness (see examples in Sect. 7.4).

Ethically relevant implications of policy means can also be exaggerated in IAM-based studies. For instance, some studies conclude that ambitious climate change mitigation is impossible or “unaffordable” without CCS, but “unaffordable” is a disputable value-laden judgement and a thick ethical concept.

8.4.4 Risk Management and Decisions Under Uncertainty

The identification of uncertainty, and its transparency, are discussed in Chap. 9. This section very briefly discusses possible *reactions* to uncertainty and risk as an ethical issue – as examples of the third type of ethical value judgements (Sect. 7.3.2). Not to mitigate climate change because of the high uncertainties related to climate impacts, for instance, is a decision that is based on the highly disputable ethical standpoint that one should only act when things are certain.

The rationality of the social planner in the above mentioned IAMs (or the social planners of different world regions in disaggregated IAMs) indirectly implies a way of reacting to uncertainty and risk. For instance, the value of δ in Stern’s discounting (in PAGE2002) is not zero because there is, as Stern argues, uncertainty as to whether people in the distant future will actually exist or not. This is but one example of a (sometimes opaque) value-laden assumption in IAM economics that is related to dealing with uncertainty. In general, the political interpretation of uncertainty – for instance, should we act even though climate impacts are highly uncertain – is clearly value-laden, for instance when following the (in Europe widely accepted, but disputable) precautionary principle (Gardiner 2006).

The economic theory of rational choice provides a wide range of concepts and tools for decision under uncertainty. However, these approaches always imply an ethical point of view and that traditional approaches seem to fail in addressing the more complex and long-term issue of climate change, which is related to catastrophic risks and "future large-scale discontinuities" such as tipping points (see Sect. 2.2.1; Betz 2009; Weitzman 2009). It has almost become a truism that risk governance is extremely complex in the context of climate change.

Furthermore, the determination of "risks" themselves (for instance, the risk of endangering food security when too much biomass is needed for ambitious climate change mitigation) is a highly normative issue, as risks are usually understood as *unwanted* possible practical implications of various options for action. Hence, normative judgements are also implied when IAM-based studies present alternative scenarios of how to respond to risks. Moreover, if IAM-based studies only present mean values instead of the full range of possible outcomes under risk and uncertainty, the Rudner-Douglas argument comes into effect again (Sect. 5.2.4), inasmuch as mean values, as decisions under uncertainty, imply normative-ethical judgements that would require transparency and careful scrutiny.

8.4.5 Non-economic Values and Ethical Gaps in IAMs

A cross-cutting aspect of the value saturation of IAM-based studies lies in their valuable integration and evaluation – or the lack of it – of different policy fields, goals and aspects that socially matter. Climate economics is embedded in integrated assessments, which already indicates that economics is leaving its traditional arena here, i.e., what is traded in markets, for a highly interdisciplinary approach.[33] Ideally, given the refined pragmatic model from Chap. 6, IAMs would assess the relevant ethical, social, political and other aspects of climate policy options. As shown in Sect. 2.2, there are many essential interdependencies with other policy fields (von Stechow et al. 2016). This is particularly obvious when considering the recent multilateral adoption of the highly interlinked, global Sustainable Development Goals (see Chap. 1), in which climate policy should ideally be embedded.

Normative questions quickly arise, for instance, concerning how to value ecosystems, biodiversity, health issues, human lives in general (see, e.g., Broome 1978), etc., and particularly, how to value these things in comparison with, or in terms of, GDP and other economic units of measurement.[34] Besides monetarising nature,

[33] Interestingly, also the concept of 'development' has shifted its meaning from mere economic growth to more emphasis on distributional aspects and well-being, as well as environmental issues (Dutt and Wilber 2010, p. 207).

[34] This is particularly true if IAMs use damage functions. Moreover, see the interesting project at http://www.teebweb.org/ or the "Copenhagen Consensus" exercise at http://www.copenhagencon-

most IAMs also inevitably make implicit (or explicit) value judgements about the much disputed issue of the substitutability of natural and social capital. For instance, to what extent can the loss of rainforests, in terms of social welfare, be compensated by GDP increase? Some also criticise the assumed "imperialism" of economic methodology; methods such as cost-benefit analysis (CBA), for instance, are widely applied *beyond* the traditional economic realms of study (Füssel and Mastrandrea 2009). It is often questionable as to whether the standard economic tools are fit for purpose in highly integrated, interdisciplinary IAMs. The Negishi weights, L in DICE, discounting and other ethically delicate IAM assumptions were originally developed for the valuation of commodities or certain market phenomena in relatively isolated and simple economic environments; now, these methods and assumptions are being applied to IAMs that are supposed to be tools for evaluating highly complex, multi-dimensional and disputed policy options.

Some critics, however, make it too easy for themselves when arguing that different kinds of values (environmental, cultural, social, economic, etc.) cannot and should not be compared in economic terms at all. Whenever a policy decision is to be taken, a comparative valuation is absolutely necessary; weighing different kinds of goods is at the heart of most political decisions. However, not everything can be reasonably valued with a single (quantitative or pseudo-quantitative) metric, such as in monetary terms.[35] A rational choice in such cases does not necessarily require commensurability, but only comparability (Beckerman 2011, p. 97). In this regard, although IAMs are helpful tools to facilitate an integration and evaluative comparison of different socially relevant aspects, they are limited as tools for such integration, and partly require further development towards even more integration. As Sect. 7.4 stated, IAMs can only integrate societal values that are transformed into commensurable quantitative values (with a uniform metric).

Thus, if IAMs are taken as instruments for a *comprehensive* assessment of policy options, then many policy issues are missing in IAMs. These could be called ethically relevant gaps. An example is provided by the IPCC AR4 (see also the examples provided in Sect. 8.4.3 already):

> For agriculture and forestry, top-down estimates are lower than those from bottom-up studies. This is because these sectors are generally not well covered in top-down models (IPCC 2007, p. 77).

Other ethically relevant gaps include the cultural aspects of poverty, or governance issues such as unfair and corrupt regimes, which are not really addressed in IAMs.[36] Consequently, both the selection (or omission) of socially relevant aspects

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sensus.com/ (both accessed 3 Mar 2015) as examples of such an integration and evaluation – without however suggesting that these are best practices.

[35] The discussion about cost-benefit analysis versus cost-effectiveness analysis in IAMs (Sect. 7.2.2) perfectly illustrates this issue. See Chang (1997) for the question of (in)commensurability of plural values (values require a common numeraire to be commensurable).

[36] A more fundamental normative implication of IAMs is the assumed need for governmental institutions, e.g., to regulate market failure and distortions. Some radical libertarians might not agree with such an active role of the state. Beckerman argues, "although market failure may constitute a

taken into account in IAM-based studies, and their evaluation, require normative-ethical judgements in these studies. These judgements could be made more transparent, which should also include the many thick ethical concepts.[37]

8.5 And So What?

Based on the framework for identifying value judgements developed in Sect. 7.3.2, and based on the background information on different approaches to welfare economics (Sect. 8.1), we found several (mostly inevitable per se, but disputed more specifically) ethical value judgements of all types implied in the IAM-based economic literature which were not always made transparent. The objective functions as well as the core restrictions and assumptions have virtually always been made explicit in these studies. Furthermore, there is an increasing awareness among IAM modellers about implied value judgements, which has actually led to considerably increased transparency of, and reflection on, value judgements in recent IAM-based literature. Nonetheless, many of the above mentioned value judgements – and others not mentioned herein – have still not been made sufficiently explicit in many IAM-based studies. Maybe because some of these assumptions are too natural for mainstream economists, or more likely, because they are not aware of them. Full awareness and full transparency regarding such value judgements have not yet been achieved in climate economics.

Values clearly shape the direction and assumptions of IAMs, which underpins the hypotheses made in Sect. 5.2 on the inevitable fact/value entanglement in the sciences in general. This also makes clear why some stakeholders and researchers have reservations against social-science policy evaluations, given their inevitable value saturation. However, the sheer finding that IAMs, as social-science contributions to climate policy debates, imply value judgements, does not, as such, qualify as a criticism of IAMs. Again, revealing value judgements is not to criticise IAMs, but to make their ethical implications more transparent.

However, as the above discussion on welfare implications in IAMs also revealed, the "mainstream" economics followed by most IAMs implies a one-sided, partially questionable set of ethical viewpoints (usually only utilitarian or libertarian values)

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prima facie case for public intervention, government failure is equally notorious in many situations. The normative significance of market outcomes in some cases may well be weak, but the public sector is also likely to be inefficient in some broad sense and the choices made by public decision-makers in many situations may be just as irrational as those made by ordinary citizens" (Beckerman 2011, p. 49).

[37] Myrdal (1898–1987), a Swedish economist and Nobel Laureate, already identified crucial economic concepts as thick ethical concepts: economic productivity, equilibrium, balance, rationality, optimality, utility, development, efficiency, etc. (Dutt and Wilber 2010, p. 21). One could add the concepts of scarcity and goods (Robbins 1945). Even the widely used concept of CO_2 equivalents is based on value judgements implied in the typical economic methods of (intertemporal) valuation that are used to define the CO_2 equivalents.

which does not cover the relevant aspects and standpoints comprehensively enough. In several cases I have indicated possible alternative ethical viewpoints that could be employed by IAM-based studies as well.

To use again the analogy from Chap. 7: If a cook (i.e., the IPCC) can only serve what the butcher (i.e., ethical values implied in neoclassical economics) is offering, it would be very difficult for the cook – i.e., an IPCC AR as explorer of alternative policy paths, including their consequences – to show that vegetarian cuisine (i.e., other sets of values) can also be a tasty option. For most people, not only *economic* well-being is relevant to their idea of welfare but also other values such as relationships, distributional justice, social order. IAMs pretend to present a welfare analysis of climate policy options, but in fact, they do not cover the full range of multiple objectives that constitute social welfare for many people. Since the IAMs discussed above primarily address long-term mitigation issues, their one-sided ethical assumptions might have implications for climate policy-making, for instance, in terms of setting a global temperature goal. In the extreme case, *hypothetically*, if many economic studies showed that a 3 °C goal is optimal in terms of costs and benefits, this could be misleading for policymakers and the public as such a conclusion may be based on one-sided value judgements in IAMs.[38]

What to do with value-laden IAM economics?

It is not possible to solve the problem of value-laden economics simply by referring to the values held by policy advice clients. Beckerman's humorous, fictitious dialogue between an economist (as a policy adviser) and a politician makes it clear why it is not easy for economists to simply offer means to given targets (Beckerman 2011, p. 26). With a horrified expression on his face, as Beckerman's story tells us, the politician rejects several policy means proposed by the economists, in each case referring to their politically or socially intolerable side effects. "OK," says the economist, "I give up. I am going off to find a different job in which I do not tread on somebody's moral sensibilities whenever I try to solve their problems" (Beckerman 2011, p. 26). As a result, as Beckerman concludes (p. 26), it is "virtually impossible for an economist to play the role of an impartial technical expert." Machlup (1969) also argued that economics could never be free from its own value judgements when advising policy makers.

> The reason for this is that situations will inevitably arise in which the economist must substitute his own value judgments (which he will generally assume are those in the best interest of society) for the value judgments of his real or hypothetical clients. Such situations occur because it is generally impossible to fully and unambiguously specify the client's objectives, except in the most restricted and artificial cases (Weston 1994, p. 9).

One can only successfully deal with value-laden IAM economics if one accepts that economists cannot avoid making value judgements. As Chaps. 5 and 6 have

[38] Millner (2013) draws a similar conclusion. Note that in the present chapter, I did not analyse IAM-based literature as a whole (rather, I performed spot checks) and therefore cannot justifiably state that there is a severe bias in the literature as a whole. But, having discussed some highly influential IAM-based works, there is actually some bias and some lack of transparency.

argued, economists should then ideally explore the practical implications of alternative disputed normative assumptions to allow for learning. Agreeing with some of the points made by Weston (1994, pp. 4–14) to some extent, economists should nonetheless keep in mind a couple of things. (1) Despite the fact/value entanglement, moral and analytic-descriptive questions are two different kinds of questions that should still be distinguished, for practical reasons. (2) Economists must make important normative assumptions transparent. This claim is endangered when *everything* in economics is deemed "normative." (3) Scientifically interesting controversies should not take place in (ideological) terms of "good" versus "evil," as was sometimes the case with capitalism versus communism. This could, however, happen when economics as a whole is declared a largely normative discipline. (4) *Objective* economic results should still be envisioned.

Allegedly objective descriptive economic assumptions regarding, for example, the economic growth rate in the twenty-first century are certainly not more reliable than, for instance, the moral claim to not seriously harm other people through climate change. Both factual and normative statements can be objective (or subjective), and both are always value-laden (as well as fact-laden). Thus, for the IAM-based literature, this does not mean that it would be good to avoid value judgements wherever possible,[39] but instead, to make the main value judgements in such studies transparent and thoroughly reflect on them along the pattern of enquiry presented in Chap. 6, in order to identify the most defensible ethical values. This may require the revision of the normative assumptions predominant in current IAMs, or at least a broader diversity of such assumptions. Despite all the valid criticism and limitations of IAMs, however, the future world normatively envisaged by IAM objective functions is surely preferable to the future world presumably resulting from currently existing, real-world climate policies and trends.

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[39] Economics usually claims to follow the sequence of "effectiveness – efficiency – justice" when developing policy options. Economics allegedly provides answers to the first two steps and society then decides about issues related to ethics and justice. The first two steps, however, already imply a lot of ethical issues, as seen above.

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Chapter 9
Trust Them? The Epistemic Quality of Climate Economics

Abstract This chapter evaluates the scientific and epistemic quality of integrated assessment models (IAMs) and related economic studies in light of Deweyan-Putnamian pragmatism. This is mainly done by analysing the treatment of three different types of uncertainty (in a broad sense), explained in Sect. 9.1. Section 9.2 discusses technical and methodological uncertainties in IAM-based economic studies. Next, the fundamental methodology underlying IAM-based economic studies is critically discussed from an epistemological perspective, and some refinements are proposed from a Deweyan perspective (Sect. 9.3). The conclusion (Sect. 9.4) regarding the overall reliability of IAM-based results is neither that IAM-based studies provide us with absolutely true knowledge, nor that we, from an epistemological perspective, should completely disregard such economic results in policy-making. Instead, a more enlightened use of uncertainty-laden economic models including IAMs is the goal, based on a revision of economic methodology in light of Deweyan-Putnamian pragmatism. A critical reflection on the predominant viewpoints in economic methodology is indispensable because it is in a worrisome state; economists often cannot compellingly explain what their results mean from a philosophical-epistemological perspective. Pragmatism (Sect. 6.2) might help overcome the disorientation of current economic methodology in several regards, without returning to the dogmatism of positivist methodology.

High scientific and epistemic quality – in the Deweyan-Putnamian sense described in Sect. 6.2 – of the IAM-based economic literature is essential for facilitating reliable scientific assessment reports that build on this literature. Can value-laden and often uncertain IAM-based economics provide reliable and objective (or at least plausible) hypotheses? Or is it rather "junk science"? This chapter will analyse these issues, mainly in terms of the treatment of three very different kinds of uncertainty (broadly understood) in the IAM-based literature. A critical discussion of economic methodology and objectivity is necessary – disagreeing with Samuelson's viewpoint that "[t]hose who can, do science; those who can't, prattle about its methodology" (quoted in Hands 2001, p. 1).

Similar to how some critics (mistakenly) complain about the sheer existence of value judgements in economics, some people do not trust economic results due to the sheer existence of uncertainty in economics. A more sophisticated argument

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states that due to the huge uncertainties in economic models, economics cannot produce more reliable results than literature theory, as opposed to the reliability of the natural sciences (McCloskey 1985). As in the case of value judgements (Chap. 8), I will join the critics here only for a few steps by pointing out some (partly) opaque uncertainties (categorised in Sect. 9.1) in IAMs and IAM-based studies (Sect. 9.2) and by critically discussing the underlying economic methodology (Sect. 9.3). However, among my conclusions (Sect. 9.4) regarding the *overall* epistemic quality of IAM-based results will be neither that IAM-based studies provide us with absolutely true knowledge, nor that we should completely disregard economic results in policy-making from an epistemological perspective. Instead, a more enlightened use of uncertainty-laden and value-laden economic models including IAMs is the goal, based on a revision of economic methodology in light of Deweyan-Putnamian pragmatism.

Overcoming a few technical uncertainties of economic modelling here and there is insufficient. The *major* problems of IAM-based literature regarding reliability lie deeper than that: economic methodology is in a worrisome state, and therefore has to be critically discussed here. The rather philosophical Sect. 9.3 on economic methodology in light of Deweyan-Putnamian pragmatism will deepen the general discussions on epistemology and philosophy of science in Part II. These earlier discussions are of course also valid for the discipline of economics *in principle*. However, a more specific reflection on the philosophy of *economics* and its methodology (Sect. 9.3) is required. Given the methodological differences between different scientific disciplines,[1] we have to find out whether IAM-based economics is, or can be, a reasonable, promising scientific endeavour at all from a Deweyan epistemological perspective, i.e. whether and how economics can come to reliable results more specifically.

Similar to Chap. 8, the main purposes of this chapter are, first, to become more aware of the problems and limitations of existing IAM-based economic studies in terms of (Deweyan) reliability[2]; and second, to help increase the epistemic quality of these IAM-based studies in the future.

9.1 Different Kinds of "Uncertainty"

Roughly spoken, economic results are reliable if their uncertainty is relatively low. There is a lot of literature on how to deal with uncertainty in scientific studies and assessments,[3] although the focus is mainly on the natural sciences (including climate modelling) rather than on uncertainty in socio-economic modelling. There is

[1] Hands (2001). Beyond predicting and explaining, the social sciences also aim at understanding.

[2] This is important both for understanding the related limitations for assessment-making (which is dependent on the material provided by climate economics), and for evaluating how well these assessment processes treated these problems and limitations; see Chap. 10 below.

[3] E.g., Sluijs (2002), Renn (2008), Mastrandrea et al. (2011).

less literature on how to define and understand uncertainty more precisely (beyond the more formal level, e.g. in rational choice theory, statistics, etc.) – perhaps because it raises delicate philosophical questions. Diverse understandings of uncertainty exist, for instance in different scientific disciplines.[4]

I will use the term 'uncertainty' in a *very broad sense*, referring to the scientific and even the epistemic quality of all kinds of statements and assumptions in economic research that are *not fully reliable*, in contrast to 'certain' knowledge. Reliability is understood here in the Deweyan-Putnamian sense explained in Sect. 6.2. In this sense, the term 'uncertainty' also comprises, for instance, cases where possibility ranges or probabilities are not determined (yet). This rather broad understanding of 'uncertainty' is the reason why this chapter on the overall scientific and epistemic quality of IAM-based studies mainly focuses on the treatment of 'uncertainty' in this studies.

According to Frank Knight's highly influential, old distinction, risks are quantifiable and measurable (in terms of probabilities),[5] and uncertainties are immeasurable. Although this volume follows this understanding of risk, uncertainty is used in the broader sense mentioned above, which also implies that risk is only a specific kind of uncertainty.[6] This points to the question of the degree of uncertainty. Between the two poles of certain knowledge and unknown unknowns (complete ignorance)[7] are, for instance, risks where a precise probability can be stated (expectation value); uncertainties where there are at least plausible assumptions, expectation values or a clear uncertainty range; and uncertainties where only a vague and broad uncertainty range (or range of assumptions) can be claimed.

Let me propose a coarse but useful distinction between the different kinds of uncertainties in IAM-based studies, based on Funtowicz and Ravetz (1990, pp. 7–16),and completed with my own thoughts.

(1) *Technical uncertainty*. This understanding of uncertainty is the most common and refers to digits, concrete facts and parameters that can be uncertain and reduced by employing a specific scientific technique (method). This kind of uncertainty includes the so-called parameter uncertainty of IAMs (Edenhofer et al. 2006; Mastrandrea et al. 2011) and refers to both model input and model output. An example of the latter are the stochastic results from PAGE2002 (see Sect. 7.2.2). One should add the type of uncertainty that refers to *qualitative*

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[4] Uncertainty is often simply understood as a lack of knowledge that can be overcome (also known as the deficit view of uncertainty). The IPCC WG III AR4 (IPCC 2007, pp. 132–134) and AR5 (Mastrandrea et al. 2011) offer more differentiated approaches.

[5] The Knightian understanding of risk – together with the assumption that risk always refers to one or more unwanted outcomes – is predominant. See Hansson (2011) for different understandings of the term 'risk.'

[6] Some scholars attempt to distinguish between epistemic and ontological uncertainties, but because of the questionable metaphysical implications, I will not use this distinction here.

[7] The possibility of complete ignorance about certain aspects or mechanisms in the world is also a kind of uncertainty, if understood in this broad sense.

(instead of quantitative, model-based) statements about individual and specific aspects of reality, for instance, expert estimates of risks.

(2) *Methodological uncertainty*. This type of uncertainty is a matter of choosing appropriate particular *methods* and *theories* for individual IAM-based studies. Different specific methods or economic approaches might come to different results concerning climate change mitigation costs, even if they use identical parameters.[8] In terms of IAMs, this category is sometimes called "model uncertainty" (Edenhofer et al. 2006; Mastrandrea et al. 2011) as it can refer to the model structure itself.[9] Such uncertainties might be reduced through methodological reflections; this is the reason why this type is called 'methodological uncertainty.'

(3) *Epistemological uncertainty.* This type of uncertainty mainly refers to uncertainty on the level of methodology choice – for instance in terms of the interpretation of the *epistemic* status of economic assumptions, model results and their interpretations. The critical reflection on this kind of uncertainties necessarily touches on typical philosophical questions of epistemology (e.g., conditions for objectivity, etc.).[10] It requires a critical discussion of economic methodology.

To explore the reliability of economic research, these three types of uncertainty are decisive. While it is impossible here to fully discuss the reliability of every technical assumption in IAMs, or of all the methods and theories employed by IAMs, I will only analyse – through a few examples – to what extent the related technical and methodological uncertainties are made transparent (Sect. 9.2). In contrast, the underlying methodological and epistemological issues (i.e., epistemological uncertainty) can and should be discussed more extensively (Sect. 9.3), because there is only a limited number of such methodologies, and because they are very decisive for the overall reliability of IAMs, as will get clear below.

Furthermore, besides the issue of uncertainty, also errors and flaws (or even fraud) must be avoided in order to achieve high reliability of IAM results. Although I will not focus on particular errors and flaws in this section, a few words are required to explain this issue. Errors and flaws can occur on several levels, parallel to the kinds of uncertainties just introduced: (1) Data and parameters can be wrong, in

[8] The categories of (1) technical and (2) methodological uncertainties are loosely related to the terms (1) 'confidence' and (2) 'significance' in statistics.

[9] Mastrandrea et al. explain, "even 'perfect validation' is only a necessary but not a sufficient condition for the selection of models. 'Ockham's razor' proposes that if a model explains the same empirical phenomena using less specific or more plausible assumptions and parameters than another model, then it can be deemed preferable […]. Yet to this date, the theoretical and empirical foundation of model types within economics remains insufficient to allow for a consensus within the scientific community according to these principles. In other words, under the present state of the art, the uncertainties about the appropriate economic model structure would remain even if there is a consensus on the stylized facts" (Mastrandrea et al. 2011).

[10] Already the choice and interpretation of data, parameters and methods, or the economic problem definition, imply epistemic and cognitive value judgements that can be highly uncertain from an epistemological perspective. Consequently, all three categories of uncertainty can simultaneously be relevant, for example with regard to a particular model output.

both model input and output. (2) The application of a method can be flawed (i.e., not according to the state-of-the-art) or the choice of a method can be fully mistaken regarding a specific research question. There can also be logical flaws in the IAM-based argumentation. As some studies show (e.g., Betz 2007, 2009), this is an often neglected but important evaluative aspect that usually occurs on the level of interpretation of the model results (drawing conclusions). Finally, (3) errors and flaws also occur on the level of methodology, including flawed epistemic or cognitive value judgements.

If IAM-based studies contained such errors, as well as uncertainty in the above sense, this would *at least* have to be made transparent to avoid IAM-based economics being regarded as junk science (see Sect. 7.3.1). Like opaque value judgements, opaque uncertainties (and errors of course) can also be dangerous in scientific policy advice. If policymakers follow economic studies that only *pretend* to provide objective and reliable results –e.g. studies with opaque uncertainties – there is the danger of making a sub-optimal policy decision from a societal perspective. However, the policymakers' (and the public's) considerable yearning for scientific certainty, as well as the technocratic promise by experts to reduce uncertainty (see Chap. 4) may be among the reasons why uncertainties are sometimes not sufficiently made explicit. Moreover, also a poor understanding of the uncertainties might lead to opaque uncertainties in IAM economics.

As already explained in Chap. 6, the issue of value judgements and the scientific and epistemic quality of economic or any other kind of scientific research are not fully distinct, but rather are highly interrelated. They are just different aspects of one and the same thing, namely a successful Deweyan enquiry into, for instance, economic aspects of climate change and climate policy. The transparency and the critical discussion of highly *disputed* (or disputable) ethical assumptions in IAM-based studies are essential also from the perspective of scientific and epistemic quality. While value judgements are not *per se* unreliable, the highly disputed value judgements are often "uncertain" (i.e., unreliable), given the broad meaning of 'uncertainty' described above (although not every contested value judgements is necessarily unreliable and uncertain). To make them more certain and reliable, better arguments are required along the Deweyan pattern of enquiry (Sect. 6.2), which always involves a factual component as well, as argued above. A further example of the close relationship between value judgements and uncertainty is that not making uncertainty transparent can also be interpreted as a social or ethical judgement about uncertainty in the Rudner-Douglas sense (see Sect. 5.2.4 and the third type of value judgements explained in Sect. 7.3.2).

9.2 Opaque Uncertainties in IAM-Based Studies on Mitigation Options

This section briefly examines a few examples of (1) technical (parameter) uncertainties and (2) methodological uncertainties. Epistemological uncertainty will be addressed in Sect. 9.3. Although there is no difference in principle between uncertainties related to the future or present (or past), statements on possible future outcomes regarding socio-economic systems play a central role in IPCC and other assessments and are associated with even more uncertainties (Grunwald 2008). As already said, there are many different and very high uncertainties related to future socio-economic scenarios. One can distinguish between (i) future uncertainties related to a lack of understanding (or a lack of determination) of nature and of the consequences of human actions, and (ii) future (irreducible) uncertainties related to unforeseeable human (political) actions themselves.[11]

Examples of technical uncertainties in IAM-based studies are numerous. Reliable and comprehensive sets of data are rarely available for future scenarios of the energy sector, for example. Therefore, model calibration is essential, but implies much uncertainty. IAMs often provide results in very precise terms (figures and numbers); however, due to the many uncertainties related to the model input and structure, these figures are sometimes misleading because they only *pretend* to be exact. This should be made even more transparent in IAM-based studies. Moreover, in most IAMs, assumptions such as population growth are exogenous. For some IAMs, this is even true for assumptions about GDP growth, evolution of oil prices, technological changes, availability of biomass such as renewable energy, etc. Yet, all of these exogenous assumptions are typically uncertain. The climate models that are integrated into the IAMs are also mostly based on uncertain data sets (Beck 2009, p. 81).[12]

While the exercise of model validation aims at reducing (or understanding) technical uncertainties, model results are called “robust” if they are similar for different kinds of IAMs which is usually explored through model comparison projects (see Sect. 7.2). The latter has to do with methodological uncertainty. Each model makes theoretical and structural assumptions about human behaviour, socio-economic structures, etc. Many of these more fundamental assumptions and theories are uncertain.[13] For example, the IAMs mentioned above follow many of the ideas of

[11] Dunn distinguishes between projections (extrapolations of historical trends), predictions (future scenarios based on theoretical thoughts) and conjectures (intuitive expert estimates). Future scenarios can be potential (e.g., hypothetical extreme scenarios such as global nuclear phase-out), plausible or normatively desirable (Dunn 1994, pp. 190–195).

[12] See IPCC (2011) for technical uncertainties in IAMs concerning the *energy sector*.

[13] E.g., before the new wave of IAM model comparisons started to prepare the IPCC AR5, some IAM-based studies (e.g., Kelly and Kolstad 1998, p. 26; or the earlier works by Nordhaus) had recommended only weak mitigation measures for policy. Beside underestimated climate impacts, this was also due to other uncertainties in these IAMs: “Inflexibilities in the energy systems, shortcomings in applications of mitigation technologies, and myopic investment behavior are among

neoclassical economics, such as neoclassical growth theory in the case of DICE (Nordhaus 2008).[14] Different economic approaches than the neoclassical one – such as the IAM E3MG, which is based on Keynesian thought – often lead to different IAM results (mainly in terms of economic costs of mitigation). Therefore, it is interesting to conduct model comparisons of IAMs that use the same (stylised) facts to compare competing economic theories (e.g., Edenhofer et al. 2006; Creutzig et al. 2012, p. 72). From a methodological perspective, however, the economic method of the model comparison is limited in its ability to fully evaluate the different theoretical or methodical approaches of the IAM community (see Knutti 2010).[15]

Another example of an uncertain theory in many IAMs is that the transformation of the global energy system towards sustainability (i.e. the capacity to adapt) is supposed to happen rather quickly and without substantial barriers, which is highly uncertain, or even unrealistic – also because institutional challenges of policy instruments are usually underestimated in the IAMs. Furthermore, Tavoni and Tol's (2010) criticism of AR4 economics also addresses methodological uncertainties. Particularly uncertain and often criticised are IAM approaches to climate change damage functions, such as in DICE (e.g., Hope 2005, p. 81); they often underestimate damages resulting from climate change. In general, unexpected extreme events of all kinds, which occur relatively often, are underestimated in economic models (see, e.g., Taleb 2010) even though their impact on model results would usually be very high. Also co-benefits seem underestimated.

With these few examples, I do not want to suggest that IAM economics is full of *opaque* uncertainties. Many uncertainties are made transparent, as scientific experts seem increasingly sensitised to the issue of uncertainty. However, similar to the case of value judgements in economics (Chap. 8), there is still some work to be done in terms of making the major technical and methodological uncertainties in IAM-based studies transparent to a satisfactory extent.

9.3 Economic Methodology and Model Theory

This section addresses *epistemological* uncertainty in economics. The question at stake is how reliable value-laden IAM-based economic results are, or can be, in terms of economic methodology, and furthermore if this is made transparent in the economic studies underlying the IPCC's assessments. To address this question, it is

the reasons why low concentration pathways have so far been assessed and achieved by only a small number of models" (Edenhofer et al. 2010, p. 13).

[14] See Sect. 8.2 for the neoclassical concept of rationality (to explain economic phenomena) as another example. Viskovatoff (2004) and Brodbeck (2011, p. 46) discuss the extent to which typical assumptions of neoclassical IAMs are questionable in terms of uncertainties. Quite a few of the points made in Chap. 8 could be repeated here because they are not only ethically disputed, but are often also related to scientific uncertainties.

[15] The choice of specific stylised facts, together with the model calibrations, may already have an effect on the results of a model comparison and should, therefore, be analysed as well.

necessary to reflect on fundamental economic methodology and to understand which methodological approach IAM economists primarily follow, as this will determine their views of the reliability of their results and, with it, what they choose to make transparent or not. Economic methodology is usually closely connected to the philosophy of (natural) science (Frey 2001). In Blaug's words, methodology

> is not just a fancy name for 'methods of investigation' but a study of the relationship between theoretical concepts and asserted conclusions about the real world; in particular, methodology examines the procedures economists adopt for validating theories and the reasons they offer for preferring one theory over another (Blaug 1990, p. 3).

Despite its obvious need, the philosophical reflection on economic methodology and the related cognitive value judgements is not very old.[16] In the 1970s, there were almost no publications about such topics, but then, "[v]irtually overnight" (Caldwell 1994, p. ix), many publications on this issue appeared, and in 1985, the Journal *Economics and Philosophy* was founded. This change was related to the fall of positivism "and no heir was apparent" (Caldwell 1994, p. ix). It was unclear "what set of doctrines might eventually replace positivism" (Caldwell 1994, p. ix). These changes in the predominant standpoints of economic methodology (Sects. 9.3.1–9.3.2, with a critical discussion in Sect. 9.3.3) are sketched below, and are mainly based on Caldwell (1994) and Hands (2001) – with a disturbing and worrying result, as we will see. However, I should add that the discussion below is selective, brief and does not claim any comprehensiveness regarding the highly differentiated discussions in the current literature on economic methodology.

9.3.1 Logical Positivism, Empiricism and Popper

Logical positivism (see Sect. 5.2) and its later development into logical empiricism were the bases for highly influential methodologies in economic history and *still* have considerable influence over economics (although the peak was in the 1930s). Friedman's famous approach developed in the 1950s is also close to positivism (Friedman 1970, Part I).

Logical positivism aimed to achieve unambiguous, objective scientific statements. The core idea was a unified science with one methodology, and even a single method based on empiricism and logical analysis, assuming that "a statement has meaning only to the extent that it is verifiable" (Caldwell 1994, p. 14) and observable.

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[16] Meanwhile, there is a considerable body of literature on economic methodology. Davis et al. (1998) provided a seminal encyclopaedia of economic methodology. Among the most interesting publications are the Friedman collection (1970), Blaug (1992), Hands (2001), Caplin and Schotter (2010), Hausman (2012), Kincaid and Ross (2009), Mäki (2012) and Caldwell (1994) as well as the entire volume 8, issue 1, of the *Journal of Economic Methodology* (2001). An outstanding work is provided by Mooslechner et al. (2004). For a more recent introduction to the philosophy of economics, see Reiss (2013). The philosophy of economics also comprises other topics besides economic methodology (Hausman 2012).

Explanations did not play a big role. The advantage of logical positivism was the provision of "rigorous and prescriptive models" (Caldwell 1994, p. 4). Due to the many problems associated with this approach,[17] logical empiricism was developed, putting more emphasis on theories as a whole. Carnap's logical empiricism suggests *confirmationism* instead of verificationism. The laws of nature, for example, can never be verified in the positivist sense using an inductive approach; at best, they can be confirmed. The related 'hypothetico-deductive (H-D) method' (Carnap and Hempel) of logical empiricism regards a theory as a mechanical calculus with several levels. It is not necessary to prove all of the elements of a theory by referencing observables; rather, the theoretical elements can indirectly become meaningful if the whole theory in which they are embedded is confirmed (Quine-Duhem thesis).[18] Moreover, logical empiricism has developed new models of explanation (such as the deductive-nomological model and the inductive-probabilistic model), although such explanations where completely irrelevant to radical positivists such as Friedman. Logical positivism and logical empiricism in economics are aimed at making economics a strict science instead of merely an art, and (2) regarding economics not only as a theoretical, abstract science (as did Walras, Menger, etc.), but rather as an empirical discipline that inter alia makes reliable predictions (Brodbeck 2011, p. 47).

However, there was no unified positivist view in this period of logical empiricism until the mid-1950s, only common topics (i.e., the role of theories and explanations) and some confusion. There was also a lot of criticism of logical empiricism due to the *still unresolved* problems associated with the role of theory, explanation and dichotomies,[19] and due to the problem of the underdetermination of theories (meaning that theories cannot be tested in isolation, but only together with other theories and assumptions or auxiliary hypotheses; see Hands 2001, Chap. 2). Also Carnap's confirmationism failed (Caldwell 1994, pp. 22f), and Quine's previously mentioned criticism of early and mature positivism (Quine 1953) led to a far-reaching revolution in methodology in the 1950s and 1960s.

Popper, who had a huge influence over post-war economic methodology (Hands 2001), criticised positivism severely in the 1930s "and would never consider himself as a positivist" (Caldwell 1994, p. 20). However, his basic approach to methodology was very similar to the positivist worldview. Although Popper's methodology is much more complicated and differentiated, and was further developed and refined due to criticisms of it (Blaug 1990, p. 5), the most famous claim is *falsificationism* (Popper 1959, pp. 40–42) instead of verificationism or confirmationism: we can never know that we have found the truth; therefore, inductivism does not work. Nevertheless, we can falsify theories and, in Popper's view, all meaningful theories

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[17] Not least the very narrow, empiricist definition of 'fact' that neglected the theory-laden nature of many scientific concepts (see Sect. 5.2).

[18] See for this paragraph Caldwell (1994, pp. 24–26).

[19] Even Hempel, one of the most important logical positivists, later stated that both the analytic-synthetic dichotomy and the sharp distinction between significant and nonsensical sentences must be replaced by a more gradual approach (Hempel 1959, p. 129).

have to be falsifiable.[20] Popper argued for a critical rationalism by assuming that the critique of hypotheses, trial-and-error, and learning from mistakes and bold conjectures promote scientific progress.[21]

9.3.2 Contemporary Economic Methodology

A coarse summary of what happened after the peak of Popper's influence over economics in the 1950s and 1960s could be presented as follows. On the one hand, there was much critique of the empiristic-rationalistic approaches to economic methodology starting in the 1960s and 1970s (Hands 2001, p. 5), led by Kuhn and others. This essentially removed the philosophical basis upon which the foundationalism of empiristic-rationalistic approaches was built and led to a revolution in economic methodology. On the other hand, there was no equivalent substitution for the strict and, therefore, attractive empiristic-rationalistic approaches (logical positivism, empiricism or Popper's falsificationism) with their rigorous and prescriptive models (Caldwell 1994, p. 4). Therefore, these traditional methodologies still prevail to some extent. Let us have a closer look at these two trends in contemporary economic methodology (see also Caldwell 1994, Chap. 5).

How many economic theories would survive a falsification test? And how can we falsify scientific hypotheses that assume an object X exists (somewhere in the universe)? These and other problems of falsificationism might be the reasons why falsificationism is *factually* not really applied in economics (Caldwell 1994; Blaug 1990, p. 4). This assumption was partly confirmed in a study by Wassily Leontief (in 1982, reported in Blaug 1990, pp. 1f), which shows that roughly 65 % of the publications in *American Economic Review* – one of the most influential economic journals – at that time were theoretical contributions without any empirical data. Even Blaug, who defends Popper's methodology, admits that economists like

> theorizing like a game, making no pretence to refer to this or any other possible world, on the slim chance that something might be learned which will one day throw light on an actual economy (Blaug 1990, p. 1).

Furthermore, Popper's theory implies that empirical evidence is "the final arbiter of truth" (Blaug 1990, p. 3). The necessity of *interpreting* empirical data – and the related epistemic value judgements – is neglected (see Sect. 5.2).

> In their haste to eradicate the flights of metaphysical fantasy, which they felt characterized the systems built by idealist philosophers, positivists became dogmatic in their refusal to allow any subjective, qualitative elements to enter into their rational reconstructions of science. That refusal artificially limited their analyses, and created gaps in their descriptions of science (Caldwell 1994, pp. 89f).

[20] "The great tragedy of Science – the slaying of a beautiful hypothesis by an ugly fact" (T. H. Huxley, source: http://en.wikiquote.org/wiki/Thomas_Henry_Huxley, accessed 1 Feb 2014).

[21] See Caldwell (1994, Chap. 4) for the thoughts on Popper in this paragraph.

This and other weaknesses of the positivist and Popperian approaches gave rise to much criticism of these approaches; Kuhn, Feyerabend and Lakatos were among the most important critics. One aspect of the methodological revolution at that time was to reverse the status of methodology itself. Instead of providing prescriptive criteria from the philosophical ivory tower for how the sciences should work (a priori), methodology had the prior task of analysing *factual* knowledge production and learning from it, particularly in the natural sciences, which were still regarded as role models (Hands 2001, pp. 126f). Therefore, each methodological and even methodical monism was criticised.[22] This was related to the "historical turn" and the "sociological turn" (Hands 2001, Chap. 5), which were mainly based on Kuhn's highly influential theory of paradigm changes. Kuhn particularly emphasised the scientific community, paradigm switches and incommensurability (Kuhn 1970, first published in 1962). Sociological analyses of scientific knowledge (Science and Technology Studies, etc.) became emerging fields in the 1980 and 1990s. These fields (although representing a heterogeneous group of scholars and assumptions) claim that scientific knowledge itself is socially constructed (Caldwell 1994, p. xi). This led to the genesis of the second camp (Sect. 5.2.1). Furthermore, economists no longer present their results as laws or theories, but rather only as theorems, models, etc. today (Blaug 1992, p. 138).

In more recent years, Uskali Mäki was among the most influential contributors to economic methodology.[23] He mainly addresses the old, key challenge in economic methodology of how to conceptualise the relationship between unrealistic assumptions[24] and realism in economics; in the 1950s, Friedman (versus Keynes) had stated that the realism of model assumptions does not matter as long as the model predictions are correct. Going beyond Friedman, Lakatos and Popper, Mäki argues that many economic approaches could be reconciled with scientific realism, despite unrealistic assumptions in economics, if one carefully distinguishes between realism – as a meta-theoretical doctrine – and realisticness as an attribute of economic assumptions etc. Mäki's realism "includes the idea that the theories and terms should be considered as *referring* to the real world" (Lehtinen 2012, p. 8), with economic theories being (at least hypothetical) descriptions of the world (against fictionalism and instrumentalism). But Mäki doubts that many economic theories can really be empirically tested (econometric testing etc.), and he doubts that this would be necessary from an epistemological perspective. Another aspect of the relationship between unrealistic assumptions and realism in Mäki's quite comprehensive and fundamental philosophical system ("unified framework" and "full philosophical system," Lehtinen 2012, p. 3) is the method of isolation. False idealisations can support the theoretical isolation of causally highly relevant parts of the

[22] Such a naturalised epistemology, however, assumes a questionable circularity: how can the analysis of what is *actually* done in the sciences be taken, as such, as the guideline for research (Hands 2001, pp. 132–135)?

[23] See Lehtinen (2012) for the following summary of Mäki's methodological thoughts.

[24] E.g., neoclassical assumptions about perfect information concerning market participants and perfectly working markets in general (fully utilised capital, labour, resources, etc.).

complex reality in order to focus on a major factor and to study one mechanism in isolation. Mäki adds, however, that economics are usually well aware of the most problematic assumptions; "economists often recognize what features a more realistic model would have, and they would build one if they only knew how" (Lehtinen 2012, p. 22). In general, among other scholars, Mäki criticised the lack of systematic reflections in the literature on economic methodology in terms of a sound philosophy of the social sciences.

Worrying disorientation in economic methodology

"[N]o single, unified approach has arisen in response to the failures of positivist philosophy of science" (Caldwell 1994, p. 68). Instead, many methodological controversies have arisen in the academic arena. Therefore, Caldwell suggests a "wait and see" strategy, which implies methodological pluralism. Blaug, however, criticises Caldwell's methodological pluralism, which he calls the principle of "let a hundred flowers bloom;" to him, "this seems to be tantamount to the abandonment of all standards, indeed the abandonment of methodology itself as a discipline of study" (Blaug 1990, p. 4). Choosing a theory would then be arbitrary and, according to Blaug (p. 4), not even consistency would be required.

Given these controversies, in practice, many economists still (pretend to) follow some variant of logical positivism or empiricism, Popper's falsificationism, Mill's traditional deductive approach (which also takes natural science as the role model), or Friedman's approach (Viskovatoff 2004; Hands 2001; Khalil 2004b) – despite the many and substantial philosophical weaknesses of these approaches that make them philosophically rather untenable (Caldwell 1994, p. xiii). Most problematic is the fact that these choices are rarely reflected upon:

> Few economists keep up with developments in the philosophy of science, and as such it is understandable that many may still labor under the illusion that economics is, or can be, a positivist discipline (Caldwell 1994, p. 4).

In fact, there

> is an almost total split between what economic methodologists prescribe and what economists do in their practical research. The gap is so vast that economists do not even take the trouble to reject the exhortations offered by the philosophers of science. They simply disregard them (Frey 2001, similar to Kuhn's argumentation).

The interest in the methodological criteria for distinguishing "good" from "bad" economics considerably decreased at the end of the twentieth century.[25] Furthermore, "methodology is nowhere explicitly taught in modern curricula; rather, the modern scientist learns his methodology by plying his scientific trade" (Caldwell 1994, p. 2). "In short, economists are very complacent about their subject" (Blaug 1990,

[25] Hands (2001, pp. 396–402). Interestingly, while in the natural sciences two incompatible views are sometimes held at the same time (such as general relativity and quantum theory), economists following different traditions "have regarded one another at the very least as rivals and usually as enemies;" they do not talk about different "fields" in economics, but rather about different "schools" (Fullbrook 2009, p. 125).

p. 2). Some even assume the end of economic methodology in general (see Hands 2001, pp. 6f).

9.3.3 *Towards a Pragmatist Economic Methodology*

If there is no compelling economic methodology, it is unclear why policymakers and society should trust IAM-based and other economic results regarding climate policy issues. Perhaps the revival of philosophical pragmatism (Hands 2004, p. 258) can reinvigorate interest in philosophically reflecting on economic methodology. A few selected thoughts on a possible pragmatist economic methodology will be presented here.[26] It may help overcome the disorientation of current economic methodology without returning to the dogmatism of, for instance, positivist methodology. Among the main aspects of a pragmatist economic methodology is the reconsidered ends-means relationship. It inter alia implies a focus on the practical implications of economic theories when evaluating them – although this is a considerable problem regarding IAM economics that is about the *distant future*.

Pragmatist methodology can fit very well in line with, and further develop, the (above-indicated) recent trends in economic methodology by (1) taking the social and historical dimension and specific contexts of knowledge production into account – as claimed by Step 2 of Dewey's pattern of enquiry; (2) focusing on practice and action (ethics has also re-entered the discussion, see Hands 2001, p. 399); (3) emphasising the pluralism of methods; (4) assuming some kind of naturalism (Hands 2004, pp. 257f).

The focus on action would require less emphasis on the cognitive values of "very broad scope" and "exactness," but higher emphasis on policy-relevant economic analyses, even if they are more uncertain and much more specific (i.e., about very specific problematic situations). As explained above, according to pragmatist economic methodology, the results of IAMs and other economic models represent hypotheses to resolve particular problematic situations. The hypotheses do not have to be absolutely certain, but should result from a successful enquiry along the pragmatist pattern which implies that the model results are instrumental in resolving the given problematic situation in a reliable manner.

Concerning naturalism, logical empiricism and Popper rightly argued that referencing observable evidence and empirical tests is important to some extent to avoid nonsensical theoretical speculation in economics. Furthermore, from the illuminative methodological controversy between Caldwell (a methodological pluralist, see Caldwell 1994) and Blaug (who follows Popper, see Blaug 1990), we can draw the following conclusions: (1) economics as a discipline is *not* only about falsifiable empirical predictions, and (2) a mechanistic interpretation – following the role

[26] Pragmatist approaches to economics are discussed, e.g., in Khalil (2004a) and Thompson (2005). Unfortunately, Dewey's own attempts to apply his philosophy to economics are questionable (Hands 2004, pp. 265–269).

model of physics – of societal phenomena such as economies does not hold, as it leads to overly narrow assumptions about rationality (Sect. 8.2).[27]

Moreover, pragmatism has various implications for the debate about the realism versus the instrumentalism of economic models. Pragmatism may reconcile these conflicting viewpoints to some extent, as pragmatism provides a theory of objectivity and realism (Sect. 6.2.3) that is based on a *consequentialist* pattern of enquiry. The major problem with Friedman's instrumentalism is that it does not really tell us what to if economic model results do not work – because the quality of the assumptions indeed becomes important then. Otherwise one would also give up the ambition of objective economic theories at all. Therefore, "most contemporary philosophers of science, whether positivist o[r] post-positivist, reject instrumentalism" and "have adopted some brand of realism in their analyses of the status of theories and theoretical terms" (Caldwell 1994 p. 53). Remember that also the definition of objectivity I developed in Sect. 6.2.3 implies that reference to the real world is crucial for economic enquiries, but that this reference to the real world can never be direct, nor can it be independent from our perceptions, concepts and values. Additionally, the social aspect (i.e., the co-production of the economic knowledge with stakeholders and the public, see Sect. 6.2.2) is often lacking in economic methodology.

These few thoughts may indicate how a pragmatist economic methodology could look that is situated between the claim to absolute certainty in positivism and related schools of thought on the one hand, and the disorientation and constructivism of later methodological approaches on the other. Pragmatist would allow for a pluralism of methods and methodologies, because pragmatism neither provides simple rules to be followed in economic research, nor does it presume to have achieved the absolute, eternal truth in methodology.

9.4 The Reliability of IAMs and Implications for Assessment-Making

Let us draw some conclusions concerning the reliability of IAM economics in particular – with regard to assessment-making that is based on such IAM economics. There seem to be many and often hardly reducible uncertainties in IAMs; for instance, their assumptions on the pace and direction of technological change differ significantly. IAMs also include some unrealistic, counter-factual assumptions (idealisations) that exist for the purpose of model simplicity and mathematical calculability (see, e.g., Sect. 8.2). Interestingly, the criticisms of current IAMs go in both directions: some argue that IAMs overestimate the benefits of ambitious climate change mitigation, while others argue that IAMs underestimate these benefits.

[27] Moreover, like Popper and Blaug's falsificationism, Dewey's pragmatism claims that critical enquiries are desirable, since much scientific progress comes from "refutations of existing theories" (Blaug 1990, pp. 3f).

Optimisation models in economics particularly require drastic simplifications (Hope 2005, p. 79). However, a total model-based analysis of all the interesting aspects of the real world is impossible (even more so regarding time and resource constraints in the sciences), and leads to confusion rather than clarity. Obtaining clarity and understanding of these issues sometimes requires a partial analysis, i.e., abstraction.[28] On the other hand, oversimplification and the related misinterpretation of model results are certainly among the main dangers of IAM modelling. The challenge of modelling obviously is to choose which aspects of reality's complexity should be taken into account, given certain goals (i.e., problem definitions) in economic enquiries. Simplifications and idealisations are not themselves uncertainties, but they may indicate uncertainty (and value judgement) in many cases.

Therefore, important uncertainties, simplifications and idealisations, limitations, etc. should be made transparent in climate economics. The transparency regarding all three kinds of uncertainty in IAM-based studies could be improved (despite the progress made in this regard). Better understanding the predominant and largely problematic economic methodologies (Sects. 9.3.1 and 9.3.2) will help both IAM modellers and assessment authors in this regard; these methodologies also have significant influence on the theory and method choice, the treatment of data and technical uncertainties, etc.

Knutti (2010) reflects on the possible criteria for distinguishing good from bad IAMs, although his focus is on climatology in IAMs. According to Knutti, some mistakenly assume that

> structural problems are too big compared to the observational uncertainty, implying that all models are so wrong that we cannot even attach likelihoods to models (Knutti 2010, p. 398).

Knutti and others, however, convincingly argue that we can still learn from IAMs regarding policy options (Knutti 2010; Beck 2009, pp. 83 and 120; etc.).[29]

The key question thus is: how to reduce uncertainty to ensure sound economics? The pragmatist thoughts on economic methodology in Sect. 9.3 may help regarding epistemological uncertainty. Moreover, the scientific quality of IAMs would also certainly benefit from more validation exercises and "second order science" (i.e., critically and systematically reflecting on the particular assumptions made in the models. Lloyd and Schweizer (2014) developed a new method for developing IAM-based, socio-economic scenarios called 'Cross-Impact Balance' in order to overcome the many rather subjective (uncertain) judgements often made by the modellers. This method draws on different bases of objectivity (see Sect. 5.2) and

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[28] The development of highly complex IAMs is expensive and time consuming, and such models are not suited for a quick reaction to new questions from policymaker, compared with smaller models that address only a few targeted aspects of reality. This seems to be one of the reasons why political institutions do not allocate much funds to scientific IAM development.

[29] See also Hope (2005, pp. 90ff) and Füssel and Mastrandrea (2009, Sect. 3) for a reflection on the suitability of IAMs for climate policy advice. IAMs are sometimes criticised for being "only" numerical (rather than analytical) models. While the most high-ranking economic journals often do not overly appreciate numerical models, the necessarily very simple analytical models cannot address many highly policy-relevant issues and aspects.

systematically elicits expert opinion on various socio-economic influences, focussing on the internal consistency of variable combinations of assumptions (instead of intuitive logics). The work by Lloyd and Schweizer (2014) is one of the few works on climate economics from an epistemological and "philosophy of science" perspective; the epistemic quality of the IAM-based studies intended to inform future IPCC WG III assessments may benefit from applying this method. Others argue for more rigorous peer review of IAM-based studies along with increased transparency of "the details of how the IAMs were used to derive the basic results" in order to make them more credible scientific tools (Rosen 2015).

Compared with alternative methods, IAM modelling is still the best economic method that is *currently available* for the major questions of climate economics (see Sect. 7.2), including particularly for discussing long-term global mitigation goals (e.g., the 2 °C goal). Although current economic models in general "are not truth machines" (Nordhaus 2008, p. 80), many aggregated studies have shown, for instance,

> that, in the end, some of the basic predictions of micro-economic theory hold well. Demand curves do tend to slope down from left to right – on the whole – and where they do not, there is usually a convincing theoretical explanation (Beckerman 2011, p. 23).

Even though the crucial issues regarding the development of energy technologies (IPCC 2011) and long-term economic growth (see above) are still highly uncertain in IAMs, it seems negligent not to make use of IAMs and to further develop and improve them as instruments for better understanding policy choices and their many side effects. However, as indicated in Sect. 7.4 already, the question is whether the further development of IAMs *in their current form and frameworks* is the best use of resources.[30] Perhaps the possibilities to use IAMs to inform climate policy debates are almost exhausted after the IPCC WG III AR5.

We can conclude that (1) there are many uncertainties of three different kinds in IAM-based studies which are sometimes not made transparent; (2) this does not imply dismissing the results of IAM-based studies altogether; (3) pragmatist thoughts may help overcome the current disorientation in economic methodology; and (4) the transparency and critical-constructive discussion of uncertainty and reliability of IAM-based studies are essential with regard to scientific assessments, because uncertain assumptions can have considerable impact on model results and policy recommendations. Although IAM results are not sufficient for a *comprehensive* policy pathways assessment (including all the ethically and politically relevant aspects), and although also other model types and approaches are needed, IAMs can contribute substantial insights to the debate.

[30] Meanwhile, it would perhaps be more interesting for IAMs to employ economics beyond the neoclassical growth theory and welfare-optimisation.

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Chapter 10
An Evaluation of the IPCC WG III Assessments

Abstract This chapter identifies some challenges, strengths and weaknesses of Working Group (WG) III contributions to the Assessment Reports (ARs) of the Intergovernmental Panel on Climate Change (IPCC). The focus is on the Fourth (AR4) and Fifth (AR5) assessment cycle of the IPCC. For this purpose, the evaluation criteria and heuristic tools developed in Part II are employed, along with the results of the critical analysis of the underlying economics in Chaps. 7, 8 and 9. Evaluating the IPCC WG III contributions in this way will help us identify the appropriate means of improving IPCC assessments. This chapter argues that in the AR4, both the policy-relevance and the transparency of ethically relevant assumptions could have been higher. This may partly result from the adherence to misguided science-policy models. The AR5 was an improvement in these regards, but faced challenges inter alia in terms of (i) considerable research gaps regarding retrospective, social-science policy analysis, and (ii) political disputes over value-laden findings with far-reaching implications for domestic policies. All things considered, however, both the AR4 and the AR5 did a good job. In contrast to some existing criticisms, there is no clear case of a considerable hidden bias in these WG III ARs, for instance towards more ambitious global mitigation goals.

Given the context analysis (Part I), the philosophical reflections on science-policy models (Part II) and the critical discussions of the economic, IAM-based material underlying the recent IPCC assessments (Chaps. 7, 8 and 9), we are finally prepared to evaluate the most recent WG III assessments (AR4 and AR5) themselves, including their Summaries for Policymakers (SPMs). The core and desirable purpose of the IPCC WG III is, in contrast to individual economic studies, to integrate and assess the existing scientific literature about climate change mitigation options. This does not only mean to review the economic studies available, but also to synthesise this knowledge in a policy-relevant and conclusive manner, to the extent possible. How well did the IPCC WG III producers and authors structure and assess the many controversial economic arguments on climate policy options? How well did they consider the potential and pitfalls of IAM-based studies? What are the specific challenges (and their main drivers and factors) faced by WG III? What can be learned for future integrated economic assessments? While Sect. 3.3 listed some popular

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criticisms of the IPCC, the present chapter aims at a systematic (but not comprehensive) evaluation of some WG III aspects based on all the insights of the previous chapters.[1]

10.1 How to Evaluate the IPCC's Social-Science Assessments

The success of a scientific assessment in terms of what was explained in Sect. 2.1 is dependent on (i) the willingness and capability of policymakers and other AR target audiences to learn and engage in a deliberative, constructive and mutually respectful discussion about the problems at stake and the policy solution space; as well as (ii) the willingness and capability of the scientific community to provide sound research that is relevant to the public policy problems at stake and to make controversial normative assumptions and uncertainty transparent (Chaps. 7, 8 and 9). However, there is also a lot that can be done by assessment makers.

Criteria for the evaluation of the IPCC WG III performance will be provided by the refined pragmatic model (Sect. 6.4) and the results from Chaps. 7, 8 and 9. Again, these evaluation criteria will only be tentative in the Deweyan sense (as ends-in-view); they are subject to supplementation during the more precise analysis of the WG III assessments.[2]

One evaluation criterion (employed in Sect. 10.2) is the policy-relevance of what is assessed and synthesised in the assessment (based on the results of Sect. 7.4). The objectives, scope and envisaged impact of the IPCC WG III assessments should respond to the current political context as the "problematic situation" (described in Sect. 2.2) by exploring different viable climate policy pathways and their implications in light of this political context. According to the refined pragmatic model, this would make WG III assessments policy-relevant (according to Sect. 6.4). A WG III assessment that does not support current climate policy-making processes in this way seems to be a waste of time and funds.

A second evaluative criterion is the transparency, healthy diversity and integrated discussion of ethical viewpoints and group-interests represented in the economic assessments of policy options. Particularly relevant are the disputable ethical assumptions implied in the IAM-based economics (Chap. 8). Section 10.3 will discuss how well the WG III dealt with these – sometimes explicit, sometimes only implicit – normative assumptions in the underlying economic literature, in order to ensure political legitimacy and avoid policy-prescription.

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[1] Systematic evaluations of IPCC (WG III) assessments are rarely done. Some scholars at least discuss a few particular aspects, e.g. Victor (2015) and Carraro et al. (2015a, b). Moreover, Sect. 3.3 has already mentioned reports on the overall scientific reliability of the IPCC AR4.

[2] See Chap. 6. A more thorough and comprehensive analysis of the problems concerning WG III AR4 and AR5, which cannot be provided in the present book, could reveal additional relevant aspects than those presented in this chapter.

Third, the discussion of Deweyan-Putnamian pragmatism (Chap. 6) and pragmatist economic methodology (Chap. 9) provided a particular interpretation of reliability and sound science that also allows for pluralism and the acceptance of uncertain, non-objective statements under some conditions. The fulfilment of the reliability criterion in the WG III ARs will be evaluated in Sect. 10.3 as well. This will merely be done in terms of the *transparency* of uncertainties along the categories outlined in Chap. 9. Making uncertainties transparent is not only important regarding the uncertainties in the literature assessed by the IPCC, but also regarding the uncertainties implied in the interpretation of the economic studies by IPCC authors themselves. Concerning the scientific quality overall, a large number of independent and critical analyses of the IPCC ARs have already shown that the major findings and results of the IPCC are scientifically sound and well justified (see Sect. 3.3); there is thus no need to extensively discuss this here.

Fourth and finally, some procedural aspects, being essential tools for achieving the assessment objectives and, with them, good scientific policy advice, will be briefly discussed in Sect. 10.4.

The understandings of the traditional science-policy models gained in Part II may serve as additional "heuristic-hermeneutic tools" for the analysis of the WG III assessments. If it turns out that these traditional models guided WG III assessments, we should be aware of the undesirable implications of their application.

Evaluating the WG III assessments in this manner will help us identify the appropriate means of improving the IPCC assessment series in Part IV of this book. I will focus on the IPCC WG III AR4 and AR5, because they are the most recent and thus currently most relevant IPCC WG III ARs, and because it is extremely interesting to compare these two *rather different* assessments. As will get clearer below, the WG III AR5 has chosen a different, and in my view more appropriate, assessment approach to address highly value-laden ethical aspects of climate policy. This approach includes the exploration of the pros and cons of alternative global mitigation pathways, but also a novel chapter explicitly on ethical issues. WG III AR5 seems to have learned (which is interesting from a social epistemology perspective) from some of the weaknesses of AR4. Consequently, although large parts of the AR5 are mainly an "update" of AR4 results, the underlying assessment approaches differ a lot and make a comparison between WG III AR4 and AR5 quite illuminating, given the purposes of the present volume.

10.2 The Policy-Relevance of the WG III Assessments

Did the WG III AR4 provide a policy-relevant assessment and adequately respond to the "problematic situation" of climate change? In a policy-relevant, but not policy-prescriptive manner, the contribution of WG III to the AR4 aimed

> to answer essentially five questions relevant to policymakers worldwide: What can we do to reduce or avoid climate change? What are the costs of these actions and how do they relate to the costs of inaction? How much time is available to realise the drastic reductions needed

> to stabilise greenhouse gas concentrations in the atmosphere? What are the policy actions that can overcome the barriers to implementation? How can climate mitigation policy be aligned with sustainable development policies? (IPCC 2007, p. ix).

With this, the main and general task of WG III was to explore the policy options to mitigate climate change (see also IPCC 2007, p. 27), which is certainly policy-relevant at first sight. The introduction to the WG III AR4 (IPCC 2007, Chap. 1) furthermore provides an explicit problem framing by describing the climate policy context at the time of writing.[3]

However, in terms of the explicit objectives for the WG III AR4, it could have improved in the following ways: (1) it could have focussed more explicitly on the crucial analysis of concrete policy *instruments* to achieve the mitigation actions, as only its Chap. 13 is devoted to this issue. In my interpretation, almost all of the questions in the quotation above would have benefitted from such an in-depth analysis of viable policy pathways. (2) If "costs" only refer to economic costs in a narrow sense, other kinds of side effects, risks, synergies and interrelations of mitigation options are neglected. (3) Distributional aspects are also not mentioned in the quotation, even though they are crucial for policy debates; neglecting these heated issues in scientific assessments certainly reduces their policy-relevance in the sense explained in Sect. 6.4. (4) Moreover, it is important to consider how climate change mitigation policy can be aligned with adaptation[4] and other important policy fields aside from sustainable development. What are the trade-offs, synergies and other important interlinkages?

A first interim result is that the given objectives for WG III AR4 are *basically* in line with my understanding of policy-relevance sketched above, but could have improved in various ways to become even more policy-relevant.

The actual policy messages of the WG III AR4: sub-optimal relevance

Let us have a closer look at what was *actually* done in the WG III AR4, i.e. to what extent the given objectives for the AR4 have been realised.

Some things in the AR4 have improved compared with the IPCC Third Assessment Report (TAR). For instance, there was a more integrated analysis of the mitigation potential of economic sectors in the WG III AR4 (IPCC 2007, p. 27). However, a satisfactory response to the WG III AR4 question of possible time-frames and costs of mitigation options (see IPCC quote above) would primarily have required a deeper understanding of their more precise political, socio-economic, natural and other conditions and premises, i.e. a thorough exploration of policy pathways and their practical implications. This would have been needed to point out the climate policy leeway and to clarify the conditions and premises. Such analyses are, however, largely lacking in the WG III AR4. This limits the policy-relevance of the AR4.

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[3] Moreover, governments always had the opportunity to co-determine the scope of IPCC ARs, which in general promises at least a basic level of policy-relevance.

[4] The Sects. 3.5 and 11.9 of the WG III AR4 (IPCC 2007) at least briefly mention this need.

Consider, for instance, the exploration of low-carbon energy technologies as a means for climate change mitigation. Although the WG III AR4 offers and explains different energy technologies and points out the need for an energy mix in principle, it does not really explore concrete policy options to achieve that. The "Energy Supply" section of Chap. 4 of the WG III AR4 only discusses the mitigation potential and the costs of individual energy technologies, such as nuclear power. Unfortunately, however, it does not provide information about different energy portfolios, their characteristics and potential practical implications (see Figure 4.25 in IPCC 2007, p. 290, as an example), let alone their interrelations. Policymakers and the public do not get much policy-relevant information about the *relative* importance of individual energy technologies, such as nuclear power and related policy options. For instance, it remains unclear what phasing out nuclear energy – as decided in Germany after the nuclear disaster in Fukushima in 2011 – would imply for mitigation policies and costs.[5]

Relatedly, a satisfactory exploration of the implications of policy means, including risks and side effects, is missing. Only a few risks (as well as very few co-benefits) of selected energy technologies are mentioned in the WG III AR4. There is a lack of comprehensive analysis in terms of the non-economic costs and risks of certain energy portfolios, i.e., other policy objectives, particularly when it comes to their interplay with climate policy objectives. Examples include the impacts of the extensive use of biomass on food production, and the potential negative implications of very ambitious mitigation pathways for the economies of developing countries. The WG III AR4 focuses on first-best world scenarios by assuming full mitigative potential of energy technologies and no implementation barriers. The conditions under which mitigation in the energy sector is possible and desirable (in terms of economic, social, political and other consequences) remain unclear in the WG III AR4.[6]

The SPM, as the decisive summary of the AR4, particularly lacks clear-cut messages for policymakers. What are the answers to the questions put forward by WG III (see the quotation on WG III objectives above)? This remains partly unclear when studying the SPM. The AR4 SPM is too inconclusive for the needs of policymakers and the public.[7]

To conclude, the WG III AR4 provides interesting and policy-relevant information regarding long-term, low-stabilisation targets and their globally aggregated

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[5] See Edenhofer et al. (2010) for an example of a comparison of alternative scenarios.

[6] Another issue is the lack of consistency and coherence between the AR4 chapters in terms of metrics (e.g., top-down versus bottom-up), baselines, basis years, etc., but also between the IPCC WGs and even other climate economics assessments. Because of this latter point, policymakers and the public sometimes seem to have difficulties understanding the results of the IPCC AR4 *in comparison with* the results of other studies and assessments. Furthermore, the separation between baseline scenarios and policy scenarios is confusing in methodical terms (IPCC 2007, p. 203), not least because there is no policy-free baseline in the real world.

[7] Compare this with the Stern Review with its clear-cut messages and crisp, interesting storyline; although, I would not argue that the Stern Review should be the role model for IPCC assessments given my thoughts in Chap. 6 and the lack of rigorous expert review.

economic costs, as well as interesting and important sectoral insights. Nonetheless, all of the points made above suggest that the AR4 is far from satisfactorily exploring the implications of policy pathways as claimed in Chap. 6. In general, if I were a national policymaker, defending my nation's interests and seeking an international agreement on climate mitigation policy, I personally would not have the feeling that I could learn a lot from the WG III AR4, particularly with regard to short-term agreements or national policies. The WG III did not satisfactorily and sufficiently answer the five (indeed interesting) questions for the WG III AR4 quoted above. The more precise policy options available, and their various implications particularly for individual nation states, remain rather unclear, and the summaries of the WG III AR lack clear messages.

In a short, yet illuminating survey that I conducted in February and March 2009 via email and furthermore orally (assuring the anonymity of the participants), many policymakers indirectly *confirmed* these hypotheses regarding the lacking policy-relevance of the IPCC WG III AR4.

I asked several policymakers at the level of (1) German federal states (26 requests, 9 responses), (2) national governments of EU countries and their climate-relevant ministries, i.e., environmental or economic ministries, as well as Members of Parliament concerned with climate policy (93 requests, 12 responses) and (3) selected national governments and ministries outside Europe about their experiences with economic advice on climate policy (17 requests, 4 responses). I put forward the following three questions. (1) What are the most important climate economics studies by which you are advised? (2) What questions or aspects are you mostly interested in and which of these are missing in reports? (3) How important for your work are climate economics studies in general? These questions were relatively open and broad.

Most respondents named the IPCC AR4 (about 65 %) and the Stern Review (about 70 %) as the most influential reports. In line with my evaluation above, the respondents mostly stated that the WG III AR4 somehow lacks policy-relevance in the sense that particular implications of available climate policy pathways are not explored to a satisfactory extent. More specifically, according to the respondents, the WG III AR4 and other climate economics reports lack[8]: (1) second-best world scenarios, i.e., *more realistic* scenarios (mentioned six times); (2) issue linkages, for instance, regarding transport policy (mentioned six times); (3) operationalisation of proposals for the energy sector, as well as proposals concerning policy or economic instruments and their costs (mentioned five times)[9]; (4) exploration of the interplay between already existing policy instruments (mentioned four times); (5) disaggregated, regionalised results in assessment reports, concerning policy options, costs,

[8] I interpreted the responses – usually they mentioned more than one issue – within the following categories.

[9] For this reason, four respondents preferred or at least appreciated the McKinsey cost curve studies, despite its many limitations, disputable assumptions and uncertainties; see http://www.mckinsey.com/client_service/sustainability/latest_thinking/greenhouse_gas_abatement_cost_curves (accessed 13 Apr 2015).

time frames, employment, climate impacts, etc. (mentioned three times); (6) provision of ideas for concrete, small policy steps towards climate change mitigation (instead of all-or-nothing options in IAM scenarios), together with a more comprehensive view of policy-making (mentioned three times); (7) transparency of how results were achieved and which assumptions are implied (mentioned three times); and (8) comparability of different metrics, basis years and baselines (mentioned three times). Furthermore, some policymakers criticised (9) a lack of exploring issues of justice (too much focus on economic efficiency in the WG III AR4, mentioned twice) and (10) a lack of issue linkage specifically with development policy and migration (mentioned twice). Only criticised once were the lack of (11) diversity of scientific viewpoints, (12) an exploration of alternative pathways into the future, particularly the comparison with a scenario without ambitious climate policy, and (13) an analysis of implementation barriers for renewables and other specific energy technologies.

In this survey, the policymakers thus confirmed my hypothesis that the WG III AR4 should have better explored the implications of climate policy pathways.

Potential reasons for the limited policy-relevance

Let us briefly discuss potential reasons and drivers underlying this shortcoming of the AR4, in order to better understand the challenge at stake for future assessments. One reason for the limited policy-relevance of the WG III AR4 are the limitations of the IAM-based studies themselves – which prevailed in the WG III AR4 compared with other economic studies – in terms of their policy-relevant scope (Sect. 7.4). In general, at this point in time, there were not many scientific studies available – be they IAM-based or not – that address the topics and aspects neglected by the WG III AR4. The IPCC WG III authors state, for instance, that "the literature does not (as yet) provide a complete picture that includes all the different types of co-benefits needed for a comprehensive assessment" (IPCC 2007, p. 677). Only very few integrated economic studies on the requirements for and implications of 2 °C stabilisation pathways were available. This lack of literature needed to conduct an assessment along the lines of the refined pragmatic model was a huge challenge for the AR4.

In addition to that, however, the WG III AR4 seemed to have lacked the idea of an exploration of the full policy solution space, and they did not sufficiently take into account the broad range of economic approaches beyond IAMs. There are also historical reasons for the limited policy-relevance. Economists were not overly represented in the AR4 also because of some disputes that had occurred in the previous assessment cycle; the WG III AR4 was rather dominated by engineers.[10]

Moreover, as a hypothesis, the WG III AR4 authors felt perhaps slightly insecure after having received so much criticism about the extensive use of cost-benefit analyses (CBA)[11] for the comprehensive evaluation of climate policy options in *previous*

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[10] IPCC authors told me about these issues in personal conversations. See also Sect. 2.3.

[11] See Chaps. 7 and 8 above, as well as IPCC (2007, pp. 231f) and Stern (2007). Also the WG III contribution to the AR5 states that "CBA may be inappropriate for assessing optimal responses to climate change" (IPCC 2014a, p. 171).

IPCC ARs such as the SAR (IPCC 1996, e.g., p. 9). This might have been among the reasons why the WG III AR4 authors did not so much explore the implications of policy options, and chose a more cautious approach to explore mitigation options in economic terms (particularly concerning sectors) instead; in order to avoid further criticism, they seem to have avoided strong political statements that would have resulted from more comprehensive policy evaluations. Unfortunately, however, this is another case of throwing the baby out with the bathwater. While much of the criticism on traditional CBA is justified, particularly concerning the narrow understanding of costs and benefits, an analysis of the practical implications of policy options in the Deweyan sense (Chap. 6) would have been valuable and feasible, also because more extensive cost-efficiency analysis would also have been an option (see also Sect. 7.2.2).

Yet another reason for the above shortcomings could be a misguided science-policy model held by some AR4 authors. As argued in Part II, the traditional science-policy models that partly influence the IPCC's work do not highlight the need for a thorough exploration of the possible practical consequences of the means of achieving alternative policy objectives. When reading the IPCC AR4, it is hard to avoid the impression that it is mostly driven by the traditional models that focus mainly on goals and means rather than on the implications of the means. However, one should keep in mind that there is a heterogeneity of action-guiding science-policy models among the IPCC producers and authors (Sect. 4.3).

Higher policy-relevance of the AR5, but still limitations

Let us turn to the IPCC WG III AR5 assessment. It consists of 16 Chapters, one Technical Summary and the SPM (see also Sect. 2.3). Compared with the AR4, the WG III contribution to the AR5 is somewhat *more policy-relevant* (in the sense described above). The WG III AR5 provided a multi-criteria, multi-scenario analysis of the global climate policy solution space which clearly goes beyond the scope of the AR4. The AR5 identified pathways to different low-stabilisation targets, their technological, sectoral and institutional requirements, as well as their risks, uncertainty, trade-offs and synergies with other policy goals. The AR5 SPM provided slightly clearer and more interesting messages than the AR4 SPM.

Key findings of the WG III AR5 include (based on AR5 SPM and Edenhofer 2014, p. 4):

- GHG emissions growth between 2000 and 2010 has been larger than in the previous three decades. Regional increase of GHG emissions usually results from economic growth.
- Many climate policy scenarios make it at least about as likely as not that warming will remain below 2 °C relative to pre-industrial levels.
- But, low stabilisation targets require deep emissions cuts irrespective of the precise target, and depend on a full decarbonisation of energy supply.
- There is far more carbon (fossil fuels) in the ground than emitted in any baseline scenario. However, only a budget of roughly 1000 Gt CO_2 can globally still be emitted in this century if the 2 °C goal is to be achieved.

- Economic growth and low stabilisation targets can nonetheless be reconciled. Global costs rise with the ambition of the mitigation goal.
- Carbon pricing is essential for low stabilisation targets.
- There is more than one technological pathway to achieve a low stabilisation target, but all sectors (differently) have to contribute to mitigation.
- Delay of mitigation or limited availability of bioenergy and CCS will cause considerable costs and additional risks.
- Reduction of energy demand is crucial to realise co-benefits (for human health and other societal goals) and hedge against the supply-side risks.
- Limiting warming involves substantial technological, economic and institutional challenges, and is necessarily based on normative assumptions.
- More fundamentally, climate change is essentially to be regarded as a global commons problem (IPCC 2014a, SPM.2; TS.1; TS.4.4) that requires international cooperation and coordination across scales.

These types of explorations of the characteristics and implications of low-stabilisation pathways are precisely what was lacking to some extent in the WG III AR4. Through these explorations, the WG III AR5 has re-stimulated the 2 °C debate (see, e.g., Geden and Beck 2014; Victor and Kennel 2014). In times of much doubt about the feasibility of low-stabilisation targets, WG III has shown that the 2 °C goal is still feasible under some conditions and requirements (see Sect. 3.1.3).

One of the reasons for the higher policy-relevance of the AR5 compared with the AR4 was that *relatively* more literature was available on some aspects than before. Another reason was that the political context had changed compared with the time preceding the AR4, which forced the AR5 to change its focus a little bit. *First*, there has been a considerable increase in national and sub-national mitigation policies since the AR4 (IPCC 2014a, Figs. 15.1 and 13.3). Issues of implementing mitigation policies become more interesting to policymakers. *Second*, during the fifth IPCC assessment cycle, hardly anybody believed any more that a far-reaching global deal that can effectively address both the climate and the development issues[12] will be negotiated in the near future, for political reasons. Currently, for most policymakers, more interesting than abstract global scenarios of policy pathways is to understand the feasibility, requirements and implications of such low-stabilisation pathways, particularly on the regional and national level. This should include interlinkages with other policy fields such as finance, energy, health, agricultural, trade and development policy. Bottom-up approaches become more appealing. The next steps in international climate policy, particularly in the aftermath of the Paris Agreement (December 2015), are to

[12] See Edenhofer et al. (2012) for cornerstones of such a potential global deal. Despite the need for more bottom-up approaches, the climate change problem is still unresolved and any effective response to this global challenge requires, more or less, *global* action and global policy coordination (Knopf et al. 2012). The Paris Agreement in December 2015 at least provided a promising framework for such global climate action (see also Chap. 1 above).

> combine elements of top-down and bottom-up policy architectures. Domestic aspirations, policies, and objectives will likely be the primary determinants of the ambition of a 2015 agreement (Edenhofer et al. 2013).

However, despite the high policy-relevance of the WG III AR5, considerable limitations and challenges remain in this regard, which are relevant to future ARs.

First, some important aspects of climate policy options and instruments are hardly addressed in the AR5. These particularly include the retrospective analysis of the climate policy instruments that are already in place. Think, for example, of the European Emissions Trading Scheme, one of the most exciting climate policy experiments worldwide. Moreover, the current German energy transition ("Energiewende") is hardly mentioned in the AR5, even though many lessons could be learned for climate and energy policies elsewhere.

Second, despite the higher integration with WG I scenarios, there still was hardly any integration with WG II insights on climate change impacts, vulnerability and adaptation (IPCC 2014a, Sect. 6.3.3). This however, would be important for understanding climate policy options more comprehensively; even in case of ambitious mitigation policies there is still a need for adaptation to unavoided climate impacts. Differential mitigation costs, adaptation costs and residual climate impacts (e.g., along the 2°, 3° and 4 °C goals) were not identified in the AR5. Closing the loop remains the main challenge (Edenhofer 2014). The so-called "Shared Socio-Economic Pathways," which would have been very instrumental in this regard, had not yet been available when the AR5 was finalised. This also prevented a systematic assessment of socioeconomic uncertainties (Edenhofer 2014).

Third, the many interdependencies of land use changes, land management and land rent dynamics with climate change (mitigation) are *relatively* poorly addressed in the AR5 (IPCC 2014a, Chap. 11). The issue of bioenergy was well addressed, but only very briefly – in an Appendix (IPCC 2014a, Sect. 11.13). These are, however, crucial aspects of climate policy, as also the WG III AR5 admits.

> Many models could not achieve atmospheric concentration levels of about 450 ppm CO_2eq by 2100 if additional mitigation is considerably delayed or under limited availability of key technologies, such as bioenergy, CCS, and their combination (BECCS) (IPCC 2014a, p. 16).

Land (and water) thus is not only affected by climate impacts, but also by climate change mitigation through the increased need for biomass production and protection of forest areas, which implies trade-offs with food security, food production prices and perhaps biodiversity (Fuss et al. 2014; IPCC 2014a, Chap. 11), as well as various co-effects on land rent dynamics. This is particularly relevant given the crucial and still underestimated need in most scenarios for negative emissions (i.e., extracting CO_2 from the atmosphere e.g. through combining bioenergy and CCS) to achieve ambitious climate policy goals, as clearly pointed out by the AR5.

Fourth, although more literature was available on many aspects of climate policy, there are still considerable research gaps – that may *partly* explain the above gaps and omissions in the WG III AR5 assessment. Most scientific communities are not organised around policy problems, but rather around disciplines, approaches, theories, etc. True interdisciplinarity, which is clearly required for most parts of an IPCC assessments, is still rarely available among the scientific publications. The available knowledge particularly from the social sciences is fragmented and hard to synthesise (Victor 2015). There is a clear lack of established paradigms for social-science policy analysis, huge uncertainty and high complexity.[13]

10.3 One-Sided Ethics and Hidden Uncertainty in WG III Assessments?

How well did the WG III AR4 ensure ethical transparency and balance (Sect. 10.3.1)? Did it make uncertainty sufficiently transparent (Sect. 10.3.2)? How did the WG III AR5 perform in these regards (Sect. 10.3.3)?

10.3.1 Ethical and Political Bias in the WG III AR4

Many of the basic IAM assumptions and metrics are explained satisfactorily in the WG III AR4. Its Chap. 11 discusses different assumptions regarding technological change at length. Section 11.4.5 of the WG III AR4 addresses further factors and assumptions influencing IAM outcomes and mitigation costs, e.g., different assumptions about baselines, political flexibilities and economic possibilities of substitutions. Section 11.4.5 of the WG III AR4 also discusses the role of different economic assumptions.

However, many of the ethical value judgements implied in IAMs and identified in Chap. 8, particularly regarding welfare economics and globally aggregated long-term mitigation costs, are not made transparent in the AR4, neither in the Technical Summary, nor in Chaps. 2, 3, 11, 12 or 13 of the WG III AR4.[14] A fair representation of the different interests and values has not been achieved. The WG III AR4, compared with the SAR or AR5, for instance, does not really discuss the predominant neoclassical model assumptions, among other things. In addition, the WG III AR4 neglects to point out that most IAMs imply precisely these mainstream assumptions; it is thus no surprise that the results of these models are very similar given that the assumptions are alike. Among the very few exceptions is the normative dimen-

[13] If this is true, the question is why the IPCC – to the limited extent that is possible for such an institution at all – did not invest more in the development of such a methodology, which may build on the insights and methods developed for the discipline of Public Policy Analysis (see Dunn 1994 and Weimer and Vining 1992). See Sect. 11.5 for a discussion.

[14] These are the chapters where one would expect a treatment of such ethical assumptions.

sion of discounting (see Sect. 8.4.2), which is explicitly discussed in the WG III AR4, although only coarsely (IPCC 2007, pp. 136–138).

Since revealing the various value judgements implied in IAM-based studies is not an easy task, as was shown in Chap. 8, it is hard for IPCC authors to point out such value judgements when they are not made transparent in the respective economic studies already. Moreover, as van Vuuren et al. (2012) highlight, there is only a very limited set of scenarios that are currently being used in global environmental assessments, and Stirling (2009) rightly argues that energy-related studies typically lack diversity of value assumptions.

However, *at least the general existence* of such (frequently disputed) value judgements in IAM-based studies could have been mentioned in the WG III AR4 – and they could have pointed out value controversies in some way or the other. Both in the case of no climate policy action where particularly poor countries suffer from severe climate impacts (Edenhofer et al. 2012) and in the case of very ambitious climate policy – e.g., a 2 °C global mitigation target – where the economic development of certain poor countries is endangered, the least well off on this planet might be among the major losers. Pointing out such value-laden implications of policy options more clearly is but one example of how the WG III AR4 could have been more transparent in ethical terms. The AR4 sometimes ignores important conflicts in climate policy and their implications for mitigation options; the role of moral conflicts and ethics is not sufficiently addressed in the WG III AR4.[15] Another example is that the WG III AR4 stated a need for 80–95 % emission reduction in developed (Annex I) countries by 2050 (IPCC 2007, Box 13.7). While the notes below this box rightly pointed out that such numbers are heavily based on disputed concepts of justice in terms of international mitigation burden sharing, it was very easy for many EU countries to misinterpret this table in terms of clear-cut policy recommendations for EU climate and energy policies.

Among the many reasons for the sub-optimal treatment of ethical issues in the WG III AR4 might again be a misguided model of the science-policy interface, such as the technocratic model of scientific consensus. Because of its value-free ideal (see Chap. 5), such a misguided science-policy model would have a negative effect on the transparency regarding value judgements in IAM-based studies, as well as on the transparency regarding the additional value judgements made by the IPCC authors themselves, for instance when (1) interpreting the results of IAM-based studies, (2) framing the problem,[16] or (3) assessing risks.

[15] Only Chap. 2 of the WG III AR4 mentions a few ethical aspects. Compare this, e.g., with Chaps. 3 and 4 in the WG III SAR (IPCC 1996) or Chap. 2 in the Stern Review (Stern 2007) that explicitly address ethical issues.

[16] The problem framing in the WG III AR4 – with its factual focus on the mitigation of GHG emissions (rather than a broader focus on the mitigation of dangerous climate change, as the WG III AR4 title suggested) – does not include a discussion on geo-engineering options for mitigating further climate change, for example.

10.3.2 Uncertainties in the WG III AR4

There were clear guidance notes for AR4 lead authors concerning the treatment of uncertainty (Manning 2006). All the WGs employed a calibrated uncertainty language, and this was the first time WG III employed such a guideline for uncertainty (Mastrandrea et al. 2011). There was no fully common, equal treatment of uncertainty across the three WGs, as each WG had its own approach at least concerning details. WG III used both qualitative and quantitative uncertainty terminology (e.g., IPCC 2007, p. 23), which resulted in non-technical transparency regarding the degree of uncertainty in the core statements of the WG III AR4. The IAC review of the IPCC (IAC 2010) inter alia scrutinised the treatment of uncertainty in the AR4 and confirmed that the AR4 – apart from minor weaknesses – did a good job in this regard.

Nonetheless, some major uncertainties remain opaque in the WG III AR4 (as likewise in the underlying economic studies). Methodological uncertainties, and even more so epistemological uncertainties, are not satisfactorily transparent in the WG III AR4. Although some sections discuss the limitations of IAMs as economic tools (see Sects. 2.2.7 and 11.4.5 in IPCC 2007), this does not really clarify the scientific reliability of IAM results, nor does it point out the fact that different approaches and methodologies in economic models might lead to very different results, for instance, regarding global mitigation costs (see Oreskes 2003).

Particularly concerning the scenarios, uncertainties often remain opaque in the WG III AR4. This could mislead political discussions about global mitigation goals. While the WG III AR4 sometimes mentions core uncertainties in footnotes,[17] the many conditions and uncertainties related to low-stabilisation scenarios remain partially unclear in the WG III AR4 and its SPM. Furthermore, there are opaque uncertainties concerning the epistemic status and methodological uncertainties or limitations of IAM-based results that feed the scenarios, as well as uncertainties concerning the specific assumptions of the scenarios, e.g., their status as first-best world scenarios. For instance, baselines are implicitly treated as deterministic projections, but they should instead be regarded as scenarios that involve considerable natural and socio-economic uncertainties.

To conclude, the transparency of uncertainty was sub-optimal when measured against the – admittedly very high – standards described in Chap. 9, which inter alia presupposes a well-reflected philosophy of economics and transparent uncertainties in the underlying economic literature.[18] Yet, one should also mention that the IPCC

[17] For instance: "[t]he number of studies is relatively small and they generally use low baselines. High emissions baselines generally lead to higher costs" (IPCC 2007, p. 18). Although this is also related to value judgements, Table SPM.6 (IPCC 2007, p. 18) is another good case for discussing the IPCC's treatment of uncertainty in scenarios.

[18] There are also major differences in the kind and degree of uncertainty (e.g., between future economic growth and future population growth), which again could have been more transparent in the WG III AR4. Moreover, if uncertainty of peer-reviewed studies is not made transparent in the ARs, it is hard to see in what sense peer-reviewed studies are so much more valuable than grey literature

assessments are often (and rightly) regarded as the benchmark for scientific rigor, compared with many other assessments.

10.3.3 WG III AR5: New Approach and Increased Transparency

Under the leadership of the Co-Chair Ottmar Edenhofer, WG III chose a novel approach for the AR5 concerning value-laden, disputed policy issues. They explored and presented alternative climate policy options and their diverse practical implications for society, while making major value judgements and uncertainties relatively transparent. As the Preface reveals (IPCC 2014a, Preface), this novel approach built on the refined pragmatic model which was presented in Sect. 6.4 above and elaborated by Edenhofer and Kowarsch (2015).

For this "exploration of the solution space for climate change mitigation" (IPCC 2014a, p. ix), different sets of IAM-based scenarios (ranging from potential 1.5 to 4 °C global temperature goals) were analysed and compared in terms of costs, risks, (co-)benefits as well as institutional and technological requirements – instead of recommending one particular goal or avoiding a discussion of these heated issues altogether. In particular Chap. 6 of the WG III AR5 demonstrates this novel approach very well.

The AR5 assumes a world of multiple and interdependent, often disputed policy objectives as well as multi-functional policy instruments. In line with the thoughts presented in Sect. 6.4 above, WG III aimed at identifying synergies and trade-offs between the multiple objectives. They did this by evaluating the interaction between different policy instruments (IPCC 2014a, Fig 10.15). For example, WG III analysed the co-benefits of ambitious climate change mitigation for energy security and health (in terms of reduced air pollution) (IPCC 2014a, Tab. 10.5). This analysis of value-laden, disputed policy issues is an example of successful transdisciplinary knowledge integration across disciplines and approaches (quantitative and qualitative). While the AR4 had acknowledged the existence of multiple and interdependent policy objectives within the sustainable development paradigm as well (IPCC 2007, Chap. 12), the AR5 for the first time presented a sophisticated, systematic analysis of some of the trade-offs and synergies in order to better understand the pros and cons of alternative climate policy options.

The Synthesis Report (IPCC 2014b) integrates major results across the three Working Groups. It provides a seminal figure (Fig. SPM.10) that presents the climate policy solution space with its alternative policy pathways. It shows the relationship between risks from climate change, temperature change, cumulative CO_2

(i.e., non-peer-reviewed literature, e.g., economic data by the World Bank). Grey literature can be crucial for up-to-date socio-economic assessments as well, but the AR4 was criticised for using it at all. For a deeper discussion of the treatment of uncertainty in assessments, see Swart et al. (2009), Funtowics and Ravetz (e.g. 1990), and Slujis (e.g. 2002).

emissions, and changes in annual GHG emissions by 2050. This figure tells us, for instance, which level of emissions reduction might lead to a particular state of the climate system and the related potential impacts (under uncertainty). For most scenarios underlying Fig. SPM.10, a decisive factor determining the required level of emission reductions is the availability of technologies for CO_2 removal from the atmosphere.

In contrast to the AR4 (see Sect. 10.3.1 above), the AR5 sagely refrains from (directly or indirectly) suggesting emission reduction targets for different country groups. The AR5 explicitly acknowledges that scientists can only *inform* the policy debate and point out the practical implications of different ethical beliefs and policy goals, but cannot decide what the "correct" level of emission reduction or the "correct" energy mix is (IPCC 2014a, Preface; SPM; TS.1). The WG III AR5 illustrates – in contrast to a widespread, yet mistaken belief – that the IPCC does *not* necessarily and always follow the consensus principle, at least not in terms of consensus over "the best" scenario or policy option, or how to weigh the practical implications of policy options for society and nature. Already the Stern Review (described in Sects. 3.1.3 and 7.1.2 above), although it did not follow the refined pragmatic model, at least offered two alternative policy scenarios and their practical implications. This had considerable political impact (Sect. 3.1.3). Unfortunately, most discussions after the Stern Review focussed on δ and η, rather than on Stern's more far-reaching innovation – the exploration of policy alternatives.

Besides the exploration of policy alternatives, other pillars of the WG III AR5 approach were the (envisaged) high transparency regarding value judgements and the extensive communication of uncertainties (IPCC 2014a, Preface).

> Working Group III included an extended framing section to provide full transparency over the concepts and methods used throughout the report, highlighting their underlying value judgments. This includes an improved treatment of risks and risk perception, uncertainties, ethical questions as well as sustainable development (IPCC 2014a, p. ix).

WG III made major normative assumptions and the ethical dimension of climate change response options in general more transparent than in previous assessments. In a remarkable clarity, the Preface of the AR5 acknowledges: "Facts are often inextricably linked with values" (IPCC 2014a, ix). Also the WG III SPM admits: "Many areas of climate policy-making involve value judgements and ethical considerations" (IPCC 2014a, SPM.2).

An outstanding feature of the AR5 is the inclusion of a chapter on ethical issues of climate change mitigation (IPCC 2014a, Chap. 3). This chapter is titled "Social, Economic, and Ethical Concepts and Methods." While it does not take a stance on which concept of justice is best, the IPCC authors (mostly non-philosophers) came to conclusions such as that equitable outcomes can lead to more effective international cooperation. Moreover, the chapter provides an overview of major viewpoints in the climate justice debate. The inclusion of such a chapter was disputed among both policymakers and researchers because some people did not want to have any ethics in a scientific report which, in their view, should be free from normative assumptions. Through this framing chapter, however, the IPCC made more than clear that climate policy is value-laden and there is no way to scientifically determine the "right" climate policy without strong normative assumptions. Similar to the Stern Review a few years earlier, the IPCC succeeded in bringing ethics back into the discussion about climate policy.

The WG III contribution to the AR5 also made major uncertainties transparent[19] and communicated uncertainties in a more consistent manner than ever before. For the first time, there was a calibrated uncertainty language across all WGs (Mastrandrea et al. 2011).

Weaknesses and limitations of the new WG III approach

Yet, weaknesses and limitations remain. The range of alternative, controversial ethical assumptions and related policy objectives (as well as of related co-effects of climate policy instruments) explored in the AR5 could have been much larger – at least theoretically. Among the reasons is the lack of literature exploring the practical implications of a broad range of ethical assumptions in different world regions[20]; in general, the predominant academic culture does not provide high incentives for applied, ethically-integrated, socio-economic policy analysis.

In practice, however, the complexity of the AR5 assessment was already overwhelming. For instance, the analysis of co-benefits of ambitious climate change mitigation for other policy fields had to ignore many other policy objectives beyond energy security and health in order to keep the model complexity manageable (particularly given that there was not much literature on certain co-effects) and in order to achieve conclusive quantitative results. Moreover, the models were not able to consider the whole uncertainty range.

Additionally, while the ethics chapter (IPCC 2014a, Chap. 3) presented different ethical viewpoints, most of the aspects discussed in this framing chapter were not highly integrated into the other parts of the WG III assessment. Such an integration, however, would be essential from the perspective of the refined pragmatic model, because it allows for learning about the practical implications of these disputed ethical standpoints. This would presuppose the willingness and training of IPCC authors, as well as appropriate resources, to conduct truly interdisciplinary assessments, including of the ethical dimensions of climate policy.

Beyond the laudable, but rather general statements on the role of value judgements in the IPCC analyses, the transparency of normative assumptions could be improved particularly by making also the individual, concrete normative assumptions underlying the IPCC results more transparent. This is especially valid for those implied in IAMs as highlighted in Chap. 8 above – particularly given their bias (Sect. 8.5). Also the different kinds of uncertainty (Chap. 9) could be made more transparent, including the technical uncertainties. Furthermore, there is still too much focus on high confidence statements in the whole IPCC AR5, neglecting other interesting and highly policy-relevant scientific insights (Victor 2015).

[19] A perfect example is Sect. 6.2.3 of the WG III AR5 (IPCC 2014a).

[20] As IPCC authors stated in personal conversation, about 80 % of the literature on climate policy analysis is US-centred.

Finally, some governments (but also some researchers) do not support an open, critical exploration and discussion of alternative sets of policy goals and their ethically relevant practical implications in the IPCC assessments, particularly if it comes to ex-post policy evaluations that may not be favourable to some countries, or analyses with undesirable political implications (Edenhofer and Minx 2014). This became particularly obvious during the IPCC plenary meeting on the adoption of the WG III AR5 SPM in April 2014 (Berlin), as already described in Sect. 3.3.2 above. Some governments did not want to agree to any alternative income-based country grouping, for instance (Edenhofer and Minx 2014). Moreover, ex-post evaluation of international cooperation was rejected. Thus, not everyone wants to engage in a painful learning process about alternative policy paths. For the full exploration of the policy solution space, including its normative dimensions, there is still no explicit mandate, nor are the required processes in place.

10.4 Reflecting on IPCC Processes and Procedures

Additionally, many process-related challenges within IPCC assessments could be discussed.[21] I will limit myself to a few comments on (1) processes to ensure policy-relevance, (2) disciplinary and regional balance, (3) managing the "epistemic complexity," (4) the SPM and the role of consensus, as well as (5) communication with stakeholders and the public. These particular procedural aspects seem most interesting given the ideal for assessment-making from Sect. 6.4.

Processes to ensure policy-relevance

The scoping phase is decisive for the policy-relevance (as explained in Sect. 6.4) of an assessment. It has to ensure that the right questions are addressed in the AR. First and foremost, to achieve policy-relevance, a scientific assessment of mitigation and adaptation options should conceptually be embedded in a decision-making framework (i.e., value-laden risk management under uncertainty; discussion of policy options), as argued in Chap. 6.

In contrast to the WG *II* AR5 and the WG III *AR4*, the WG III AR5 results are largely related to decision-making contexts. Unfortunately, however, in the scoping phase for the WG III AR5, there was no agreement among governmental representatives to provide clear policy questions to be addressed by the AR5.[22] Some argued that the sciences would not be able to answer these questions anyways. Perhaps some governments were also afraid of potential policy-related results in the AR5 that could be unpleasant for them. The lack of clear policy questions made it hard for the AR5 authors to provide a truly policy-relevant assessment; they had to think

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[21] Discussions of procedural issues can be found in IAC (2010) and Beck (2009), abut also in the work by Carraro et al. (2015a, Sect. 4) regarding the general efficiency of IPCC assessments.

[22] This is what governmental representatives involved in the IPCC AR5 process told me in personal conversations.

for themselves what the interesting policy questions could be and had to work with a rather cumbersome outline for the WG III AR5. Providing clear policy questions would be useful even if there is not much research. For both policymakers and researchers, it would have been helpful to understand the existing research gaps as well. These gaps could then be filled by the scientific community with regard to future assessment cycles.

Achieving a high degree of policy-relevance would require much exchange between assessment authors and stakeholders (including the governmental officials), but also successful communication and integration across the IPCC WGs themselves. This was insufficiently realised in both the AR4 and AR5.

Disciplinary and regional balance

The selection of WG III authors was challenging in both the AR4 and AR5. This is also due to the fact that there is still no clear guideline for how to select authors more precisely. Ideally, given the refined pragmatic model, the author selection (1) ensures that authors have the relevant expertise (in terms of discipline, approach, thematic focus, etc.) for the respective chapter, (2) chooses the best and widely respected experts in their field, and (3) envisages diversity (regional, gender, disciplines, etc.). Obviously, however, there are many trade-offs between these criteria. IPCC WG III assessments, including the contribution to the AR5, often suffered from a bias toward authors from developed countries.[23] Due to the inequality regarding scientific capacities in different countries (resulting in a relatively low share of IPCC authors from developing countries), the IPCC has always faced tensions between the ambition of scientific excellence, and achieving regional balance and legitimacy (which is not the IPCC's fault, but a more fundamental global problem). Also in the IPCC plenary meetings, the delegations from wealthier countries have often been rather large and powerful, comprising many knowledgeable experts, compared with the small delegations from poorer countries.

There is also a light bias in terms of scientific disciplines involved in the WG III AR4 and AR5 (Victor 2015).

> From a disciplinary perspective, economists, engineers, physicists and natural scientists remain central to the process, with insignificant participation of scholars from the humanities (Corbera et al. 2015).

Furthermore, while the IPCC seems highly attractive for leading scholars to contribute, there are little academic incentives (apart from network effects) for researchers to contribute to these time-consuming and often laborious, exhausting IPCC assessment processes. The authors are not paid, it is voluntary work. Particularly for highly skilled younger researchers, there are still high costs (time requirement) and little benefits of participating in large-scale assessment processes. Given this chal-

[23] See Corbera et al. (2015). In general, as participant of the IPCC plenary session on the approval of the AR5 synthesis report (IPCC 2014b) in October 2014 (Copenhagen), I learned that the tensions between "developing" and "developed" countries are still a predominant and explicit conflict in the IPCC.

lenge, it is great to see how many distinguished researchers nonetheless contribute to these social learning processes of the IPCC assessments.

Managing the "epistemic complexity"

For the WG III AR5, 235 authors (from 58 countries) and more than 800 reviewers addressed close to 10,000 references in close to 1,500 pages, and addressed more than 38,000 review comments made on the WG III AR5 drafts.[24] Both the available literature on some aspects of the climate issue and the number of review comments on the WG III AR5 drafts has significantly increased compared with previous assessments. Specialisation and fragmentation of the literature and expertise is but one challenging result of this development, the overwhelming workload for the WG III AR5 author teams is another. This is even more valid in light of the fact that the scope of the WG III AR5 is slightly broader than in the AR4, also because the exploration of alternative policy pathways implies an extended discussion of policy objectives and implications related to policy fields other than climate change. Another challenge for WG III was the lack of elaborate policy assessment methodology (see Sect. 10.2 above) for exploring alternative climate policy pathways, as well as the lack of review papers and "pre-assessments" that would have helped facilitate the IPCC assessment process. Such pre-assessment studies provide partial knowledge integration or quantitative meta-analysis.

Moreover, it is questionable whether the scientific review process for the WG III chapters is still adequate – although the IPCC ARs are widely respected for their scientific rigor in general. In contrast to journal editors, WG III chairs and the reviewers do not have the possibility to reject an entire chapter in case its scientific quality is insufficient.

SPM and the role of consensus

The most disputed procedural element of IPCC assessments is the SPM process. In this line-by-line approval process, governments can accept, reject or modify the SPM draft prepared by the IPCC authors (see Sect. 2.3 above). However, all changes proposed by the governments must be strictly consistent with the underlying AR (Edenhofer and Seyboth 2013) – which is actually ensured in practice. The SPM process ensures governmental buy-in. Furthermore, for many policymakers and their assistants, the SPM is important since they usually do not have time to read full reports (Dunn 1994, p. 23). Providing a SPM was demanded by the governments when the IPCC was established in 1988 (Beck 2009, p. 153).

The IPCC SPMs are often criticised in terms of suggesting a scientific consensus where there is none. In Sect. 3.1.2, it was argued that scientific consensus may entail high clout regarding policy impact, but in most (highly policy-relevant) cases, there is no full scientific consensus.[25] Moreover, Chaps. 5 and 6 explained that scientific consensus is not necessary for achieving objective statements; consensus-based

[24] See http://mitigation2014.org/, accessed 30 Jun 2015.

[25] See also Mulkay (1978).

decisions usually do not belong to the scientific world where controversies are an important driver of progress and innovation (Skodvin 1999, p. 7).

This tension between clout (of consensus) and existing scientific controversies was challenging for both the AR4 and the AR5 as well. One can, however, increasingly observe a re-interpretation of "consensus" within the IPCC towards a weaker understanding of consensus. Since the AR4, or even earlier, consensus only means that all IPCC authors agree that the statements are scientifically justifiable and according to the state-of-the-art. This allows for the presentation of dissent. While the AR4 did not present much dissent (see Sect. 10.3.1 above), the AR5 explored alternative, disputed climate policy pathways, as explained above.[26]

Moreover, another problematic implication of the consensus-oriented IPCC SPM process is that it sometimes suffered from political intervention. Consensus can be misused to hide scientific or political controversies as well as clear policy options ("non-controversial conservatism," see Beck 2009, p. 134). Any undesirable scientific conclusion can be rejected or at least weakened by any nation (Beck 2009, pp. 153–156). For instance, as already said in Sects. 3.3.2 and 10.3.3, some SPM figures for the WG III AR5 had to be deleted because governments did not like the potential policy implications (Edenhofer and Minx 2014). However, governments cannot significantly add content to the SPM beyond what it stated in the full IPCC report. It should be emphasised that it is very difficult for governments to considerably alter the direction of the argumentation in an IPCC SPM because so many different country groups are involved with divergent viewpoints that in the end often neutralise each other.

Despite these challenges, the SPM process is highly valuable as a co-operative deliberation process between scientific experts and stakeholders. As such, governmental inclusion in the SPM can be much more than merely a "buffer" for scientific experts against political influence in the AR main text, as some assume (e.g., Beck 2009, p. 153). This does, however, not necessitate a strict consensus on specific scientific assumptions.

Communication with stakeholders and the public

IPCC assessments have always engaged with stakeholders. Governmental officials, but also other stakeholders, are involved at various stages of the process. To improve the iterative aspect during the chapter writing process, however, WG III organised a meeting with business representatives and other stakeholders towards the end of the AR5 cycle.[27] Moreover, the "Structured Expert Dialogues" after the release of the AR5 went very well according to those who participated; at these

[26] For a further discussion on the role of consensus, see Beck (2009), Skodvin (1999), Agrawala (1998), Hulme and Mahony (2010) and Sluijs et al. (2010). "Guaranteeing the scientific reliability of IPCC reports is indeed essential but it does not address the main weakness of the consensus approach: the underexposure of both scientific and political dissent. As a result of this weakness climate science has become politicized over the past decades" (Sluijs et al. 2010).

[27] "Expert Review Meeting for the 5th Assessment Report," Washington, 6–8 August 2012. See http://www.ipcc.ch/scripts/_calendar_template.php?wg=8 (accessed 30 Jun 2015).

events, selected IPCC authors had to directly respond to specific questions formulated by UNFCCC policymakers.[28] Governments may hopefully learn from this exercise that asking specific policy questions to scientific experts can be useful.

Still, however, public participation in the IPCC is sub-optimal (Beck et al. 2014); the focus thus far is on governments. Furthermore, the AR5 SPM partly remains hard to understand for non-experts, particularly given the fact that the IPCC addresses various target audiences with very different needs.

In addition, many have argued that the IPCC should deliver smaller reports more frequently in order to provide more timely expertise to policy processes.

10.5 Concluding Part III: Current Challenges for the IPCC WG III

All things considered, WG III did a good job for both the AR4 and the AR5. Some aspects have been improved in the WG III AR5 compared with previous assessments, and there is, as far as I can see, no clear example of a significant hidden bias in the WG III ARs, for instance towards very ambitious global mitigation targets. The IPCC – particularly its rigorous scientific quality assurance and the relatively successful balance between governmental buy-in and scientific independence – has become a role model for a number of other assessment projects. Compared with other policy fields, the extent to which governments accept the scientific findings by the IPCC – i.e., both the SPMs and the underlying reports – is indeed remarkable and perhaps unprecedented. "By endorsing the IPCC reports, governments acknowledge the authority of their scientific content."[29]

The brief evaluation in the previous sections, however, although far from being comprehensive,[30] has also revealed a couple of challenges that the IPCC WG III is currently facing. Even though many problems of the IPCC assessments are related to the lack of appropriate economic studies (see Chaps. 7, 8 and 9) available to support the IPCC's idea of an integrated policy assessment, there are also considerable weaknesses of the WG III assessments themselves that should be taken into account by any future IPCC guidelines (Chap. 11). The five most profound current challenges for the integrated economic assessments by the IPCC include:

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[28] See http://unfccc.int/science/workstreams/the_2013-2015_review/items/7521.php (accessed 30 Jun 2015).

[29] Source: http://www.ipcc.ch/organization/organization.shtml (accessed 30 Jun 2015).

[30] A recent expert workshop on the IPCC (where I also participated), for example, discussed these issues more comprehensively (Carraro et al. 2015a, b). A more comprehensive analysis and evaluation is also envisaged by a joint MCC-UNEP research initiative on contemporary, solution-oriented global environmental assessments (see http://www.mcc-berlin.net/en/research/cooperation/unep.html, accessed 30 Jun 2015) which I am coordinating.

1. most importantly, the need for even more (scientifically sound) knowledge integration and synthesis across various disciplines, policy fields, governance levels and IPCC WGs, in order to better understand the full policy solution space;
2. the lack of a more comprehensive, explicit and integrated discussion (and transparency) of disputed, normative viewpoints, including different ethical values and principles, and including critical (multi-criteria) ex-post policy evaluation;
3. the limited capacity and effectiveness of the IPCC given the huge "epistemic complexity," procedural inefficiencies and sub-optimal support by stakeholders;
4. insufficient public participation, while facing various trade-offs; and
5. existing research gaps regarding scientific policy analysis and meta-analyses on some specific policy aspects.

The IPCC plenary meeting after the AR5 release (February 2015, Nairobi, see IISD 2015) discussed potential improvements of the IPCC process. Unfortunately, however, the governments did not agree on any far-reaching reform of the IPCC assessment process and format.[31]

To conclude Part III as a whole, we learned that the WG III AR5 has, *to some extent*, successfully realised the refined pragmatic model from Part II already, but that this can still be significantly improved. We also learned, however, that this ambition implies a couple of challenges for the IPCC assessments, including those related to the quality of the underlying scientific publications (Chaps. 7, 8 and 9).

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[31] In response to the big IAC Review (IAC 2010) that was conducted after much criticism of the IPCC (see Sect. 3.3.1 above), however, the IPCC reformed its processes and structure to some extent; see http://www.ipcc.ch/organization/organization_review.shtml (accessed 30 Jun 2015).

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Part IV
Towards Improved Integrated Economic Assessments for Climate Policy

Chapter 11
Elements of a Guideline for Future Integrated Economic Assessments of the IPCC

Abstract Part IV identifies (in this chapter), and reflects on (in Chap. 12), some elements of a more specific guideline for improving the integrated economic assessments by the Intergovernmental Panel on Climate Change (IPCC). This is based on the preceding analysis of the challenges faced by these assessments (Parts I–III). A short check list for integrated economic assessments summarises the key recommendations (Sect. 11.1). Section 11.2 addresses the question of what information we want the IPCC to provide in its next assessments. The IPCC should map alternative policy pathways and their implications even more comprehensively and specifically. More specific proposals for the appropriate treatment of disputed value judgements and uncertainties in IPCC assessments are given next (Sect. 11.3). It is also argued that the multi-scenario analyses should more explicitly explore disputed ethical viewpoints. Then, potential improvements of the IPCC's processes, formats and public participation are discussed (Sect. 11.4). Finally, Sect. 11.5 argues that the scientific community could better support the IPCC assessments.

So far, the focus in this volume has been on the Step 2 of our Deweyan enquiry (see Sect. 6.2) into the IPCC's integrated economic assessments. This refers to the thorough problem analysis regarding the IPCC's economic assessments and the determination of the "ends-in-view" (i.e. goals) to be achieved by these assessments. The analysis in Chap. 10 concluded the problem analysis by providing several insights on strengths and weaknesses as well as major challenges of recent IPCC WG III assessments. We are now prepared to identify some elements of a more specific guideline for improving the IPCC's upcoming integrated economic assessments. This corresponds with Dewey's Step 3, i.e. the identification of possible means of overcoming the problems and weaknesses of the current IPCC's integrated economic assessments. This will be done in the present chapter.

More precisely, the structure of the present chapter directly responds to the five profound current challenges for the integrated economic assessments by the IPCC (Sect. 10.5). *First*, after a summary in terms of a short check list for upcoming integrated economic assessments (Sect. 11.1), Sect. 11.2 addresses the question of what information we want future integrated economic assessments to provide. *Second*, the appropriate treatment of disputed value judgements and major uncertainties is discussed in Sect. 11.3. *Third*, Sect. 11.4.1 presents options to improve the IPCC's

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procedures and formats in light of epistemic complexity, inefficiency, etc. *Fourth*, Sect. 11.4.2 suggests enhanced public participation in IPCC assessments. *Fifth*, Sect. 11.5 argues that the scientific community could better support integrated economic assessments, and the IPCC could provide better incentives and recommendations for what would be needed for future assessments.

In addition to the present chapter, which identifies potential means for improving integrated economic assessments, Part IV will also address Step 4 of a Deweyan enquiry (in Chap. 12), concerning the critical evaluation of the proposed means in light of their possible practical implications.

It is impossible to develop an all-embracing IPCC guideline in the present volume. This would presuppose a fully comprehensive analysis and evaluation of the problematic situation of the IPCC's integrated economic assessments.[1] This would go far beyond the space limits of this book. The thoughts and results of the previous parts, however, enable us to develop some crucial *cornerstones* (elements) of an IPCC guideline. Although these cornerstones can only be tentative in the sense of Deweyan-Putnamian pragmatism (see Sect. 6.2),[2] they can still be well-grounded and reasoned based on the preceding analyses above. The recommendations presented in the present chapter directly result from the detailed problem analysis presented in Parts I–III above. These cornerstones may help improve future assessments and evaluate existing ones.

As argued in Chap. 10 above, the IPCC WG III AR5 provided a *relatively* useful and reasonable integrated economic assessment, despite its potential for improvement. Hence, to simplify matters, the present chapter will discuss the potential improvements on the basis of the given AR5 approach. The assumption is that future IPCC assessments are well-advised to build on and further develop the model established by the WG III AR5 – including, for example, the exploration of alternative climate policy pathways, the analysis of various co-effects of climate policy options and the more explicit discussion of ethical issues.

11.1 A Short Check List for Integrated Economic Assessments

The following overview – which intends to serve as an executive summary of this chapter – presents five key elements of the aspired guideline for future IPCC's integrated economic assessments. These five recommendations respond to the five challenges for current economic assessments of the IPCC identified in Sect. 10.5.

[1] A collection of different (governmental and other) proposals for and discussions about the future of the IPCC can be found at http://www.ipcc.ch/apps/future/ (accessed 30 Jun 2015). Literature with proposals for improving (the IPCC) assessments was already listed in Chap. 1.

[2] If the actual practical consequences of the proposed elements of an IPCC guideline are not desirable, a revision of the guideline will be required (see Sect. 6.2).

Enhanced Mapping of Policy Pathways and Their Practical Implications With the help of interdisciplinary multi-scenario analysis, concrete future climate policy pathways and their possible implications need to be explored and critically compared. Based on broader problem framings, the pathways should represent different (climate) policy objectives and major uncertainties, as well as different possible policy means. Consensus is only needed regarding the consistency and comparability of the different viable policy pathways. The focus should currently be on short-term bottom-up mitigation approaches and national pledges – in their combination with the long-term global climate policy targets, and in a second-best world risk management framing. Moreover, the IPCC could focus on the integration with climate change impacts and adaptation issues (IPCC WG II), as well as on the interdependencies between different sustainable development goals at various governance levels, including particularly via land-related policy effects. The pathways need to be analysed and evaluated in light of their actual and potential practical implications, being both quantitative and qualitative. They comprise a broad range of – largely uncertain – direct effects (benefits), implementation obstacles, barriers, costs, trade-offs with other objectives or values, as well as synergies. Ex-post evaluation of policy instruments is required to identify them. Among the most policy-relevant effects requiring better exploration are distributive ones.

Improved Treatment of Value Judgements and Uncertainty Controversial ethical (or other) value judgements implied in the assessments, as well as crucial uncertainties of different kinds (see Sect. 9.1) need to be disclosed in the IPCC assessments. Facts and values, as well as means and ends, are always entangled. The already mentioned multi-scenario analyses should be used to also explicitly explore the implications of disputed ethical viewpoints, in terms of exploring alternative policy pathways related to these viewpoints. This is a promising way to integrate and mainstream ethics (and philosophers) into integrated economic assessments. Instead of watering down political or scientific conflicts, or negotiating a mean value, assessments should reveal the alternative disputed standpoints and determine their implications more concretely. While it is crucial to explore disputed ethical viewpoints embedded in the predominant policy narratives, the ethical sensitivity analyses should also not forget minority views and the various "silent losers" of climate policy. If value beliefs or uncertainties cannot be directly addressed in a multi-scenario analysis, there should at least be a brief discussion of them in the reports to highlight existing alternative views. Concerning scientific quality, also plausibility statements can be useful. The IPCC's integrated economic assessments may benefit from increased methodical pluralism, which may also increase their epistemic quality.

Making the IPCC's Structure, Procedures and Assessment Format Fit for Purpose The challenge of realising the above ideas for future integrated economic assessments is huge. IPCC assessments need to be provided with the necessary resources in terms of funds, time and authors. It also requires appropriate procedures, formats and structures. Major reform proposals include: (1) strengthening the process of expert peer review and the functionality of author teams; (2) providing more timely, shorter thematic (sectoral, regional, etc.) reports, based on peer-reviewed pre-assessments; (3) merging WG II and WG III; and (4), reducing governmental resistance against critical ex-post policy evaluation inter alia by providing an appropriate mandate for assessing the full policy solution space.

Enhanced Public Participation at Different Stages Involvement of the public at different stages is crucial. This includes problem framing, scenario selection and the in-depth analysis of the implications of alternative policy pathways. Stakeholder engagement and public participation are not only useful for the improved communication, legitimacy and increased impact of IPCC assessments, but are also required for epistemological reasons (Sect. 6.2.2). The IPCC should not only aim to influence national policymakers, but should support a deliberative public debate to initiate a democratic learning process. Promising approaches are available. Different AR summaries for different target audiences are also useful.

Incentives and Suggestions for Climate Economics Research While overcoming the research gaps regarding different aspects of climate policy pathways is largely beyond what assessment bodies or processes could directly achieve, the IPCC could at least provide incentives and ideas for the research community concerning the gaps in knowledge (or methodology) that must be filled. Pre-assessments on particular policy aspects provided by the scientific community are essential to facilitate the larger-scale IPCC assessments.

These are cornerstones for future integrated economic assessment by the IPCC. In addition, a regular systematic meta-reflection on the IPCC's assessments should be institutionalised in order to refine and further develop these criteria and ideas. The five recommendations will now be explained and elaborated on in the subsequent Sects. 11.2, 11.3, 11.4 and 11.5.

11.2 What Social-Science Information Do We Want the IPCC to Provide?

The first profound challenge identified in Sect. 10.5 is about the overly limited scope of policy aspects actually assessed in the most recent integrated economic assessments of the IPCC. How can the IPCC enhance the knowledge integration and synthesis across various disciplines, important policy fields, governance levels and IPCC WGs – primarily regarding the relevant practical implications of policy means, but also regarding the selected policy goals and means themselves? This could significantly increase the IPCC's policy-relevance.

Broadening the problem framing

A first step is broadening the problem framing in IPCC ARs, which is the necessary basis of the envisaged enhanced coverage of diverse relevant policy aspects. Problem framing predetermines the scope of the conceivable climate policy solution space to be assessed. Different framings of the problem of climate change (mitigation) have been mentioned in Sects. 2.2 and 7.1.2 above. For example, given the irreducible uncertainty, any reasonable framing must include the concept of risk management. Moreover, the problem framing must address issue linkage more clearly than in previous IPCC assessments (see examples further below).

The WG III AR4, and even more so the WG III AR5, provided useful framing chapters to address and discuss such problem framings. Future IPCC assessments should keep to this idea of including extensive framing chapters, but perhaps be more explicit about alternative possible problem framings (as described, e.g., by Hulme 2009) and about their pros and cons. Moreover, the IPCC may better align and integrate the other assessment chapters with the framing chapters. These other chapters need to adequately address as many aspects as possible of the "problematic situation" identified in the IPCC AR framing chapters. The aim thus is to broaden the range of societally relevant aspects of climate policy to be addressed in IPCC assessments (see also Sect. 11.3).[3]

Exploring highly relevant policy pathways

An appropriate, sufficiently broad problem framing that incorporates (at least) the societally most relevant aspects of climate change (mitigation) should lead to a related exploration of possible concrete policy pathways. This helps decision-makers better understand and compare the available options and implications corresponding with this problem framing (see Sect. 6.4.1). In general, the pathways should represent a broad range of (climate) policy objectives and major uncertainties (e.g. regarding climate sensitivity) – all of which directly result from the problem framing –, as well as different sets of possible policy means (see below). To allow for learning about, and the critical comparison of, available policy pathways, all of these future world scenarios should be (theoretically) viable and scientifically consistent, but also comparable. While multiple metrics should be employed for evaluating scenarios (Sect. 8.4.5), the set of metrics employed would ideally be the same for every scenario to allow for comparison. Besides the metrics, also baselines and basis years should be the same for every scenario, including for those of other

[3] For instance, in the non-framing chapters of the WG III AR5, there is hardly any reference to framing concepts such as 'climate justice,' or to cultural aspects of climate change, which have, however, been highlighted in the WG III AR5 framing sections (e.g. IPCC 2014, Chap. 3). This is among the reasons why the scope of the exploration of alternative policy pathways in the AR5 was still too narrow, despite the promising approach taken there. These thoughts also suggest that there is, or should be, a clear connection between a serious problem framing exercise and the identification of relevant positive or negative implications of policy means for achieving the climate policy goals. In Dewey's terms, Step 4 of a Deweyan pattern of enquiry is basically adding to or refining the (preliminary) results of Step 2. Including a broad range of policy objectives implies the need to develop appropriate indicators that help to identify and evaluate the direct effects of policy options that are intended to achieve these particular policy objectives.

IPCC WGs (Edenhofer and Seyboth 2013). Consensus is only needed regarding the consistency and comparability of viable policy pathways.

Prioritising certain types of policy goals – together with prioritising types of policy means, and types of practical implications (see further below) – to be assessed in future IPCC assessments will help address the issue of epistemic complexity, as the third profound challenge for current IPCC assessments (identified in Sect. 10.5). This is because one aspect of this challenge is the increasing scope and number of objectives for IPCC assessments, which is considerably worsened by the proposals made here for enlarging the scope of policy aspects to be considered in future IPCC assessments.

In this sense, a major focus of upcoming IPCC reports should be on the assessment of bottom-up climate change mitigation approaches and national pledges (as an international "Nash equilibrium"?) in light of the long-term global targets. This would be most policy-relevant given the Paris Agreement (see Sect. 2.2), which should be seriously considered in any current framing of the climate policy problem. Although climate change is a global problem (Sect. 2.2), climate policy (both mitigation and adaptation) is an issue for all governance levels, from the global and international level to the municipal level. A critical scientific evaluation of national emissions reduction pledges would undoubtedly be highly relevant to current climate policy debates. The focus of climate policy debates has considerably shifted to bottom-up (and second-best) climate action and away from ambitious global coordination efforts.

The sheer fact that climate change remains as a serious global issue, irrespective of the still ineffective international cooperation, should be reason enough to *also* explore the global dimensions of climate policy. Consequently, one thing the IPCC should definitely continue and deepen is the evaluation of different long-term global climate policy goals. Ideally, the IPCC would present a rich image of how the world would look in the cases of a 1.5°, 2°, 3°, 4° and 6–8 °C global average temperature increase, and what the requirements, conditions and implications are. These images represent different possible global policy pathways, also for the not so unlikely case that the ambitions of the Paris Agreement will not be realised.

Another focus of future assessments should be issue linkage in terms of the integration with climate change adaptation goals (see below, section on implications), as well as in terms of the global Sustainable Development Goals. More than anything else, the Sustainable Development Goals adopted in 2015 show the fundamental need for a better scientific understanding of the various significant interdependencies (synergies, trade-offs, etc.) between multiple policy objectives, including climate change mitigation, at various governance levels.[4] Discussing goals for sustainable development in IPCC assessments should particularly address land-use issues, such as, for instance, the many interdependencies of land use

[4] The IPCC and the underlying literature have extensively analysed issue linkage regarding the economic costs of climate change mitigation and furthermore energy security. There are, however, also many other policy objectives (e.g., fair distribution of wealth or resources) that must be more thoroughly considered and assessed.

changes, land management and land rent dynamics with climate change (mitigation) (see also Sect. 10.2). Non-climate policy goals closely interlinked with climate change mitigation thus also have to be considered by the IPCC. Consequently, the IPCC should explore broader bundles of different policy objectives and related indicators under the framework of sustainable development.

These recommendations for an appropriate scope of social-science information we want the IPCC to provide should not be misunderstood as static, absolute statements. Rather, context matters considerably; policy-relevance is determined by the current and constantly evolving climate policy discourse.

Extended evaluation of policy instruments, including extreme scenarios

It is also necessary to much better understand and evaluate the range of available *means* of achieving the various policy objectives, for instance different policy instruments to realise a certain energy mix. While previous IPCC assessments clearly focussed on technological means, future assessments need to explore policy instruments more extensively, both international and national or regional ones. Particularly the interactions between various policy instruments (e.g., technology standards versus carbon pricing instruments) and between various governance levels have hardly been assessed in past IPCC assessments.

Another example of what the IPCC could focus on include current infrastructure investments. Energy infrastructure investments (or the lack of them) can create tremendous path dependencies and can lead to carbon lock-in in some regions. For instance, the many new coal-fuelled power stations currently planned in several countries will presumably have a lifetime of roughly four decades. If these power stations are actually built, meeting the ambitious goals of the Paris Agreement (2 °C or below) will become more or less impossible. While the IPCC provides some information in this regard (IPCC 2014), more extensively exploring alternative investment options in light of climate policy goals, and exploring the potentially huge revenues from carbon pricing that could be spent for all kinds of infrastructure, would make the IPCC even more policy-relevant.

Scientific analyses of national and short-term policy instruments are often more interesting for policymakers and the public than long-term scenarios. Mapping the means of achieving climate policy goals also requires the mapping of very concrete options for different periods and regions; short-term policy entry points (be they domestic or multilateral) need to be better explored. It is hard to arrive at a distant destination without knowing in which direction the first steps should go.

A valuable extension of this would be to assess appropriate policy instrument choice in case of delays in mitigation actions by certain countries. This has already been done by WG III AR5 to some extent, while the AR4 focused too much on unrealistic first-best world scenarios with limited policy-relevance (see Chap. 10 above). Instead, second-best world scenarios[5] can take into account delayed climate

[5] This has in principle been discussed in economics for a long time, for instance by Ng (1983) who discusses "second-best" welfare economics.

change mitigation action, barriers for trade and sub-optimal policy instruments, for instance.

Furthermore, while not being the highest priority for future IPCC assessments, the scenarios do not always have to be politically or statistically highly realistic options; "extreme scenarios" that explore the possible implications of potential radical political decisions on policy instruments, or the implications of uncertainty ranges related to the availability (e.g. biomass) or effectiveness (e.g. carbon capture and storage, CCS) of certain technologies or policy instruments, can also be very helpful for decision-making.[6] This can lead to a better understanding of the leeway that policymakers have (i.e., the potential boundaries of the decision space). It also provides the opportunity to more constructively discuss the strengths and limitations of particular energy technologies. An example would be a scenario with a very high global share of nuclear power, or a scenario with 100 % renewable energies in a future energy mix – just to show the prospects and limitations of certain energy technologies within a potential global or regional energy mix that is, for instance, related to a specific mitigation goal.

More in-depth exploration of practical implications and obstacles

Finally and crucially, the range of practical implications considered in IPCC assessments should become broader. According to the refined pragmatic model, the evaluation of policy goals and means requires the exploration of the various (potential future or actual past/present) practical implications of these policy options. Much can be learned from these implications about the appropriateness of given sets of policy objectives and means; such analyses may reveal societally relevant implications that go beyond the policy fields and objectives originally considered for the multi-scenario analysis, for instance unexpected implications of climate policies for the religious practices of some indigenous people.

Assessments should particularly enlarge their "ex-post" policy evaluation, i.e. more extensively analyse the implications of already implemented policy instruments (such as the European Emissions Trading Scheme, for instance) in order to learn from them for future policy options. Step 5 in a Deweyan enquiry reminds us that the actual practical consequences of policies after their implementation matter a lot.[7] Climate policy, which has been discussed for several decades, is a good

[6] An example of how this could be done is creating extreme scenarios regarding "system shocks" or non-linear developments, as also argued by Kunreuther et al. (2013) and Weitzman (2009). Following these authors further, the discussion of uncertainty needs to be better integrated into a decision-making framework with a focus on risk management. This would help policymakers to better understand the choices they are facing and the related risks and perils, particularly regarding highly disputed issues. The AR5 provided some information in this regard, but much more analyses of this kind would be needed.

[7] There is hardly ever a "singular" development of policies. Until the 1970s, it was common (in political science and political practice) to regard a policy process as finalised as soon as there was a decision about a law or regulation. The implementation and practical consequences did not play a considerable role at that time (Blum and Schubert 2009, pp. 122f).

example of the assumption that we actually have the time needed to learn from the actual consequences of policies.

Compared with the AR5, the analysis of synergies of climate policy pathways with other policy fields must also be enlarged. This, however, presupposes the development of appropriate methods and methodologies to identify synergies (see Sect. 11.5 below). Moreover, more thoroughly analysing implementation barriers and obstacles would be particularly interesting given the current developments in the climate policy realm, as described above. As the IPCC evaluation in Chap. 10 suggests, technological and other *risks* of ambitious mitigation options, as well as the reactions of market agents to regulations could be better assessed as well.

A huge innovation compared with previous IPCC WG III assessments would be to better integrate WG II findings into WG III assessments, and the other way round. It is essential for any climate policy evaluation – given the multiple policy objectives along the sustainable development paradigm – to also understand the avoided or occurring climate change impacts that are, for instance, related to the different global climate stabilisation levels (e.g., Gerten et al. 2013). Given that the costs and risks of ambitious climate change mitigation can be high in some regions and under some conditions (IPCC 2014), decision-makers need to weigh this with the benefits including avoided climate damages. Mitigation, adaptation and impacts have not yet been satisfactorily brought together – neither in the AR4 nor in the AR5. The huge problem is, however, that we still do not know what the differential regional climate impacts will likely be comparing, for instance, a 1.5°, 2°, 3° and 4 °C warmer world.

Another major improvement compared with previous IPCC assessments would be the deeper analysis of the highly disputed and most relevant *distributional* implications of climate policy options. Let me give an example. Since there are still so many fossil resources in the ground and since ambitious climate policy implies limiting the global budget of GHG emissions, a large share of fossil resources would have to remain in the ground (IPCC 2014). Countries that have a lot of fossil resources or heavily use of such resources would thus be among the economic losers of ambitious mitigation, if there is no compensation for them. An IPCC assessment would be substantially more policy-relevant if it extensively addressed the many controversial distributive issues. As climate policy must deal with these distributive conflicts between nations and between other interest groups anyways, these issues should not be so radically ignored as they had been in some previous IPCC assessments (for understandable political reasons though).

Such enquiries, however, would require more – and more diverse – involvement of the social sciences and the humanities (Victor 2015), including philosophy and including economic methods beyond the IAMs (see also Sects. 7.4 and 9.4 above). They require truly inter- and transdisciplinary collaboration. This helps cover a broad range of implications, both quantitative and qualitative ones.

Given the high number of possible practical implications that could theoretically be assessed – unwanted side effects, co-benefits or even overlaps between policy options for different policy goals, given multiple policy objectives, multiple externalities and multi-functional policy instruments –, these examples could be the priorities of future IPCC assessments.

11.3 Treatment of Disputed Value Judgements and Uncertainty

This section responds to the second profound challenge of current IPCC assessments identified in Sect. 10.5. i.e. the lack of a broader, explicit and integrated discussion, and lacking transparency, of disputed normative viewpoints. Section 11.2 was about the scope of the policy-relevant aspects considered, irrespective of whether there are disputed ethical viewpoints or not. In contrast, this section discusses how to deal with disputed normative assumptions within this scope in a legitimate manner. Furthermore, this section will briefly address challenges of current IPCC assessments related to scientific and epistemic quality and reliability.

Transparency regarding value judgements

It is fair to say that the transparency regarding value judgements in the AR5 was much better than in many other scientific (particularly economic) publications on climate change (policy), as the analyses in Chap. 10 above indicate. However, disputable, highly relevant normative implications need to be made more transparent than in previous IPCC assessments. This is valid for all stages of an assessment process, beginning with the problem framing and scope. Chapter 8 explained how difficult it is to actually achieve a high level of transparency. One reason is that mainstream economics often makes use of a particular, limited set of values and questionable assumptions without always making them transparent, let alone critically discussing them.

One of the first things to do in order to improve transparency of disputable value judgements in WG III assessments is to make those fundamental value judgements more transparent that have been identified in Chap. 8 above, i.e., the many, but often opaque, value judgements in IAM economics. Merely discussing, for instance, the ethics of discounting or questions of distributive justice as briefly done in both the AR4 and the AR5 is good, but insufficient. The claim of "transparency" must be translated into a much more differentiated IPCC guideline. The framework for identifying value judgements in IAM-based economics developed in Sect. 7.3.2 is proposed here as a conceptual tool for this ambitious purpose. Since many economists are still relatively unaware of implied value judgements, the IPCC may perhaps have to engage with the scientific community to raise awareness for these issues.

Constructive treatment of value judgements

It is not problematic *per se* that value judgements are involved in integrated economic assessments, as Chaps. 6 and 7 already claimed. Rather, beyond making them transparent, the refined pragmatic model of scientific expertise in policy envisages a constructive and societally useful treatment of disputed normative assumptions in assessments. The core idea is to use multi-scenario analyses to explore selected, disputed ethical viewpoints related to climate policy via the practical implications of the means required for realising these ethical viewpoints. The guiding question of such an in-depth "ethical sensitivity analysis" (Biewald et al. 2015) is: how would the world, as a consequence, actually look if one fully acted according to ethical viewpoint in question? Ideally, the results of this exercise help us to revalue previously held value beliefs.[8] Thus, instead of watering down political or scientific conflicts, or negotiating a mean value or only one "consensus scenario," assessments should reveal the alternative disputed standpoints and determine their implications more concretely – for instance regarding the controversial normative dimension of the ex-post climate policy evaluation (see Sect. 10.3.3). This is a promising way to integrate and mainstream ethics (and philosophers) into integrated economic assessments.

Compared with the existing IPCC WG III assessments, future assessments should aim to better realise this idea of a "multi-scenario analysis." In a sense, WG III had the ambition to do this for the AR5 *to some extent* with regard to alternative and disputed, global climate stabilisation goals (see Sects. 10.2 and 10.3), which can be interpreted as normative-ethical scenario assumptions. Through these long-term scenarios, WG III AR5 indirectly (implicitly) assessed the costs, risks and requirements of alternative standpoints regarding intergenerational justice. As became clear in Chap. 10, however, this analysis could be significantly enlarged – for instance by exploring alternative views related to the examples from Chap. 8, or the implications of those ethical aspects that are omitted in most IAM-based economics (see Sect. 8.4). Building on the broad set of policy objectives in a sustainable development framework, a huge variety of politically highly relevant, alternative ethical viewpoints (in terms of different bundles of policy objectives) could theoretically be explored in multi-scenario analyses.

What about all those "silent losers," as Weimer and Vining call them (1992, pp. 110f), who often have no voice in politics or scientific assessments? The concepts of social welfare used in IAMs sometimes neglect crucial aspects of poverty (see Chap. 8), as do large-scale assessments that do not critically reflect on these IAM implications. In contrast, from a normative-ethical perspective, I suggest that the least well-off of both current and future generations worldwide should be given particular attention in such scenarios (Kowarsch and Gösele 2012). This can be achieved, for instance, when the climate policy scenarios also include – more specifically and more directly than previously done – the long-term policy objective to eradicate different forms of extreme poverty (for instance, in terms of particular Sustainable Development Goals), and when the assessment subsequently explores the required policy means, and their various practical implications and challenges.

Given that many philosophers have also criticised the anthropocentrism in most of the welfare economics and argued for a (more or less) biocentric ethical

[8] I have elaborated on how to constructively treat and better integrate ethical viewpoints in scientific assessments in Biewald et al. (2015) and Kowarsch and Edenhofer (2016). One of Dewey's examples (1927) is the controversy between radical liberalism and communism back then. Instead of endless debates into abstract values, a critical comparison of the complex practical implications of these concepts may lead to the insight that both are undesirable in their extreme variant due to hardly acceptable practical implications for society.

perspective, it would also be very interesting for the public discourse to include such more biocentric viewpoints as well in IPCC assessments.

A selection has to be made, however. There are so many disputed normative assumptions implied in integrated economic assessments[9] that not all of them can be analysed in an ethical sensitivity analysis. If one attempted to create scenarios that addressed all of these interesting aspects, thousands of scenarios would have to be explored, given the many dimensions mentioned above, which would lead to an exponential increase of scenarios with each additional dimension. The selection of policy alternatives to be critically explored and compared in IPCC assessments is, as already discussed in Sect. 6.4.1, in itself a highly contentious, value-laden decision. The highest priority should be given to those (disputed) climate policy goals (or related values) that have relatively high support from parts of the international community respectively. This is also certainly among the reasons why the WG III AR5 focussed on the exploration of the 2 °C global temperature goal.[10]

A reference to the predominant "policy narratives"[11] may be very helpful in this regard. Policy narratives often can provide a simplified orientation of such complex value-laden issues in public debates (Shanahan et al. 2011). They include claims about the problematic situation at stake and appropriate response strategies.[12] Typically, important disputed ethical viewpoints are embedded in these policy narratives. In a co-operative manner (see Sect. 11.4.2), some prevailing policy narratives have to be selected; they should include the most relevant alternative (disputed) policy narratives prevalent in the public debate. Next, these selected policy narratives have to be transformed into consistent scenarios to explore their ethical assumptions and their many relevant implications and uncertainties in great detail, in order to allow for learning about the validity of these policy narratives.

In the context of climate change and especially in the discussion about global mitigation goals, the major policy narratives may currently be represented by: (1) "the environmentalist," who refers to the planetary boundaries and the assumed physical limits of economic growth (sometimes even arguing for "de-growth"), which is similar to Malthusianism, and who assumes severe climate impacts, arguing for ambitious climate change mitigation; (2) those proponents of economic

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[9] For a taxonomy of the disagreements in climate policy see Robert and Zeckhauser (2011).

[10] IPCC assessments can also only examine a limited number of *non-climate* policy objectives. Maybe the IPCC should focus on those that are most interlinked with climate policy *and* most relevant for social welfare. For instance, the policy goal of access to affordable energy sources for the very poor – which may perhaps be endangered by too ambitious climate change mitigation policies – may have rather high priority.

[11] "Narratives are a way of structuring and communicating our understanding of the world. Whereas political narratives are persuasive stories for some political end (e.g., to win an election), a *policy* narrative has a setting, a plot, characters (hero, villain, and victim), and is disseminated toward a preferred policy outcome (the moral of the story)" (Shanahan et al. 2011).

[12] Understandable and exciting storylines or narratives are required to achieve high political impact of integrated economic assessments. See, e.g., the success of the Stern Review or the "Copenhagen Consensus" (Lomborg 2007) with their respective clear-cut and exciting narratives. See Sect. 7.1.2 for existing alternative approaches to climate economics problem framing.

growth, who assume high mitigation costs and rather low climate impacts, and who regard environmentalism as a hysteria that underestimates the benefits and importance of economic growth to society and the value of individual liberty; (3) "the social view," that assumes the historical responsibility of Western countries and argues for placing priority on poverty eradication and development; (4) "the technocrats" and green growth optimists who put their hopes in low-carbon technology (without serious carbon pricing efforts required); and (5) the "pessimists" who argue that climate change can no longer be avoided and the 2 °C goal cannot be attained any more (for these and further examples see also Urhammer and Røpke 2013; IISD 2013). Exploring the implications of these competing narratives in the climate policy arena would make the IPCC truly policy-relevant.

In addition to representing predominant policy narratives, the IPCC should initiate various pre-assessments (or even carry out a full-fledged assessment) to explore also the implications of other ethically highly relevant viewpoints that are not implied in the predominant policy narratives. This could include, for instance, scenarios on poverty eradication, or on intergenerational justice. However, the IPCC would be dependent on the scientific (and philosophical) community that would have to deliver the studies on such issues before an assessment of the literature would be possible (see Sect. 11.5 for this challenge).

The remaining highly relevant, disputed policy narratives or individual value judgements for which no multi-scenario assessment (or pre-assessment) is available could at least be disclosed by mentioning them in the assessment report; there could be a brief discussion of these value beliefs in the IPCC reports to briefly highlight also existing alternative views.

Transparency and appropriate treatment of uncertainty

The transparency of uncertainty in the previous IPCC assessments was already acceptable to some extent, but still could be improved substantially (Chap. 10). For instance, the results of Chap. 9 suggest improving the transparency regarding the epistemic status of scenarios and the many uncertainties related to these scenarios. The distinctions made in Chap. 9 regarding the three different types of uncertainty (i.e. technical, methodological, epistemological) and the examples given in Chap. 9 for these categories may help future IPCC assessments to be better aware of the range of uncertainty types in integrated economic assessments.

In his *Nature* Comment, David Victor (2015) rightly argues that in the IPCC assessment reports, we should not strive for high-confidence statements only, particularly when it comes to social-science inputs. Less certain, but plausible social-science statements, if transparent as such, can also enrich the future scenarios and provide valuable and interesting information that would otherwise get lost. This is in line with pragmatist philosophy as explained in Sect. 6.2.3. Beyond Victor, one can also argue that focussing too much on high-confidence statements entails severe pitfalls at the science-policy interface. Assessment authors may face an undesirable incentive to exaggerate the confidence level of their findings. However, this does not mean that the scientific community and the IPCC assessments should not strive for reducing uncertainty wherever possible.

To facilitate a constructive treatment of major uncertainties which allows for learning about the uncertainties, Sect. 11.2 has already highlighted the possibility of assessing also such major uncertainties through multi-scenario analysis.[13] Moreover, the analysis of the epistemic quality of IAM economics (Chap. 9), and the evaluation of the IPCC's treatment of uncertainties (Sect. 10.3) reveals the need to improve the epistemic quality of IPCC economics by striving for a more compelling economic methodology and philosophy. While this is largely a task for the scientific community itself, the IPCC could perhaps incentivise this search for a refined philosophy of economics. Increasing the methodical pluralism of the IPCC's assessments would be highly desirable from the perspective of Part III, although, this does not mean that all methods are equally appropriate for the integrated economic analysis of climate policy options.

Another, much discussed, issue after the IPCC AR4 regarding its scientific quality and reliability was the handling of grey literature, i.e., non-peer-reviewed literature (e.g. IAC 2010). On the one hand, some examples demonstrate the importance of grey literature for the IPCC's assessment-making. The regional assessments in poorer regions as well as the assessment focus outlined in Sects. 11.2 and 11.3 require data that is often unavailable in the form of peer-reviewed scientific literature (e.g., economic data by the World Bank or national governments). Furthermore, if regional impact assessments were not allowed to use grey literature, an IPCC assessment would hardly reach a regional balance regarding its analyses as well as the origins of the literature taken into account by the IPCC WG III assessments. For the mapping of the practical implications of alternative global mitigation goals, for example, data should be as up to date as possible when an IPCC AR is published, which is hardly possible with peer-reviewed literature.

On the other hand, making use of grey literature can endanger the quality of scientific reports, as the mistakes in the IPCC WG II AR4 report revealed (see Sect. 3.3); all of the alleged mistakes discussed in the media had to do with the regional chapters in this WG II report, for which much grey literature was used.

The IPCC could still allow grey literature to be used for the reasons given above under the condition that it is fully transparent. Moreover, the IPCC would have to provide better reasons for the credibility and need for this kind of literature in each case. Furthermore, the IPCC should support academic knowledge production and capacity building in poorer countries, as well as incentivise the production of the kind of literature needed for its integrated policy assessments (see also Sect. 11.5 below). In the long run, this may alleviate the problematic issue of grey literature to

[13] Uncertainties directly explored in multi-scenario analyses may be technical or methodological uncertainty (see Sect. 9.1). Both kinds of uncertainties can occur concerning natural systems (climate sensitivity, etc.), socio-economic trends and circumstances (economic growth, etc.), technologies and political issues. One could even think of alternative scenarios concerning different epistemological viewpoints and their implications for climate policy scenarios, which is certainly an exciting philosophical project. But, this might be too ambitious for an IPCC assessment, for which it would be sufficient to point out the existence of such epistemological challenges and uncertainties. It could, however, be an interesting research project for the philosophical community.

some extent. But the IPCC should not forget that achieving a high scientific quality of its assessments, particularly concerning regional and local issues, requires "local knowledge," pluralism and the inclusion of people affected by climate change, given Deweyan-Putnamian pragmatism (see Chap. 6).

11.4 IPCC Procedures, Formats and Public Participation

Having discussed possible improvements of contents and strategies for future integrated economic assessments provided by the IPCC, how can these improvements be realised in organisational, procedural and institutional terms? This section will focus on such formal issues of the IPCC's assessment-making.

IPCC assessments need to be provided with the necessary resources in terms of funds, time and authors.[14] However, procedural issues, including public participation in global assessments, are also crucial for their success. Institutional arrangements are decisive for the trust in, and clout of, scientific policy advice, and for avoiding a misguided use of expertise in policy.[15] There is already much literature on procedural issues concerning the IPCC.[16] Only a few thoughts on procedural issues and formats, as well as on public participation processes, will be briefly discussed now. This responds to the challenges (see Sect. 10.5) of the limited capacity and effectiveness of the IPCC (in Sect. 11.4.1), and insufficient public participation (in Sect. 11.4.2).[17]

[14] While the inclusion of a higher diversity of authors both in terms of disciplines and regions is desirable in principle, IPCC author teams could also be set up more functionally regarding their expertise (Victor 2015). Perhaps the only way of overcoming the old tension between scientific excellence and regional representation is long-term capacity building, which however seems to go beyond the IPCC's mandate and (financial) capacities. In any case, the transparency of author affiliations and where their incomes come from is useful for the legitimacy of an assessment.

[15] Dewey did not regard specific institutional reforms at a specific point in time as absolutely crucial (Dewey 1927, p. 68), also because undesirable attitudes etc. of people would often remain nonetheless. Institutional arrangements must constantly change in his view since the "problematic situations" are continuously changing (Sect. 6.2). This does not mean, however, that he was not interested in particular institutional arrangements. For instance, he was calling for experimenting regarding social structures, conditions and institutions "of debate, discussion and persuasion. That is *the* problem of the public" (Dewey 1927, p. 208).

[16] See, e.g., Beck (2009), IAC (2010), Edenhofer (2014), and Carraro et al. (2015a, b). For a discussion on procedural aspects at the science-policy interface in general, see, e.g., Farrell and Jäger (2006), Renn (2009), Lentsch and Weingart (2011), OECD (2015) and Jasanoff (1990).

[17] More responses to the challenge of lacking support by governments and stakeholders for the full exploration of the solution space, including its normative dimensions, are given in Chap. 12.

11.4.1 Increased Efficiency of IPCC Assessment Processes

Given the discussion in Chap. 9 about the need for high scientific and epistemic quality of integrated economic research and assessment, a reliable and effective peer review process is essential for the IPCC in order to keep and strengthen its scientific credibility and excellence. According to Edenhofer (2014), the IPCC could do several things to improve the scientific quality of its assessments and to perhaps become a fully respected scientific publication with impact factor[18] etc.: (1) it should be made possible for the WG Chairs and Review Editors to reject entire chapters at all stages of the production process if necessary; (2) alternatively, there could be an open call for AR chapters and the best submission could be selected in the end – although I do not find this proposal overly realistic given the highly resource-intensive production process of an IPCC chapter; and (3), although the IPCC review process is usually highly comprehensive, rigorous and perhaps the benchmark in the assessment landscape, the question is whether most of the review comments are actually useful, scientifically thoughtful and driven by appropriate motives – they often address very specific, minor aspects, sometimes even based on personal or sectional interests, rather than scientifically judging the overall quality of a chapter.

Moreover, what are legitimate and efficient formats and procedures to deal with the increasing epistemic complexity? I have heard many complaints about the inefficiency of the IPCC process and the procedural constraints, as well as about the huge and increasing amount of work for the IPCC teams. Among the ideas to improve this situation are (1) strengthening the Technical Support Units and providing funds for scientific assistants to leading IPCC authors in order to lighten the IPCC authors' load; (2) free training offers for coordinating lead authors in terms of process management, conflict management and assessment philosophy; (3) less, and more flexible, procedural rules; (4) allowing the IPCC WGs to commission parts of the work again to lighten the load; and (5) the IPCC could reduce the workload for its author teams if it focusses more on shorter, thematic, more timely reports that can build on each other, and if pre-assessments are available, which is essential (see Sect. 11.5).

The latter point has often been made by critics of the IPCC, and would be crucial to facilitate a highly policy-relevant assessment. I was arguing above (Sects. 11.2 and 11.3) that the IPCC should broaden the range of policy aspects considered in the assessments. This does, however, not contradict the idea to carry out assessments with a reduced scope, i.e. more thematic assessments on particular topics. These assessments with narrower thematic focus would still, or particularly, allow for the multi-dimensional, more comprehensive evaluation of related policy aspects suggested in Sects. 11.2 and 11.3. The IPCC could additionally provide, or commission, regionalised integrated economic assessments, if the IPCC is provided with

[18] This would also provide additional incentives for excellent scholars to contribute to the laborious assessment processes.

the resources required to do this (but this idea was rejected by the governments several times).[19] Furthermore, at least worthwhile considering is the idea of an interactive and multi-layered website (instead of, or in addition to, thick reports) that is updated, say, once a year followed by press conferences all over the globe. This may make it easier to deal with the complexity of the topics addressed by WG III and the many interrelations of the sub-topics.[20] This format would allow for a much quicker response to political developments, which is a huge challenge for the current, relatively sluggish format of the IPCC's assessments (Beck 2009, pp. 173f).

This presupposes a closer co-operation between the IPCC WGs II and III as suggested above, in order to achieve a more integrated understanding of the possible practical implications of alternative climate policy pathways. One way to facilitate this would be to merge the two WGs.[21] The narrow problem framing of WG III regarding global mitigation goals should be widened, concerning both other mitigation aspects (geo-engineering and more regionalised approaches, as suggested by Lenton 2011) and the integration of impacts and adaptation (WG II). Otherwise, the IPCC will hardly be able to fully discuss alternative global climate policy pathways, e.g., in terms of different climate stabilisation levels, since this also requires an evaluation of the vulnerability of different regions to climate impacts and options for adaptation. Given the Deweyan pattern of enquiry (Sect. 5.2), two WGs would be needed (as well as their close collaboration). One would explore the problem at stake, including its social, cultural, economic and other dimensions as well as the different policy goals related to the problematic situation. The other would focus on possible solutions and their practical implications.

However, a fundamental challenge remains regarding the effectiveness of IPCC assessments; it was already presented in Sect. 10.3.3. Some governments showed discomfort with ex-post policy evaluation that may be disadvantageous for their countries and weakened the messages in the WG III AR5 SPM (including deletions). Given the even more ambitious ideas for critical and ethically relevant policy assessment by the IPCC suggested above (e.g. Sect. 11.3), it is questionable whether such an assessment could realistically be accepted at all by a IPCC plenary, and by different stakeholder groups. The following improvements may perhaps help to mitigate this challenge. *First*, from the outset of an assessment process, a much clearer general mandate would be required for the IPCC WGs to scientifically assess alternative climate policy options, even if it turns out to be unpleasant for some

[19] Such additional regionalised assessments would make the inclusion of stakeholders and the public easier, and it might help improve communication of the assessment results as their presentation could be specially tailored to the respective target audiences in a particular region. It would also be easier to access local knowledge then.

[20] See projects like the one described at http://environment.yale.edu/seeforyourself/, or the decision theatre in Arizona at http://dt.asu.edu/about/vision (all links accessed 30 Jul 2015), or projects concerning "e-governance." See also the UNEP live project mentioned further below.

[21] See also Carraro et al. (2015b). Interestingly, mitigation and adaptation were combined in the SAR (WG II: "Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses," WG III: "Economic and Social Dimensions of Climate Change"), but due to many overlaps between the WGs, this was changed in later IPCC ARs (Beck 2009, p. 141).

countries. *Second*, the IPCC should raise the status of other summaries, in particular the Technical Summary. It summarises the IPCC assessment quite well without being adopted line by line by the governments. Why not regarding this as the executive summary for the academic world, in addition to the SPM for the policymakers (Carraro et al. 2015b)? *Third*, the IPCC assessments should continue to be balanced and should highlight positive aspects and developments as well, besides criticising insufficient progress and effectiveness of given policy instruments and measures. This makes scientific policy evaluation more acceptable to governments who already suffer from permanent domestic attack.[22] *Fourth*, several members of different country delegations told me in personal conversation that perhaps the figures of the WG III AR5 SPM draft would not have been deleted if there had been more time for the governments to discuss these issues both with the scientific experts and with other country delegations, and if the experts had better prepared the SPM draft in this regard. *Finally*, the hope is that further improvement of the reliability of the social-science policy analysis feeding into IPCC assessments may increase their credibility and legitimacy also in the eyes of the governments who had disagreed with parts of the WG III AR5 SPM draft.

A fundamentally different, but not compelling proposal for IPCC reform to address the above issues, including the governmental discomfort with particular ex-post policy evaluations by the IPCC, is institutional pluralism. Why should there be only one (the IPCC) orchestrated and institutionalised global scientific assessment of climate policy alternatives, as opposed to institutional pluralism? The orchestrated policy advice offered by the IPCC may reduce the danger of using scientific advice as a mere symbolic resource in politics. It also provides the valuable opportunity of having a platform and dialogue forum for a deliberative discussion of the knowledge about viable climate policy pathways. If the IPCC provides assessments along the lines explained above (Sects. 11.2 and 11.3), there will not be a monopoly on knowledge or even policy recommendations, as mistakenly suggested by Tol (2011). Instead of having a plurality of opinions institutionalised in different scientific assessment bodies, it would be much better to fruitfully compare and critically discuss these diverging viewpoints, based on a scientifically sound mapping of alternative policy pathways. Competition is often useful and forces scientists to reveal their assumptions, etc. But competition can also take place within one assessment process. This would make a more or less rational resolution of the controversies much easier. Hulme rightly states, referring to Winston Churchill that “the IPCC is […] the worst of all possible ways of assessing knowledge about climate change … apart from all the others” (Hulme 2009, p. 98).

This does neither mean, however, that there should not be other large-scale climate policy assessments as well (for instance, on the regional level), nor that the IPCC should forever be the central assessment body in this regard. If the

[22] Strict regulations to counter severe and democratically undesirable conflicts of interest are required, and the existing IPCC rules should be improved in this regard (Edenhofer 2011). It is, however, impossible to completely avoid interest-guided or value-guided work by scientists, as they will always be influenced by their values, beliefs, interests and circumstances (see Chap. 5).

intergovernmental structure of the IPCC does not allow for more critical (ex-post and other) policy evaluation and more open discussion of ethical issues in future IPCC assessments, other assessment bodies may be required.[23]

While my proposals above may help the IPCC deal with epistemic complexity in an integrated and more efficient manner, the decision about what IPCC assessments should more precisely focus on, i.e. how more precisely to narrow down the scope, additionally requires a fair and open dialogue with stakeholders and the public. This dialogue, going beyond the intergovernmental structure, is, inter alia, needed to narrow down the range of disputed ethical viewpoints and related possible scenarios to be explored. This leads us to the issue of public participation.

11.4.2 Enhanced Public Participation in IPCC Assessments

The need for a public participation as part of the assessment process was pointed out in Sect. 6.2.2.[24] This would ideally entail an iterative democratic learning process among all actors involved.

While the AR4 regards itself as "the standard reference for all concerned with climate change in academia, government and industry worldwide" (IPCC 2007, p. i), I am wondering why they do not focus on "the public," "civil society," or similar groups. The IPCC traditionally focuses too much on governments only – as an *intergovernmental* panel. On the other hand, the IPCC also engages with non-governmental stakeholders to some extent, and the WG III AR4, for instance, directly discusses issues of public deliberation (IPCC 2007, pp. 713–716). These few comments on public debate in the AR4 certainly did not have a remarkable impact to my knowledge, but they still address important and interesting issues.

Public participation and stakeholder engagement in the IPCC assessments could be improved, particularly regarding the need for greater dialogue concerning the here envisaged highly integrated policy assessment. As Sect. 10.4 already suggested, particularly in the scoping phase of an assessment, the dialogue between scientific experts, governments, other stakeholders and the public needs to be intensified in order to increase the policy-relevance of IPCC reports (Carraro et al. 2015a). We want the IPCC to respond to societally highly relevant policy questions – even if, against Victor's (2015) idea to focus on solvable questions, the IPCC would have to admit that there are knowledge gaps.

[23] Furthermore, I want to at least mention the issue that – if the IPCC and perhaps also other assessments actually address a broader range of policy objectives under the sustainable development framework – there seems to be a convergence of the scope of existing larger-scale scientific assessments. Consequently, an appropriate coordination between the various, resource-intensive assessments out there is definitely required to avoid duplication and unproductive competition.

[24] See, e.g., Renn (2009) and Goodin (2008) for how to possibly realise public participation and deliberation more generally. This should include intercultural dialogue.

For the later stages of an IPCC assessment process, the "Structured Expert Dialogues" that were already mentioned in Sect. 10.4 seem to have worked quite well and can serve as role model for engaging with governments. However, mass media, internet platforms and other methods and channels should also be more often used to organise broader public participation beyond governments and the exchange of information and views before, during and after assessment processes.[25] A very promising approach is the "WorldWideViews" project on climate and energy.[26] In 2015, this project employed innovative methods to facilitate the participation of 10,000 citizens from 76 countries in 97 debates. Different representative groups (roughly 100 people each) met in their respective countries to exchange their views of climate change and energy policy. The structure was the same for all of these debates, which allows for comparison. Such methods may also be highly promising for the IPCC in order to facilitate a balanced, effective and broad collaborative involvement of the public in the assessment processes.

Public participation faces huge challenges, starting with the available resources and time restrictions of an assessment. It has to be feasible and realistic. It should not lead to a lengthy and fruitless discussion with a faded consensus at the end, nor is it necessary to include the entire public, especially since the Deweyan ideal of an enlightened and well-informed public has not (yet) come true. Again, given the divide between rich and poor nations in terms of their scientific and other capacities to participate in an IPCC assessment, it would be essential to increase the resources and capacities of the poorer countries in order to achieve a deliberative learning process on a global level.

To perhaps increase the impact of IPCC assessments on policy discourses in the end, the IPCC might (1) engage professional communicators who simplify messages for governmental officials and mass media; (2) better take into account the existing issue attention cycles in policy processes and the other dynamics at the science-policy interface pointed out in Sect. 3.1, for instance through providing more timely and thematic special reports and policy reviews; and (3) better address stakeholders and governmental agencies beyond the UNFCCC and the environmental realm (e.g., finance ministers), given the important economic, industrial and financial dimensions of climate change, among many others.

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[25] See, e.g., Petersen et al. (2015) for the IPCC. See also UNEP's activities to establish an internet platform called UNEP live (see http://www.uneplive.org, accessed 30 Jul 2015); this platform serves several purposes.

[26] See http://climateandenergy.wwviews.org/ (accessed 30 Apr 2016).

11.5 How the Social Sciences Could Better Support the IPCC Assessments

The IPCC WG III should also provide incentives and proposals for the scientific community, which delivers the material on which the IPCC assessments are based. This topic goes beyond the core realm of assessment-making, but the IPCC WG III assessments (as the cook) are highly dependent on what climate economics in general, and the IAM community in particular, actually deliver (as the ingredients). The IPCC can perhaps have some influence on these ingredients, in terms of providing incentives for the scientific community – and for funding agencies – to fill research gaps and to envisage higher transparency of implied normative assumptions and uncertainty (see the current problems described in Chap. 10). Consequently, to improve the IPCC's integrated economic assessments, various social-science and other research communities must be better involved and need to be convinced to produce the literature required for the integrated policy assessment outlined above (see also Carraro et al. 2015a and Victor 2015).

No one is going to mandate to scientists what they should do. Having a clear knowledge gap, however, can provide incentive to fill it, and further, funding agencies can incentivise research in the needed areas. Many climate-related researchers would be highly interested in ideas for how to make their research more policy-relevant, according to my experience. IAMs are already *per se* scientific instruments constructed for the main purpose of better understanding politically relevant issues, and the IAM community is a perfect example of successful, self-organised research feeding prominently into the IPCC WG III AR5. But other methods and studies are required as well to provide the information needed in light of Sects. 11.2 and 11.3 above, as the scope of IAM-based studies is generally limited (Sect. 7.4).

Given the epistemic complexity of scientifically analysing multi-level governance in a world with multiple, interdependent policy objectives, the commissioned or self-organised pre-assessments (i.e., meta-analyses of the existing literature including literature reviews, but also quantitative meta-analyses; see Sect. 10.4) provided by the scientific community are crucial to facilitate the larger-scale assessment process. IPCC authors cannot do the research and all the integration work themselves. Maybe future IPCC assessments can benefit from assessment activities going on in the social sciences, in particular by the International Panel on Social Progress.[27] Pre-assessments could limit themselves to particular regions, policy instruments or ex-post evaluations, for example.

This presupposes the elaboration of existing scientific policy analysis and assessment methodologies by the scientific community. Moreover, an alternative to the predominant IAMs could perhaps be – besides vague qualitative studies – more econometric approaches based on historical data. However, such approaches usually fail to predict economic developments in the distant future. A more promising approach could therefore be "overlapping generations models" that promise to

[27] See http://www.ip-socialprogress.org/, accessed 30 Jul 2015.

better address some of the distributional and allocational effects of climate policies. More IAM validation (e.g., regarding uncertainties related to energy technology) and sensitivity analyses would furthermore be useful. Another step forward would be more transparency regarding the value judgements implied in economic studies (see Chap. 8). Otherwise the IPCC will always have a great deal of difficulty in making these ethical issues transparent. The framework for identifying value judgements introduced in Sect. 7.3 could be used by scientists to reflect on their assumptions. For all of these purposes, (networks of) the national academies of science and their international alliances could become suitable and influential institutions to promote this kind of research.

According to Edenhofer (2014), IAMs have to be further developed particularly towards game theory applications and integrated policy instrument analysis, going beyond the aggregated social planner perspective and recursive CGE models; new analytic IAM tools for "sustainability diagnostics" are required in a dynamic second-best setting given multiple policy objectives. Moreover, as Edenhofer continues, more heterogeneity of actors, addressing distributional issues and going beyond expected utility theory would be desirable for the IAM development.[28]

A serious involvement of the public in standard scientific knowledge production is hardly ever done, mostly because this would require much more resources (time, funds, personnel) as well as lay people who are willing and capable of contributing to scientific knowledge production. Yet, regarding the climate impacts, ethical values or potential side effects and synergies of certain policy options, asking the people directly affected by a problem might lead to new or refined scientific insights. Dewey points out that the "man who wears the shoe knows best that it pinches and where it pinches, even if the expert shoemaker is the best judge of how the trouble is to be remedied" (Dewey 1927, p. 207).[29]

The major obstacles for the scientific community to meet the above demands for IPCC assessments include (see also Sects. 12.1 and 12.2): (1) restrictions of time and funds, meaning that research is often not well-reflected on methodologically, let alone politically. Furthermore, it is rarely validated, often conducted in an ad hoc manner (rather than on a long-term basis) and driven by the need for externally funded projects and related tactical behaviour (Bammé 2004); (2) monopolies or hierarchies in the academic realm, where a few institutions or individuals sometimes have the power to control agenda setting and review procedures (Bammé 2004); (3) insufficient awareness about problems related to epistemology, meta-ethics (value judgements, etc.), policy-making (theories of policy change, etc.) and the science-policy interface. This might also be due to misguided models of the science-policy interface and scientific objectivity (Chaps. 4 and 9); (4) hardly any contact with policymakers and the public, leading to highly delayed reactions to

[28] See Sect. 7.4 for additional ideas. Further hypotheses include that numerical models can perhaps cover more complex issues than analytical models, and that particularly the macroeconomic component of climate economics requires further development.

[29] For additional interesting proposals of what the IAM community could do, see Knutti (2010) and Ravetz (1997).

political developments; (5) science-internal inertia,[30] including the tendency to stick to one's economic theories even though there is evidence of promising alternatives (Chap. 9); (6) one-sided ethical judgements due to the respective worldview and the academic disciplinary culture or economic school; (7) perhaps the IAM community could provide more suitable studies for assessments along the above ideas, if the IPCC presented its ideas for and the importance of assessment-making in a more compelling manner; (8) a lack of academic incentive to do policy-relevant economic research, let alone for engaging in assessments. World-class economic journals hardly publish papers on applied economics or interdisciplinary issues regarding policy appraisal.[31]

The IPCC should clearly define the research gaps in light of the recommendations made above (Sects. 11.2 and 11.3). Moreover, many IPCC WG III authors are members of the IAM community; therefore, convincing the authors that assessment-making is highly socially valuable as well as a genuinely, challenging and exciting scientific endeavour would possibly provide further incentives in that regard. For world-class economists and policy analysts, it should also become more attractive to engage in large-scale scientific assessments. The contribution to such assessments should also be honoured and appreciated in terms of the academic career of researchers.

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[30] "By the very nature of scientific practice, scientists utilizing the same cognitive perspective in a field come to see themselves as a group with group interests. If relatively strong in number, such a group may become inclined to promote itself by discouraging or even stopping empirical inquiry in its field from cognitive perspectives, especially promising ones, other than its own. Such a state of affairs constitutes a degenerate empiricism, as it wishes to limit inquiry to a single vantage point, thereby holding back the advancement of knowledge" (Fullbrook 2009, pp. 123f).

[31] See already Dewey (1927) where he complains about the existing preference of theoretical science over applied science by building on a misled philosophy of science.

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Chapter 12
Potential Implications of the IPCC Reform: Deliberative Learning and Difficulties of In-Depth Policy Assessment

Abstract This chapter concludes the enquiry of this book into a new guideline for integrated economic assessments. The proposals for future integrated economic assessments made in Chap. 11 are briefly evaluated (Sect. 12.4) in light of the assumed direct effects of these proposals regarding the general norms for scientific expertise in policy from Part I (Sect. 12.1), risks and unwanted side effects (Sect. 12.2), and possible co-benefits (Sect. 12.3). This discussion can be regarded as Step 4 of a Deweyan enquiry; it is about evaluating (1) the means proposed for overcoming the problems of current integrated economic assessments by the Intergovernmental Panel on Climate Change (IPCC), and (2) perhaps even the underlying general norms for scientific expertise in policy themselves – in light of the possible practical implications of these means. It is argued that realising the proposals from Chap. 11 may have several valuable positive effects, including on deliberative policy learning, while perhaps also facing some remaining challenges regarding feasibility and acceptance. Gaps in research and potential applications of the proposals to institutions other than the IPCC are discussed in Sect. 12.4. Finally, the thoughts on a philosophy-based framework for future integrated economic assessments developed in the present book are summarised (Sect. 12.5).

Having developed elements of a guideline for future integrated economic assessments of the IPCC, we can now draw conclusions. This chapter will primarily highlight potential practical implications of a possible future IPCC reform along the lines presented in Chap. 11. The recommendations from Chap. 11 will be discussed in light of their assumed direct effects regarding the general norms for scientific expertise in policy from Part I (Sect. 12.1), in light of risks and unwanted, negative side effects (Sect. 12.2), and in light of possible co-benefits (i.e., positive side effects; Sect. 12.3). Next, gaps in research and the application of the proposals to institutions other than the IPCC will be discussed in Sect. 12.4. Finally, the thoughts on a philosophy-based framework for future integrated economic assessments developed in this book will be summarised (Sect. 12.5).

The concluding discussions of the potential implications of the recommendations from Chap. 11 can be regarded as the realisation of the essential Step 4 of a Deweyan enquiry (as explained in Sect. 6.2.1). This step is about testing and revising (1) the means (i.e. the recommendations) proposed for overcoming the problems of

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current integrated economic assessments by the IPCC, and (2) perhaps even the underlying general norms for scientific expertise in policy themselves – in light of the possible practical implications of the recommendations made in Chap. 11. While so far, I only focused on criticising the role of the scientific experts and, with it, acted as an advocate of the public and the policymakers in this book (see Sect. 1.1), the potential (co-)effects considered below for the evaluation of the IPCC reform proposals from Chap. 11 also have to include effects related to the roles and responsibilities of policymakers, other stakeholders and the public at the science-policy interface.

Given the Deweyan method employed in this book, it is absolutely essential to identify, and be aware of, the potential practical implications of the elements of a guideline for the IPCC from Chap. 11. However, in order to simplify matters, and to present less preliminary results in Chap. 11, I have already taken these expected practical implications into account in Chap. 11. Thus, the insights from this chapter will not require substantial revisions of (but only minor amendments to) the proposals presented in Chap. 11, but should certainly be kept in mind when realising the proposals.

In general, the (co-)effects of a potential full application of the ideas from Chap. 11 are hard to predict and thus highly uncertain. Besides the IPCC WG III AR5 (see Chap. 10), there are a few other examples[1] of past scientific assessments that have attempted to map alternative policy pathways and their implications to a greater or lesser extent, which was one of the core claims of Chap. 11. Only few such examples exist, however, and none of them have fully realised the ideas above. In addition, to my knowledge, hardly any systematic evaluation of these assessments and their impacts and consequences is available. As a result, many of the assumed implications of the proposals from Chap. 11 are rather based on theoretical considerations than on actual practical experience.

12.1 Expectable Direct Effects, and Their Preconditions

How likely is it that the proposals from Chap. 11 actually help to meet the general norms for scientific expertise in policy, i.e. policy-relevance (Sect. 12.1.1), political legitimacy (Sect. 12.1.2), sound science and good communication (Sect. 12.1.3)? These general norms were identified as key conditions under which scientific expertise can make a substantial and desirable contribution to deliberative democracy. As explained in Sect. 2.1, according to Dewey, deliberative democracy essentially aims

[1] Such examples include, e.g., (1) alternative scenarios for the controversial issue of bioenergy in the IPCC SRREN (see particularly the exemplary figure TS.2.9 of the Technical Summary; IPCC 2011, p. 59); (2) the two volumes of the Mirrlees Review of the tax system (see http://www.ifs.org.uk/mirrleesReview; accessed 30 Jun 2015); and (3) an assessment of geo-engineering options by the Royal Society (see http://royalsociety.org/policy/publications/2009/geoengineering-climate/; accessed 30 Jun 2015).

at a joint, intelligent and critical public debate into the potential options for the regulation of indirect consequences of human actions; a learning process among all interested stakeholders and citizens is envisaged and should be informed by scientific expertise.

12.1.1 Towards True Policy Pathway Exploration

Do the proposals from Chap. 11 lead to highly policy-relevant assessments (as defined in Sect. 6.4)? Can they facilitate learning processes concerning the regulation of indirect consequences of human actions?

There is certainly reason for hope that mapping policy pathways and their implications is extremely valuable and useful for public policy processes related to climate change – given the Deweyan understanding of the purpose of such policy processes (Sect. 2.1). Rather than merely focusing on problem framing, or merely highlighting potential means of achieving the given policy objectives, the additional, critical analysis of a wide range of practical implications of the means proposed in Chap. 11 could inform public policy debates to a considerably larger extent. The assessments could provide scientific expertise regarding alternative policy pathways that represent different policy goals and problem framings. They would also address actual current policy processes and regimes, clear policy questions, particular socio-economic, cultural and political contexts, etc. Moreover, it was suggested to also include statements with lower confidence level in integrated economic assessments (Sect. 11.3), if they help to better understand important aspects of the policy issue at stake. This may help assessments to become more informative and policy-relevant.

Both the assessment reports and the assessment process itself could theoretically lead to the intended effect of policymakers and the public, scientists and other stakeholders in the end having a better understanding of the actual policy choices, trade-offs and opportunities at stake. As Sect. 6.4 already pointed out, the enquiry into the implications of policy means can lead to a revaluation of a particular set of means, the underlying policy objectives (i.e., ends-in-view) or the entire problem framing. This also helps to understand the conditions under which a certain policy pathway can be acceptable for society.

These thoughts are based on the assumption (see Sect. 2.2.4) that we do not yet fully understand what the best climate policy options are from a societal point of view in light of the existing multiple, interdependent policy objectives as well as uncertainty; often, unforeseen, highly relevant implications of policy means are revealed once policy pathways are more thoroughly analysed in integrated assessments. Likewise, it is often unclear what the climate policy options loudly advocated in public debates would actually mean more precisely and what their various implications would be if they were implemented.

Let me present an example. Although it is difficult to reliably trace the impacts of IPCC assessments – i.e., of the process and products – on climate policy discourses (see Sect. 3.1.3), one can reasonably assume that the IPCC AR5 informed the policy debates. This even goes beyond, for instance, providing interesting numbers for the remaining carbon budget in the twenty-first century given a 2 °C climate policy goal. It became much harder for both the critics and the proponents of a 2 °C goal to defend their standpoints *without* significantly referring to the AR5 explorations of the costs and benefits, conditions and requirements of such a policy goal. Explaining the policy options and their implications in publicly available, credible assessments such as those by the IPCC could perhaps put pressure on all players in climate policy to engage in more differentiated argumentation and perhaps even public deliberation, i.e. pressure not to fall behind the relatively differentiated scientific discussions in the IPCC assessments, which have officially been approved by the governments and thus are given clout.

In comparison with many existing assessments, realising the proposals presented above could make future assessments more policy-relevant. However, these assumed prospects are inter alia dependent on the willingness of players at the science-policy interface to considerably support a critical and scientifically sound exploration of alternative climate policy pathways and their implications. The degree of policy-relevance realistically achievable in integrated economic assessments by the IPCC can be considerably limited, if some governments, scientific experts or other stakeholders do not see the need for such an in-depth exploration of the policy solution space (see also Sect. 12.2 below). Promoting a critical, serious reflection on science-policy interactions as attempted in this book and several other publications perhaps helps to convince people that the proposals in Chap. 11 are at least worthwhile considering and being supported.[2] Consequently, specific IPCC and other assessments should make the choice of their actual science-policy approaches more transparent – if there is a conscious choice at all. This would presumably provoke more, and more constructive, critical discussions of science-policy models and IPCC assessment guidelines.

Another potential limitation for the envisaged assessments is that there are considerable gaps in knowledge about particular climate policy options and their implications. These knowledge gaps are hard to fill due to the high uncertainty. It is unclear to what extent the envisaged maps of alternative policy pathways can actually be realised given the constraints of knowledge production in this field. These constraints, inter alia, include methodological constraints (Sect. 9.3), deep uncertainty and complexity of multi-level climate policy analysis, but also the lack of funding for social-science policy analysis in many regions. There are, however, some measures (outside assessment processes themselves) that could help fill the existing research gaps: (1) governments etc. need to provide more funds for

[2] As a feedback to my proposals developed in this book, I sometimes heard assessment practitioners saying that these are precisely the ideas that guide their own work. However, when analysing the practice at the science-policy interface (IPCC and beyond), my feeling is that they significantly underestimate how far-reaching the proposals developed here actually are.

social-science policy analysis and developing methodologies[3]; (2) the research community should be better organised; self-organised processes in the social sciences leading to policy analysis should be encouraged – the IAM community can serve as a role model (see Sect. 11.5); and (3) more exchange between decision-makers and researchers may increase the policy-relevance of scientific expertise.

One has to accept that mapping complex climate policy pathways and their potential implications will always remain incomplete and uncertainty-laden. I have argued above (Sects. 6.4, 9.4 and 11.3) that providing at least some information and plausible claims on the policy solution space can nonetheless be highly valuable from a societal point of view – more valuable than the alternative approaches discussed in Parts II and III.

12.1.2 Overcoming the "Iron Cage of Bondage" Through a Proper Treatment of Divergent Viewpoints?

Another major intended effect of the proposals above is to enhance the political legitimacy of assessments. There are at least four ways in which the proposals made in Chap. 11 could help promote political legitimacy and perhaps even help overcome ideological conflicts over contentious climate-related value beliefs.

First, the proposals may help to avoid society's "iron cage of bondage" (Weber 2006), which can be created through the rule of experts as a potential consequence of the traditional models of scientific expertise in policy (see Sect. 5.4). The exploration and presentation of *alternative* policy pathways will hopefully avoid the use of the legitimisation model in the IPCC, and avoid other kinds of severe misuse of scientific expertise in public policy. It opens up the debate, instead of closing it down. Given the presentation of policy alternatives, politicians and scientists can no longer legitimise policy options by referring to the alleged "inherent necessity" of a certain policy option without alternatives, based on a (pseudo) scientific consensus. They can no longer easily delegitimise policy options simply by referring to uncertainties or disagreements in the sciences. In the end, explaining the available policy options in the large-scale assessments is perhaps more effective for a public policy debate than providing a sophisticated decision theory.

Second, higher legitimacy could perhaps be achieved through intensified, more far-reaching engagement with stakeholder and the public. The participation of diverse players, as encouraged by the refined pragmatic model, could reduce the risk of the political exploitation of scientific authority in assessments.

[3] Methodological questions include, e.g.: how to deal with the complexity of multi-level governance and the various interdependencies? How to deal with value judgements in policy analysis? What are appropriate indicators and methods for ex-post policy evaluation?

Third, the envisaged high transparency regarding different kinds of value judgements and uncertainties would certainly help to strengthen the legitimacy of integrated economic assessments. Furthermore, by revealing the value assumptions underlying certain climate policy viewpoints, assessments following the ideas from Chap. 11 could make existing policy conflicts more transparent.

Fourth, the proposed treatment of disputed, value-laden viewpoints in a scenario-based ethical sensitivity analysis via the practical implications is promising. It holds great potential for constructive iterative deliberation and learning processes concerning contentious, value-laden issues among all players involved (see also Ansell 2011). In contrast, a consensus procedure (Siebenhüner 2003, Sect. 2.3) does not allow for a very constructive and open discussion of divergent viewpoints.

The low-hanging fruit is certainly the identification of overlap between alternative contentious policy pathways. The term 'overlap' denotes the possibility that one can achieve different bundles of policy objectives with one and the same set of policy means. Such overlap, however, does not so often occur.

Additionally, the proposed treatment of divergent, value-laden viewpoints in a multi-scenario analysis may facilitate and promote learning and a change in formerly held value beliefs. The discussions about different global climate temperature goals already provided some examples in this regard. Even if someone is totally convinced to have identified the best climate policy option or the right set of underlying value beliefs, others can more easily be convinced by confronting them with concrete, rich scenarios of future worlds than with abstract moral principles.

In case of extremely contentious issues, assessments following the ideas in Chap. 11 could at least clarify what the more specific trade-offs and conflicts are about. Translating disputed value beliefs into concrete future scenarios may help to overcome the hardened, counterproductive disputes over these competing, abstract value beliefs at a later stage of the policy process. It may perhaps support the political negotiation of a compromise outside the assessment process then.

The proposed integration of various viewpoints into a complex map of alternative, disputed policy pathways with comparable metrics etc. seems to better allow for a learning process than the predominant type of scientific advice to climate policy. Hundreds of reports on climate policy have already been produced. Explicitly or implicitly, each of them advocates for a specific policy, for instance, regarding specific energy technologies. However, this kind of pluralism cannot yield the same outcome as the proposals made in Chap. 11 because it does not enable a direct and consistent comparison of different policy pathways via their practical implications.[4]

There are some preconditions and limitations for achieving political legitimacy. Not even an exploration of alternative policy pathways is *fully* free from any power

[4] Furthermore, the standpoints of some societal groups – that do, e.g., not have the funds and networks to initiate the production of scientific studies advocating for *their* interests – are often neglected in public debates. My arguments here, however, do not necessarily imply that the IPCC should continue producing voluminous reports over a long period of time (see Chap. 11).

games and disputable preselection of alternatives or indicators, nor is it always and fully free from bias towards one or another policy option in the evaluation. Moreover, the envisaged extended stakeholder engagement and public participation must be done properly and thoughtfully because they can also be counterproductive if badly organised (Rayner 2003). Another crucial precondition for the assumed positive outcomes of the proposals in Chap. 11 is that both the IPCC and the underlying scientific (IAM) studies are willing to seriously follow the proposals from Sect. 11.3 and make use of the categorisations of value judgements and uncertainties explained in Sects. 7.3.2 and 9.1; yet, this alone cannot warrant the full transparency of value judgements and uncertainty. Finally, the outcomes assumed above are based on a relatively optimistic view of the possibility of a rational public debate even about contentious policy issues. If this optimism turns out to be wrong – for instance, because many people turn out to lack intelligence, interest in political issues or far-sightedness –, an implementation of the ideas from Chap. 11 would presumably not have such remarkable positive effects (compare, however, Sect. 2.1.2). Of course, policy processes have never been overly rational in human history, and politics always matters. But I still have the hope – and the available evidence does not show its infeasibility – that more deliberative policy learning among various players at the science-policy interface is actually feasible (see also Goodin 2008). To my own surprise, my experience with the IPCC on the SPM of the synthesis report (IPCC 2014) has been that a remarkably rational and well-informed deliberation took place between scientific experts and governmental officials (see also Sect. 10.4).

In the end, it is hard to predict the extent to which the different players, stakeholders and citizens regard an assessment realising the proposals from Chap. 11 as "legitimate." The proposals from Chap. 11, however, at least provide a reasonable and relatively far-reaching basis for political legitimacy.

12.1.3 Reliable and Well-Communicated Results Through Pragmatism?

The given IPCC processes and procedures, including expert review, already ensure sound science to a large extent; the IPCC is often referred to as the benchmark for the scientific quality of assessments. Nonetheless, the proposals for improving transparency regarding all three types of uncertainty (Sect. 11.3), for improving the use of grey literature (Sect. 11.3), and for improving the review process (Sect. 11.4.1), may strengthen the overall scientific reliability of IPCC assessments. Focussing on various extreme scenarios rather than on mean values is a further promising step towards higher reliability of assessment findings, as are the increased methodical pluralism and the methodological reflection. Moreover, my IPCC reform proposals based on pragmatist philosophy may free scientific experts from misleading concepts of objectivity (see Chaps. 5 and 6) and allows them to acknowledge both the epistemic limitations and the strengths of their integrated economic knowledge production.

Yet, it is unclear to what extent the IPCC and the scientific community will actually be able to realise particularly the ideas of higher methodological reflection and transparency also regarding epistemic uncertainties – given that these are highly philosophical challenges for which scientific experts often do not have the time nor the training needed, and assuming that only a small number of philosophers are currently working on such "applied" issues of philosophy of economics. From a longer-term perspective, this will perhaps take some more convincing and training in academia as well as require more time, funds and academic incentives for the scientific experts to critically reflect on their economic models etc.

Furthermore, the extensive stakeholder involvement and public participation claimed by the refined pragmatic model may help to improve the communication of assessment findings. However, the analyses in the previous chapters did not focus a lot on these communication issues. Much more could be said and done to improve this, but this goes beyond the scope of this book.

12.2 Potential Negative Side Effects

The proposed means for improving the integrated economic assessments seem helpful overall. However, there could also be unwanted side effects.

Too much burden on assessment-makers and the scientific community?

One potential problem of the proposals made in Chap. 11 is the issue of time requirement, which involves particular trade-offs. As we can learn from the IPCC WG III AR5 (see Chap. 10 above), exploring the major aspects of the climate policy solution space in the scientific literature as well as in the integrated assessment thereof is extremely demanding and challenging. So many dimensions and aspects – a thorough problem analysis; ex-post and ex-ante policy analysis of policy instruments given multiple, interdependent objectives; enquiries into the diverse implications of policy means; etc. – would have to be interdisciplinarily analysed if one wanted to make qualified judgements of climate policy options. In assessments, exploring the *full* policy solution space in a literal sense is impossible; instead, only relatively few aspects can be explored, often entering *terra incognita*.[5]

[5] On the other hand, it is increasingly hard for the IPCC to conduct a comprehensive literature review and assessment regarding specific topics such as bioenergy (as a crosscut that is crucial to all the global mitigation goals), because thousands of papers were published on this topic in recent years. Developing better methods for synthesis and meta-analysis would be required to mitigate this challenge.

The contributions to the IPCC reports by scientific experts are usually voluntary and unpaid, researchers also have other obligations at work[6] and most of them also appreciate leisure and time for their families. Being so demanding, the proposals from Chap. 11 thus imply high opportunity costs. If an assessment was conducted less thoroughly in order to reduce the burden for the authors, the achievement of sound science, political legitimacy, policy-relevance or good communication would be endangered.

What are potential measures to alleviate such possible unwanted effects and high opportunity costs? (1) In order to reduce the burden and complexity for assessment processes, the scientific community needs to provide as many pre-assessments and analyses of specific, under-researched policy aspects as possible – ideally taking into account the need for comparability and transparency (see Chap. 11). (2) Concerning the assessment format, Sect. 11.4.1 already argued for shorter, thematic assessment reports to increase policy-relevance and reduce the workload for assessment processes; increasing the efficiency of assessment processes could also significantly reduce the burden for assessment authors (Carraro et al. 2015). (3) Higher academic incentives for providing policy analysis (Sect. 11.5), fees for assessment authors (Stocker and Plattner 2014) and more research funds (e.g., for particular policy analysis, methodology development, additional staff and training in interdisciplinarity) may incentivise policy-relevant research as well as assessments and may reduce at least some of the opportunity costs for the experts.

Trade-offs with academic objectives, interests and values

Besides opportunity costs, there can be even more substantial trade-offs with other academic objectives, interests and values if one implements the proposals from Chap. 11. In academia, the emphasis is still on disciplinary and theoretical research rather than on interdisciplinary policy evaluation which implies so many value judgements, potential politicisation and uncertainty. If the assessment idea presented in the previous chapters is not acknowledged as genuinely scientific work, or even regarded as inferior from an academic perspective, then it is very hard to convince the best researchers to contribute to such large-scale, time-consuming assessments or to investigate policy-relevant issues, given the threats to their academic reputation. Researchers are sometimes almost required to apologise for being involved in integrated assessment processes, or for carrying out policy evaluation. It is risky to cross the boundaries of a given disciplinary culture.

How can assessment-making along the lines discussed in Chap. 11 nonetheless be regarded as genuinely and valuable scientific work? Although assessment-makers do not produce new research themselves, policy pathways need to be explored, according to Chap. 11. To some degree, this generates new scientific knowledge. This interpretation would allow economists and other scientists involved in assessments to be regarded as “true researchers” in the sense that they explore the uncharted territory of the climate policy solution space – particularly if the

[6] This implies risks for their career perspective if they are heavily engaged in assessments. It can furthermore imply health risks (burnout, etc.).

assessment avoids too much "politicisation" by exploring alternative pathways instead of advocating or negotiating a particular policy option.

Consequently, what is required to mitigate these trade-offs with predominant academic values goes beyond the proposals made above for overcoming the problem of high opportunity costs, because the former trade-offs are even more tricky. From the longer-term perspective, owing to the inertia in academia and disciplinary cultures, a cultural change in both academia and science policy is required towards a higher appreciation of applied research on policy options and implications.[7] This may result in more extensive, high-quality scientific policy analysis and more public trust in the policy evaluations provided by the social sciences and humanities. This would also strengthen true interdisciplinarity, which is not yet widespread, particularly with regard to the inclusion of philosophical perspectives.

> Professional ethical philosophers tend to deal with the subject in the most general way. Economics is concerned with some particular questions, such as private property and distributive justice, along with a practically infinite number of variations on those themes. One thing that economists could do is to divert more resources to the study of ethics, in an effort to become as proficient at philosophical ethics as they now are at mathematics (Weston 1994, p. 16).

Trade-offs with other political objectives

Another potential trade-off related to the reform proposals from Chap. 11 is that many players at the science-policy interface have strong political interests and beliefs of which they are highly convinced (e.g., their own clear and rather fixed understandings of a first best world climate policy scenario); therefore, they may not be supportive of an assessment strategy that aims to highlight *alternative* policy options in a collaborative and open learning process. Some stakeholders, for instance in the climate policy debate, are not willing to engage in an open social learning process because they fear that exploring alternative pathways may lead to public opinions that are misled or disadvantageous from their individual or group perspective. This may also explain why some governments wanted to delete some figures in the WG III AR5 SPM draft (see Sects. 3.3.2 and 10.3.3 above), why many stakeholders in general do not want to see any explicit discussion of contentious distributional or other issues in IPCC assessments and why some governments block more far-reaching IPCC reforms intended to strengthen its effectiveness and policy-relevance (Sect. 10.5).

Another good example to illustrate this point is the politicised negotiation process for the SPM in the IPCC SRREN report (IPCC 2011), as described by Ottmar Edenhofer who was mainly in charge of the SRREN (Schiermeier 2013). The SRREN draft presented a few rather abstract alternative pathways for bioenergy use. However, obviously because of national economic interests, some country delegations tried everything to avoid the mentioning of the negative side effects of a

[7] A good example of what I mean is the current academic debate in Germany about whether or not "transformative research," i.e., highly policy-relevant, solution-oriented research, poses a threat to scientific purity, integrity and credibility (see, e.g., Grunwald 2015).

potential high share of bioenergy in the future global energy mix in the SRREN, or they tried to at least water these messages down.

Besides avoiding certain statements in IPCC assessments, some policymakers, scientific experts or other stakeholders advocate particular policy options and therefore reject the proposals for assessments provided in Chap. 11. They might argue that given the urgency of climate action and the tough, very slow international climate policy negotiations (Sect. 2.2.3), we currently do not need more in-depth analysis and deliberation of alternative pathways, although this might be valuable in other contexts. Rather, as they might continue, it is more important to convince governments of immediate climate action by providing a scientific consensus on both the assumption that there is anthropogenic, dangerous climate change and the assumption that it can be successfully tackled. They might find the legitimisation model of scientific expertise in policy (Sect. 4.2.4) better suited for current climate policy contexts than the refined pragmatic model. In their view, the latter cannot have much clout in climate policy, as it does not lead to clear-cut, specific policy recommendations.

I disagree with the notion of a significant trade-off between promoting ambitious climate policy on the one hand and assessment-making along the lines presented in Chap. 11 on the other hand. Exploring alternative pathways in a participatory manner does not render assessments toothless in terms of political clout. Consider again the global mitigation goals as an example. While one might argue that the IPCC WG III AR5 should better *not* have explored mitigation goals beyond the 2 °C goal, in order not to encourage and strengthen the proponents of less ambitious global goals, I think the opposite is true. The fact that the WG III AR5 has revealed the conditions, costs, risks and requirements for alternative global mitigation pathways did not weaken, but rather strengthen the 2 °C goal. Maybe it was the only way to keep the 2 °C goal debate alive, given that so many people, including eminent scientists, had criticised the 2 °C goal in recent years (Sect. 10.2). Additionally, the technocratic and legitimisation models do not have much impact on public policy in the longer-term perspective, because different reports making different recommendations are pitted against each other (Sarewitz 2004).

Another way for stakeholders, including the experts themselves, of responding to the trade-off between their particular political interests and the open exploration of the policy solution space is to only pretend to follow the pathway exploration model, but in fact insert some kind of hidden bias in such an assessment. Chap. 6, however, argued that a misguided use of the refined pragmatic model is relatively unlikely *once* the refined pragmatic model is already and fully implemented. The question remains, however, whether there are sufficient incentives for science-policy institutions to actually implement the ideas from Chap. 11.

What are measures to mitigate the risk that governments reject the idea and practice of policy pathway exploration? Two things seem particularly worthwhile discussing: (1) the longer-term cultural change at the science-policy interface already demanded and explained above – which would make it very hard for individual governments to argue against, or sabotage, an open scientific exploration of the climate policy solution space; and (2) changes in the stakeholder engagement strategy of the IPCC, given the very high influence of governments in intergovernmental science-policy bodies. For the containment of this influence, one could either argue for broadening the public participation and strengthening the role of other players (Parliament representatives, civil society, business and industry, etc.),[8] or for excluding governments altogether.[9] In both cases, however, the obvious and substantial downside is the potential decrease in buy-in from the governments.

12.3 Possible Co-Benefits

There are also possible co-benefits of the proposals for integrated economic assessments made in Chap. 11. The first co-benefit may be to give the marginalised a stronger voice. Climate change impacts, adaptation and mitigation policies will have a broad range of impacts particularly on very poor people, depending on the ambition level of the climate policy (Edenhofer et al. 2012). An assessment following Chap. 11 would ideally improve the inclusion of the viewpoints of marginalised people as well, now and in the future. This is due to the above idea that the full set of the relevant practical implications of policy options is to be explored. The impacts of policies on marginalised groups in society and people in the distant future are often neglected in past assessments and the underlying economic literature (Chap. 8). In this sense, assessments could become more democratic.

The above proposals may even facilitate the resolution of some political conflicts. Political parties would no longer have to (endlessly) quarrel about rather abstract, ideological issues. In fact, they may no longer be able to do so at all, as the practical implications of their assumptions would be relatively transparent for everyone to see and, therefore, could no longer be ignored in political debates.

Another potential co-benefit exists with the goal of intellectual self-realisation in a deliberative democracy. Given the above thoughts on public debate, on stakeholder involvement and on participatory approaches to assessment-making (Chaps. 6 and 11), the assessment proposals in Chap. 11 may considerably promote deliberative democracy – via promoting deliberative policy learning. People could then be part of an assessment process where the issues and policies that affect them are explored in detail. According to Dewey (Sect. 6.2.2), this is an essential element of the intellectual self-realisation of human beings. The assessment process itself is highly valuable in this sense, as it ideally implies learning and better mutual understanding.

"Translating" abstract ideological controversies into vivid future scenarios, explicitly connecting technical economic analyses with policy-relevant normative assumptions as well as the idea of a multi-layered public discourse related to an

[8]An example of this approach is the Intergovernmental Platform on Biodiversity and Ecosystem Services, see http://www.ipbes.net/ (accessed 30 Jun 2015).

[9]An example of this approach is the International Panel on Social Progress, see http://www.ip-socialprogress.org/ (accessed 30 Jun 2015); it does not (yet) have a mandate from policymakers.

assessment process (Sect. 6.2) could be means for motivating people to actively participate in discussions about policy issues that have a high impact on their own lives and the lives of their descendants. The above ideas could lead to a new culture of democratic, rational and open-minded discussion of policy options and might enlarge the informational basis of society in terms of policy-making.

> Knowledge of conditions as they are is the only solid ground for communication and sharing; all other communication means the subjection of some persons to the personal opinion of other persons (Dewey 1988).

As long as the opposite has not been proven, it seems worthwhile to believe in the possibility of deliberative policy learning among various players and citizens, also due to its tremendous ethical value. It is the highest virtue – in the traditional Aristotelian sense – of the public because it takes the cognitive and moral potential of each person seriously. Well-designed assessments can help to achieve this.

Yet another potential co-benefit of the ideas for assessment-making in Chap. 11 may be that it helps democratically elected policymakers to regain opportunities to rule. In many countries, their capability to act and decide is currently limited, inter alia because of the financial crisis and declining influence of nation states compared with global companies etc. The proposed type of assessment-making may help democratic governments to regain power, but also responsibility for policy decisions, because policy debates would then be more open again and face alternatives instead of only one policy option that is considered "the only objective one" by scientific consensus. The scientists would then no longer act as political decision-makers by presenting a alleged scientific consensus on policy options or by negotiating an agreement on particular conclusions and numbers, which should clearly be the responsibility and task of the policymakers.

Finally, innovation and progress in the sciences and regarding assessment-making methodology could be another positive co-effect of implementing the ideas from Chap. 11. The need to tackle the scientific and methodological challenges of producing such policy pathway assessments as well as the demanded pluralism of methods and assumptions claimed above could promote the development of new methodologies, more interdisciplinary research and new insights about the complex relationships between nature, society, economy, technology, culture and policy. Furthermore, the inclusion of the public could, according to Dewey (Sect. 6.2.2), contribute to the improvement of scientific knowledge production as well as to its relevance for society and policy.

Additionally, the proposed kind of assessment can help the sciences regain their trustworthiness (see Bammé 2004 for this challenge).

12.4 Final Reflections on the Recommendations

12.4.1 Results of the Evaluation and Outlook on Dewey's "Fifth Step"

Given all of these assumed potential (co-)effects of my proposals from Chap. 11, should these proposals actually guide future integrated economic assessment-making? There are considerable challenges inter alia regarding the multitude of issues to be explored in the proposed type of assessment as well as regarding the fact that not everyone will happily accept an open, science-based learning process concerning the policy solution space. Nonetheless, the proposals from Chap. 11 seem feasible and reasonable to a large extent. Moreover, the IPCC WG III AR5 shows that the exploration of alternative pathways and their practical implications is not infeasible both in scientific and political terms, and that the dominance of the traditional models of scientific expertise in policy can be overcome. One could argue that there is no better science-policy tool regarding complex, disputed, longer-term and uncertain policy issues – such as climate change policy – than larger-scale, participatory integrated assessments of alternative policy pathways and their implications, if one aims to achieve a reliable scientific assessment of policy-relevant issues and political legitimacy (Kowarsch 2016). However, some amendments – as presented in Sects. 12.1, 12.2 and 12.3 – to the proposals from Chap. 11 should be considered.

Even if one does not accept the pragmatist philosophy underlying my proposals, at least some of the proposals still seem relatively robust. As far as I am aware, many scholars involved in the current literature and academic discussions regarding the science-policy interface argue for high transparency regarding value judgements and uncertainty, public participation as well as the presentation of policy alternatives – i.e., claims made in Chap. 11 that are apparently also acceptable for scholars who do not subscribe to pragmatism. Some major aspects of the refined pragmatic model, however, can presumably only be understood and justified if one accepts Deweyan-Putnamian pragmatist philosophy, including, for instance, the ends-means interdependency and the related issues of objectivity in scientific knowledge production (see Part II).

To conclude Step 4 of our Deweyan enquiry into current integrated economic assessment-making, the majority of the potential practical implications of the proposals from Chap. 11 are highly desirable, but several actions are required to avoid potential negative side effects (Sects. 12.1 and 12.2).

Step 5, which requires an ex-post evaluation after the real-life implementation of the proposal for assessment-making, cannot be conducted here as long as these proposal are not fully implemented. Theoretically, the analyses undertaken for Step 5 could lead to substantial revisions of the proposals, as was explained in Sects. 6.2.1 and 6.3. Moreover, a regular critical and systematic ex-post evaluation of the IPCC assessment approaches should be institutionalised in order to facilitate continuous learning about, and adaptive refinements of, the assessment guidelines.

As the experience with the desirable ethics chapter in the IPCC WG III AR5 shows (see Sect. 10.3.3 above) – it took a very long time until the governments accepted such a chapter for an IPCC assessment –, truly interdisciplinary dialogue and overcoming the misguided assumptions about the fact/value relationship require much time and patience; likewise, an approximation of the ideas presented in Chap. 11 can perhaps only be implemented step by step. In line with the proposals made in Chap. 11, however, there is some indication in the landscape of global environmental assessments[10] of a shift towards more focus on disaggregated, solution-oriented policy evaluation, policy implementation (barriers) and, with it, the social sciences. Additionally, in my personal perception, there is an increase in the number of journal articles containing solution-oriented scientific policy analysis. The work presented in this book could thus be very timely. It may help to inform the transition within the assessment landscape from risk analysis to maps of alternative policy response options, i.e. risk management.

12.4.2 Application to Institutions Other than the IPCC

The IPCC was chosen in this book as the key example, inter alia, because international climate policy is a case where scientific advice is undoubtedly crucial and highly debated. Moreover, the IPCC is the most influential science-policy institution and seems to face almost the full range of possible challenges of science-policy interaction due to complexity on both the political and the scientific sides. The ideas developed here may attract some interest inter alia for the incipient discussions on how to design the IPCC AR6. Different assessment bodies as well as different kinds of policy advice involving disciplines other than economics might require different guidelines because the underlying "problematic situation" may be different (see Dewey's pattern of enquiry explained in Sect. 6.2).

However, due to analogies, there is no reason to doubt that at least some elements of the above proposals can be highly relevant to other IPCC WGs as well as other assessment bodies that also conduct larger-scale integrated policy assessments, provided these bodies also have to deal with huge complexity, uncertainty and contentious value beliefs regarding a longer-term policy issue (be it climate change, health,[11] agriculture, public finance, etc.). For each assessment body that aims to analyse such policy issues rather than a mere natural scientific problem analysis, for example, it might be appropriate to follow the idea of mapping policy alternatives and performing in-depth analyses of the implications of policy means. However, the

[10] See again the research project on assessments already mentioned in Sect. 10.5 at http://www.mcc-berlin.net/en/research/cooperation/unep.html (accessed 30 Jun 2015).

[11] Two interesting examples of health-related assessments include http://ctb.ku.edu/en/table-of-contents/overview/models-for-community-health-and-development/health-impact-assessment/main and http://www.integrated-assessment.eu/ (both accessed 30 Jun 2015).

applicability of these proposals to other types of scientific assessments must be checked in each case.

In cases where there is not enough time or resources to initiate a larger-scale assessment process – for instance, because rapid political action is required – the above ideas will not be particularly suitable because they will presuppose an iterative learning process that usually spans several years. In contrast, climate policy has been discussed for more than 25 years, which makes climate change a suitable example regarding the above proposals (Kowarsch 2016). Moreover, if there are no real value controversies or disputes about policy goals, the assessment could take a shortcut and only analyse different sets of possible *means*.

12.4.3 Outlook on Further Research Needs

The present book addressed the arising, new philosophical questions related to solution-oriented, integrated economic policy assessments. A lot of issues and aspects were touched on in the previous chapters. Many of these issues could and should be elaborated on in greater detail.

Many empirical studies of science-policy interactions already exist in the literature on Science and Technology Studies. Therefore, I chose another perspective to reflect on assessment-making – a philosophical one. This theoretical piece of work could help to structure future, well-targeted empirical research on large-scale assessment-making, as it directs our attention to the crucial issues of assessment-making.

Major research gaps include (1) how to involve the public and stakeholders in a feasible manner in global assessment, and more concretely, whom to involve; (2) how an assessment would look *more concretely* along the lines described in Chap. 11; (3) how such assessments can contribute to the solution of ethical controversies more precisely in order to pave the way for a political solution to highly value-laden controversies in climate policy; (4) what the appropriate assessment methods are for integrated policy appraisals beyond the existing IAMs and policy evaluation tools and what the appropriate processes and resources could be to develop these methods; (5) what can be learned from practical experiences with the above proposals as well as from the practical experiences with other formats of assessment-making, requiring systematic ex-post analysis; (6) what the potential impact is of such assessments (e.g., regarding deliberative democracy and concepts such as “democratic learning”), and the conditions and incentive structures under which players at the science-policy interface would follow the proposals outlined in Chap. 11; and (7) what an appropriate economic methodology could be in light of Deweyan-Putnamian pragmatism.

In any case, there is a lack of research on assessment-making (see Sect. 1.2) as well as a lack of continuous reflection on assessments. Better understanding the appropriateness of global mitigation goals, for instance, requires a better understanding of how the sciences can contribute to this issue. Furthermore, the sheer magnitude of time and resources spent on large-scale assessment-making should be reason enough to seriously reflect on it and improve it.

12.5 The Proposed Answer to the Guiding Question of the Book

The steps and structure of the arguments of the book are explained in Chap. 1. Let me now summarise its core results, which are based on a Deweyan pragmatist philosophy of social science in public policy. How does this work actually help the orientation for large-scale integrated economic assessments of climate policy options (or other complex, disputed policy issues)? This is the guiding question of the book.

In a nutshell, good assessments are essential for public policy-making because we do not yet know which the best policy options are, given that so much is at stake for society. However, to overcome the fundamental assessment trade-offs between sound and objective science, policy-relevance, and political legitimacy, the book primarily proposes an open, in-depth and interdisciplinary exploration of concrete, alternative policy pathways (i.e., different sets of policy objectives and means) and their various practical implications, together with stakeholders and the public. This refined pragmatic model of scientific expertise in policy facilitates an iterative learning process concerning disputed and inevitably value-laden policy means, policy objectives, and the underlying value beliefs and problem framings. The actual or potential practical implications are always decisive, in terms of concrete, but often uncertain, scenarios of future worlds. The more specific recommendations in Chap. 11 and their light refinements in this chapter help to realise this ideal of future integrated economic IPCC assessments.

In the following paragraphs, I provide more detail of the major results and findings along this intellectual journey that was structured according to Dewey's pattern of enquiry (Sect. 6.2.1), and add some conclusions.

The key challenge of integrated economic advice for climate policy

Refining the existing science-policy literature, the book starts by providing a systematic and analytic introduction to the prospects and challenges of integrated economic assessments in climate policy (Part I).

According to Dewey, we can reasonably understand public policy-making as the joint and democratic regulation of the indirect consequences of human actions; scientific expertise is essential to appropriately inform this regulation of indirect consequences (Sect. 2.1.1). As derived from the core of Dewey's political theory, however, scientific advice has to meet four general norms: (1) sound science, (2) policy-relevance, (3) good communication and (4) political legitimacy (Sect. 2.1.3). With it, I have given philosophical reasons for the widely shared basic criteria for scientific policy advice, and have refined and amended the interpretation of these basic criteria towards a more normative and "material" understanding.

Dewey's idea of regulating indirect consequences in public policy relates perfectly to anthropogenic climate change, which has many, often crucial, economic implications and which – because of its huge complexity and uncertainty – needs to be better informed by economic expertise (Sect. 2.2). In a world with multiple, interdependent policy objectives, currently the biggest challenge for climate policy is to mitigate trade-offs between different policy fields. In order to develop an appropriate "integrated" climate policy, the economic policy advice must also be better integrated with other perspectives in the social sciences, etc. (Sect. 2.2.4). Larger-scale integrated economic assessments on climate policy, for example the useful and influential assessments by the IPCC (Sect. 2.3), are identified as the most appropriate tool for such complex, longer-term and highly disputed policy issues. They need to seriously involve the social sciences and can help fill the many existing research gaps – such as, for instance, the various distributional co-effects of ambitious carbon pricing instruments (Sect. 2.2.4). Simply pointing to our (abstract) moral responsibility concerning potentially disastrous climate change impacts is insufficient; the existing complexity and knowledge gaps necessitate social-science assessments of climate policy options that are better integrated and aligned with other sustainable development goals.

Science-policy interaction is typically characterised by a diversity of relevant motives, much politics and complex dynamics (Sect. 3.1). Despite this, better integrated economic assessments are absolutely essential for achieving more successful climate policy. These assessments face tremendous challenges – particularly the trade-offs between sound science, policy-relevance and political legitimacy (Sect. 3.4), as illustrated by many hypothetical (Sect. 3.2) and empirical (Sect. 3.3) examples. The difficult role of value judgements in the production of social-science knowledge seems to be at the core of many of these trade-offs. Hence, as the core topic of this book, the integrated economic assessments of the IPCC require orientation in terms of an appropriate – currently lacking – framework (Sect. 3.4).

Philosophical evaluation of normative science-policy models

A first step towards the envisaged normative and theoretical framework for integrated economic assessments is the development of a general, normative model of the role of scientific expertise in public policy (Part II). Regarding the design of assessments, such science-policy models can be seen as: (1) potential means for meeting the general norms for scientific expertise in policy and for mitigating the trade-offs between them; and (2) potential refinement of our understanding from Part I of the problematic situation concerning economic advice for climate policy, given that an appropriate general science-policy model can only be an intermediate step towards a more specific guideline for future IPCC assessments. As such, it also provides more specific evaluation criteria for evaluating assessments.

Four science-policy models are introduced in Sect. 4.1 – along the distinction between problem framing, policy objectives, means and implementation on the one hand, and different players with their suggested responsibilities on the other. They are (still) prevalent in practice and therefore largely guiding the actions at the contemporary science-policy interfaces (including the IPCC). They include the decisionist, the technocratic, the pragmatic and the legitimisation models of the role of scientific expertise in policy (Sect. 4.2). These models mainly differ regarding assumptions related to philosophy of science and furthermore political theory (including concepts of democracy). The attempt to provide a coherent, differentiated and systematic characterisation of different models may perhaps promote a more explicit and critical discussion of the often implicit science-policy models among assessment practitioners.

The legitimisation model does not even expect to meet the general norms for scientific expertise in policy (Sect. 4.3). The decisionist and the technocratic models aim to meet these general norms, but suffer from a misleading philosophy of science. These models assume that, in order to achieve sound, objective scientific knowledge, facts and value judgements – and likewise science and policy – must be neatly separated at the science-policy interface. The heritage of logical positivism is still perceptible here. Yet, the thorough discussion of different arguments made in the philosophical literature for and against a fact/value dichotomy indicates that facts and values are always entangled in the sciences (Sect. 5.2), and particularly in the climate policy debate. Following the decisionist and the technocratic models may thus entail misguided use, or even misuse, of scientific expertise in policy in light of the general norms or expertise in policy (Sect. 5.4).

Unfortunately, despite the current debates in the philosophy of science, many natural and social scientists, as well as some other stakeholders in assessment processes, are still hesitant to accept that the following cannot reasonably be separated at the science-policy interface: (1) scientific facts or their uncertainty; (2) ethical issues and other value judgements; and (3) public policy-making including aspects of politics. At best, they can only be conceptually and gradually distinguished as these three dimensions belong together. In the literature on scientific policy advice and assessments, the widespread separation between issues of uncertainty on the one hand, and the ethical dimension on the other hand is somewhat misleading, as is the attempt to completely separate the treatment of ethical or political conflicts from scientific disagreements in assessments. In terms of an assessment guideline, it may be better to think about the appropriate treatment of divergent viewpoints in general; this may also help to highlight the importance of stakeholder engagement and public participation.

The (diverse) pragmatic model cluster is much more promising. It emphasises the need for public participation and legitimacy in scientific policy advice, and acknowledges the existence of fact/value hybrids more than the other models. It is, however, obviously very difficult to provide a compelling philosophical explanation for why and how value-laden scientific knowledge, co-produced with stakeholders and the public, can lead to reliable, objective scientific knowledge (Sect. 6.1). Without claiming that this is the only possible workable philosophy, pragmatism in the tradition of John Dewey and Hilary Putnam provides such a compelling philosophy of science. The central idea of this tradition is to trace and evaluate practical consequences of all kinds of scientific hypotheses, which always function as means for achieving given ends-in-view (i.e., goals, see Sect. 6.2). Following the steps of a Deweyan enquiry (Sect. 6.2.1), both the means and the ends-in-view should be reconsidered in light of the actual and potential practical implications of the means, jointly with the affected people (Sect. 6.2.2). Despite being highly value-laden and always fallible, analyses based on this – very special, absolutely key and often neglected – ends-means interdependency can lead to objective scientific claims (Sect. 6.2.3).

A refined pragmatic model can be developed (Sect. 6.4), in order to overcome the weaknesses of the prevalent models, by building on and amending this philosophy, particularly regarding the assumed ends-means interdependency. This novel model claims that even highly value-laden, contentious policy issues regarding policy goals or means can be critically and systematically discussed in a rational manner. It essentially claims an open, in-depth and interdisciplinary exploration of concrete, alternative policy pathways (i.e., different sets of policy objectives and means) and their various practical implications, involving stakeholders and the public. This novel science-policy model facilitates an iterative learning process concerning these policy means, objectives, as well as underlying value beliefs and problem framings. The actual or potential practical implications are always decisive in terms of concrete, but often uncertain, scenarios of future worlds, which have to be evaluated and compared. Learning about the severe side effects of the means may require a revision of the policy means or even of the goals themselves, as they should never be regarded as fixed and infallible. According to the refined pragmatic model, value judgements in climate economics are not only unavoidable, but, in a positive sense, can and should be subject to rational, constructive public learning processes for which their practical implications need to be analysed.

One of the major achievements of this book may be the specification of the widely accepted general norms for scientific expertise in public policy (Sect. 2.1.3) in terms of the refined pragmatic model.

Policy-relevance is re-interpreted as an interdisciplinary exploration, evaluation and comparison of integrated policy pathways and their diverse relevant implications in society. This must be based on a thorough problem analysis. *Political legitimacy* is, inter alia, transformed into the claim that highly disputed divergent viewpoints require constructive treatment. They include different ethical values, principles, policy narratives, indicators, evaluation criteria, minority perspectives, etc., and accepting that scientific expertise is inevitably value-laden. These viewpoints do not only have to be made transparent, but also can be critically, constructively and legitimately analysed in terms of their practical implications, in close, serious and iterative cooperation with stakeholders and the public. Scientific advice on climate policy should not result in clear-cut recommendations for policy action, but rather provide policy assessment that opens up the debate into alternative policy pathways and options. Moreover, *sound science* no longer needs to be defined according to misleading positivist ideals for objectivity. It can be defined in terms of plausibility and robustness regarding the expected practical implications of scientific hypotheses in particular contexts, making major uncertainties more transparent. Strict review processes and improvements of economic as well as assessment methodology would be particularly helpful in this regard, as would be systematic learning from actual practical consequences of past policies. Finally, although I have not reflected much on *good communication* in this book, the claim for more serious public participation and higher policy-relevance may have positive co-effects for the communication and outreach of assessments.

This specification of the general norms also helps to better conceptualise, and overcome, the challenges of achieving these norms, particularly regarding potential trade-offs between them. It becomes obvious how laborious and difficult the legitimate and scientifically sound mapping of the policy solution space can be, and what is required from the scientific community to facilitate such assessments (see Part IV). However, despite these challenges, the refined pragmatic model holds great potential for resolving the old and crucial challenge for assessment-making that was so clearly identified by the Harvard "Global Environmental Assessment" project more than a decade ago (see Sect. 2.1.3). This project highlighted the sometimes discouraging trade-offs between salience, legitimacy and credibility. John Dewey is certainly among the most important philosophers of science in policy. By bringing his thoughts more extensively and consistently to bear concerning the science-policy interface, and by refining his pragmatist philosophy, the proposed novel science-policy model can help to promote the transition from risk analysis and consensus-driven scientific advice to the open, more solution-oriented assessment of policy alternatives and their implications. This means to more effectively focus on public policy decision-making under multiple, interdependent objectives, risks and uncertainty.

The discussions in Part II can serve as a perfect example of the deep, serious and often underestimated *philosophical* challenges that need to be addressed when critically reflecting on the science-policy interface and its role in contemporary policy processes. In other words: discussing philosophical issues, such as, for example, the often unpleasant and confusing issue of the relationship between scientific expertise, ethics and public policy, is not just a matter of luxury and a playground for intellectuals. Rather, these complicated philosophical issues can have substantial implications for the practices at the science-policy interface, for science policy and research funding, and in the end for the policy decisions themselves. Although the academic interest in philosophy of science in policy seems to have increased in recent years, this field is still highly under-researched, particularly when also seriously considering the value dimension, ethics and political philosophy. What I have tried to develop here is a (pragmatist) philosophy of social science in public policy that also includes the ethical and value dimensions as appropriate.

A critical look at the IPCC's integrated economic assessments

Based on evaluation criteria systematically derived from the findings in Part II (Sects. 7.3.1 and 10.1), Part III makes the relatively ambitious and rare attempt to philosophically analyse both the IPCC WG III assessments themselves (in Chap. 10) and the economic literature underlying the IPCC assessment (in Chaps. 7, 8 and 9), on which the IPCC is so dependent. This double analysis is intended to better understand the specific, current challenges and prospects for the IPCC WG III assessments, particularly including the more specific challenges for realising the refined pragmatic model (as refined ends-in-view for Part III). In this sense, in addition to Part II, Part III provides another refinement of the problematic situation regarding integrated economic assessments.

IAMs, which have been significantly developed in recent years, are decisive tools for climate economics in the IPCC assessments (Sect. 7.2). While their further development might be severely constrained by the increasing complexity and the methodological limitations of the models, they have been very informative for the previous IPCC assessments. They could, however, be improved further in order to address an even wider range of highly policy-relevant aspects (Sect. 7.4).

The treatment of normative assumptions in IAM-based literature is an interesting evaluation criterion, besides the policy-relevance. While increasing the transparency regarding value judgements implied in climate economics is a widely shared goal, there are few conceptual frameworks for identifying such value judgements. The framework proposed in Sect. 7.3.2 focuses on normative assumptions that are closely related to the ends-means interdependency, which is so crucial to the Deweyan-Putnamian pragmatism. This framework for identifying normative assumptions aims to combine careful philosophical reflection on these assumptions with practical applicability and utility for both assessments and the underlying economic literature.

When applying this framework to the example of IAM economics feeding into the more recent IPCC assessments (Sects. 8.2, 8.3 and 8.4), it becomes clear that climate economics is full of disputable, rarely transparent normative assumptions with far-reaching potential implications for society. This may be a spectacular finding for those who believe in value-free economics, and the value-saturation of these studies is the reason why some shy away from solution-oriented, integrated economic assessment-making. There is also a light bias towards particular sets of value judgements in mainstream welfare economics (Sect. 8.5). Consequently, the climate economics community should, if possible, include a broader range of normative assumptions in their analyses. It should also try to make these assumptions more transparent (although much has improved in this regard) with the help of the proposed framework which would better support the larger-scale assessment processes by the IPCC (Sect. 8.5). If a cook (the IPCC) can only provide his/her guests (decision-makers) with what he/she can get at the butcher's shop (the climate economics literature with the implied one-sided value judgements), it would be very difficult for the cook to show that vegetarian cuisine (other sets of implied value judgements) can also be a tasty option for the decision-makers.

Concerning the scientific and epistemic quality of IAM-based economics, an initial finding is that there are many uncertainties (broadly understood) in IAM-based studies that are not always transparent (Sects. 9.1, 9.2 and 9.3). These can be categorised in three ways: technical, methodological and epistemological. There seem to be many and often hardly reducible uncertainties in IAMs; for instance, their assumptions on the pace and direction of technological change differ significantly. IAMs also include some unrealistic, counter-factual assumptions (idealisations) that exist for the desirable purpose of model simplicity and mathematical calculability. These weaknesses do not suggest that the results of IAM-based studies should be dismissed altogether, as lower levels of scientific confidence should be accepted in assessments, as long as they are made transparent (Sect. 9.4). Although IAM results are not sufficient for a *comprehensive* policy pathways assessment (including all the ethically and politically relevant aspects) and although also other model types and approaches are needed, IAMs can contribute substantial, relatively reliable insights to the debate. Compared with alternative methods, IAM modelling is still the best economic method *currently available* for some key, long-term questions of climate economics (see Sect. 7.2). It is particularly relevant for discussing long-term global mitigation goals (e.g., the 2 °C goal). Yet, despite the progress made in this regard, the transparency regarding all three kinds of uncertainty in IAM-based studies could be improved.

A more fundamental finding shared with large parts of the existing literature on the philosophy of economics is that often economists cannot compellingly explain what their results mean from a philosophical-epistemological perspective (Sect. 9.3). A critical reflection on, and refinement of, the predominant economic methodologies are therefore indispensable to the achievement of more reliable economic research. Pragmatism might help overcome the disorientation of current economic methodology without returning to the dogmatism of positivist methodology. It can further develop the recent trends in economic methodology (Sect. 9.3.3) by: (1) taking the social and historical dimension and specific contexts of knowledge production into account; (2) focusing on practice and action; (3) emphasising the pluralism of methods and methodology; and (4) assuming some kind of naturalism. Despite some resentments and historical misunderstandings between the disciplines of economics and philosophy, an interdisciplinary co-operation between these two (and other) disciplines is crucial to improve integrated economic research and assessment.

Based on the better understanding of the scientific material underlying the assessments, the evaluations of the WG III AR4 and AR5 finds that the WG III assessments are acceptable to a greater or lesser extent (Chap. 10). They could, however, be substantially improved in several regards, also given the recent changes in the climate policy context. The WG III AR5 has attempted to explore the climate policy solution space more broadly and deeply than in previous assessments, inspired by the refined pragmatic model. This method of assessment was a very promising approach that should really be further developed. Currently, however, there are several big challenges for the integrated economic assessments by the IPCC (Sect. 10.5): (1) most importantly, the need for even more (scientifically sound) knowledge integration and synthesis across various disciplines, policy fields, governance levels and IPCC WGs, in order to better understand the full policy solution space; (2) the lack of a more comprehensive, explicit and integrated discussion (and transparency) of disputed, normative viewpoints, including different ethical values and principles, and including critical (multi-criteria) ex-post policy evaluation; (3) the limited capacity and effectiveness of the IPCC given the huge "epistemic complexity," procedural inefficiencies and sub-optimal support by stakeholders; (4) insufficient public participation, while facing various trade-offs; and (5) existing research gaps regarding scientific policy analysis and meta-analyses on some specific policy aspects.

The IPCC WG III AR5 and several publications reflecting on the role of scientific expertise in policy agree with a few elements of the refined pragmatic model (see also Sect. 12.4.1). However, assessments in practice rarely attempt to openly explore the complex policy solution space, let alone in the more precise manner proposed by the refined pragmatic model. Instead of presenting alternatives, assessments usually attempt to identify mean values and try to reach a consensus.

Towards improved integrated economic assessments for climate policy

Finally, based on the previous parts of the book, Chap. 11 and this chapter present elements of a guideline to improve future integrated economic assessments by the IPCC. Chapter 11 also presents ideas for a reform of IPCC AR scope and contents beyond the typical procedural reform proposals. The recommendations are summarised in Sect. 11.1. The major envisaged outcome of implementing these proposals envisaged is the strengthening of deliberative policy learning. This aims to provide the basis for a deliberative policy debate and learning process in society – beyond mere procedural liberalism and value dogmatism – where competing arguments in the political arena can be rationally scrutinised in order to make the best political decisions.

> It is not the business of political philosophy and science to determine what the state in general should or must be. What they may do is to aid in creation of methods such that experimentation may go on less blindly, less at the mercy of accident, more intelligently, so that men may learn from their errors and profit by their successes (Dewey 1927, p. 34).

The goal of integrated economic assessments by the IPCC or any other assessment body should not (necessarily) be a scientific consensus on a particular, ambitious climate policy agreement. Advocating particular, contentious policy options in scientific policy advice is, in any case, ineffective (Sect. 4.3). The sciences can neither resolve climate policy conflicts nor provide absolutely true and value-free knowledge. Rather, assessments should aim to deliberate the trade-offs between different policy options in a transparent and inclusive manner. A great success of integrated economic assessments would be if they – be it the products or the assessment process itself – facilitated a serious learning process among different stakeholders and the public. This could highlight the policy solution space, its pitfalls, complexity and uncertainty, the “silent losers” of different policy options, and the conditions and requirements for, as well as various co-effects of, realising certain value beliefs in public policy. This could help to discuss contentious issues less ideologically, via the implications of policy means. Societies can then consider whether they want to live in such a world (compared with other possible worlds).

Final Remarks

In clear words, Keynes pointed out both the potential impact of scientific ideas and the responsibility of economists regarding scientific policy advice:

> The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly believed. Indeed, the world is ruled by

> little else. Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back. I am sure that the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas. Soon or late, it is ideas, not vested interests, which are dangerous for good or evil (Keynes 1936, pp. 383f).

Like Keynes, this volume emphasises the need for a critical reflection on policy-related scientific expertise – not only because of its de facto impact on public policy, but also because adequate climate policy-making requires scientific expertise. In this book, I have proposed comparing alternative policy pathways and their practical implications. Future assessments will certainly benefit from more reflections of this kind, and from a systematic "assessment of assessments."

In common with many others, I personally have relatively strong opinions about climate policy options. Why should we therefore spend so much time on such a complex and resource-intensive assessment exercise that aims to critically scrutinise alternative ideas and opinions? The crucial point is to involve disparate groups in a single assessment process in order to get them to constructively communicate with each other and to *jointly* explore the practical implications of alternative policy pathways. The result would be a more differentiated evaluation than usually achieved in policy processes. In accordance with a truly philosophical attitude, this idea would enable an iterative learning process and allow errors of opinion regarding a very complex issue, such as climate change, to be recognised. This would help to avoid Weber's "iron cage of bondage" for society and policy-making, and would allow scientific assessments to truly serve society.

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