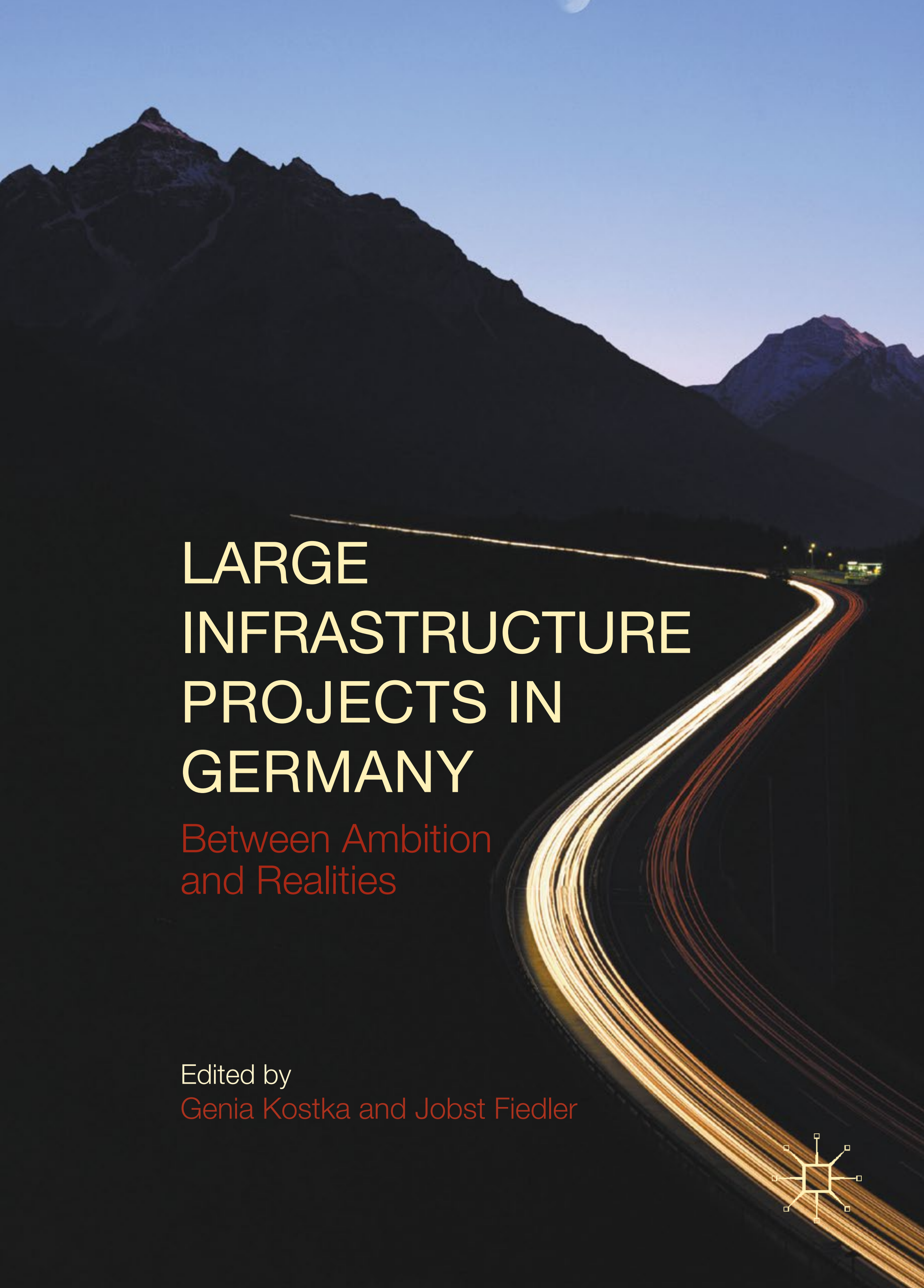

LARGE INFRASTRUCTURE PROJECTS IN GERMANY

Between Ambition and Realities

Edited by

Genia Kostka and Jobst Fiedler

Large Infrastructure Projects in Germany

Genia Kostka • Jobst Fiedler
Editors

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List of Abbreviations

AC/DC	Alternating Current/Direct Current (electricity transmission)
BBF	Berlin Brandenburg Flughafenholding GmbH
BDEW	Bundesverband der Energie- und Wasserwirtschaft (German Association of Energy and Water Industries)
BER	Berlin Brandenburg Airport
BMUB/BMU (until 2013)	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy)
BNetzA	Bundesnetzagentur (Federal Network Agency)
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency)
CEER	Council of European Energy Regulators
DCMS	Department for Culture, Media and Sport
DP	Delivery Partner
DWG	Deutsche WindGuard
EC	European Commission

EEG	Erneuerbare Energien Gesetz (Renewable Energy Act)
EESI	Environmental and Energy Study Institute
EEZ	Exclusive Economic Zone
EIB	European Investment Bank
EnWG	Energiewirtschaftsgesetz (Energy Economy Act)
EPC	Engineering, Procurement and Construction
EU	European Union
EWEA	European Wind Energy Agency
FBB	Flughafen Berlin Brandenburg GmbH
FBS	Flughafen Berlin Schönefeld GmbH
FIT	Feed-in-tariff
GHG	Greenhouse Gas
GOE	Government Olympic Executive
GWEC	Global Wind Energy Council
HdM	Herzog & de Meuron
IMEC	International Research Program on the Management of Large Engineering and Construction Projects
IPAA	Infrastrukturanpassungsbeschleunigungsgesetz (Infrastructure Planning Acceleration Act)
IWR	Internationales Forum Regenerative Energien
KfW	Kreditanstalt für Wiederaufbau (Credit Agency for Reconstruction)
LOCOG	London Organising Committee of the Olympic and Paralympic Games
MPA	Major Projects Authority
MPLA	Major Projects Leadership Academy
NEC3	National Engineering Contract 3
ODA	Olympic Delivery Authority
OWF	Stiftung Offshore-Windenergie (Offshore Wind Foundation)
OWP	Offshore Wind Park
OWT	Offshore Wind Turbine
PFI	Private Finance Initiative
Pg bbi	Planungsgemeinschaft Berlin Brandenburg International
TSO	Transmission System Operator

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Introduction

Genia Kostka and Jobst Fiedler

Introduction

Infrastructure is high on the agenda as Europe faces an investment bottleneck. EU-28 investment in infrastructure has been declining by 11 % since 2010 to below €400 billion in 2013 (Roland Berger Strategy Consultants 2015). There is a considerable gap between actual investment and the amounts needed to keep European nations competitive economies by international standards. Standard & Poors (S&P 2015) estimates €1 trillion investment needs in the EU member states for the next 3 years. To meet the investment needs, the European Commission introduced the "European Fund for Strategic Investments" (EFSI), an ambitious plan to attract €240 billion private investment in Europe's infrastructure between 2015 and 2017 (European Commission 2015).[1] The EFSI is intended to give the traditionally publicly financed infrastructure sector access to the liquidity of international capital markets. Many of the about 2000 infrastructure projects submitted for the EFSI

[1] The EFSI includes further €75 billion planned investment in small and medium enterprises (SME) and mid-cap companies.

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are large—45 % are larger than €100 million in volume and 9 % are even larger than €1 billion (Roland Berger Strategy Consultants 2015). As a result, many infrastructure projects need to be delivered in Europe in the near- to long-term future.

A key reason for the lack of private investment is the high-risk nature of such large-scale infrastructure projects (Roland Berger Strategy Consultants 2015). Such ventures are often finished late and over the initially planned cost. According to Flyvbjerg et al. (2003), nine out of ten large-scale infrastructure projects face significant time delays and cost overruns while benefit shortfalls of more than 50 % are not unusual. With high initial investment in the planning and construction stage with no cash flow returns for years and risks of frequent time delays and capital-destroying cost overruns, infrastructure projects have been traditionally publicly financed, despite the opportunity of stable returns on capital (Roland Berger Strategy Consultants 2015). The risk factor of time delays and cost overruns is a problem of project delivery governance and the key dimension of this book. In order to analyze the issue of project delivery governance in depth, this book chose Germany as a case study.

Germany, Europe's largest economy, has built up a backlog in infrastructure investment. S&P (2015) has calculated a €60 billion investment shortfall since 2004. According to the Cologne Institute for Economic Research (IW 2014), Germany needs to invest €120 billion by 2024 in transportation, broadband, and electricity infrastructure to remain a competitive economy. In addition, Germany has ambitious plans to significantly transform its national electricity infrastructure by introducing renewable sources of energy into its power generation fleet on a large scale (Energiewende). According to the German Institute for Economic Research (DIW 2013), this transition will require €31 to €38 billion per year until 2020. Germany, because of its size, centrality, and ambitious plans, is a key actor in European infrastructure policy and an important case to study failure and success in project delivery.

But so far, public budgets in Germany being constrained by tight fiscal rules do not plan for infrastructure investments of this size during the next 5 years. Against this background, time delays and cost overruns in visible public projects have been subject to heated controversy over the waste of taxpayer money and funds dedicated to infrastructure. Numerous large-scale public infrastructure projects such as Stuttgart 21, the Hamburger Elbphilharmonie, and the Berlin Brandenburg Airport (BER) have faced devastating criticism and mockery by the media and the public in recent years. While the problem of time delays and cost overruns is not new, the scale of recent failures in project delivery in Germany and Europe suggests an alarming trend, making it necessary for policymakers and academics to study the management and governance of large-scale infrastructure projects more closely. The particular questions this book seeks to answer are:

1. How do the *patterns* of infrastructure project delays vary among sectors in Germany?
2. What are the *causes* of these cost and time delays?
3. What are the *lessons* for large-scale projects in the future?

To address the first question, we collected a database on large infrastructure projects in Germany from 1962 to 2015 and examined particular implementation *patterns*. In-depth case studies on the BER, the Hamburg Elbphilharmonie, and offshore wind parks help to address the second and third questions. We selected in-depth cases from different sectors—transportation, residential and commercial constructions, and energy—to analyze similarities and differences in the governance of infrastructure projects. Overall, the case of Germany includes various new forms of project delivery, such as public–private partnerships (PPPs), and draws particular attention to the risks and opportunities of ambitious first-mover or "pioneer" projects.

Patterns of Infrastructure Delivery

Large-scale infrastructure projects are typically megaprojects. A common definition is that megaprojects are "…large-scale, complex ventures that typically cost US$1 billion or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people" (Flyvbjerg 2014).[2] Such projects can include a variety of types, ranging from industrial processing plants, oil and gas pipelines, and large dams to government administrative systems, mergers and acquisitions, and Olympic Games (Flyvbjerg 2014).

Research on various types of megaprojects has shown considerable differences in average cost overruns (see Table 1.1). For example, IT and ICT projects performance comparatively well on average, but they have a lot of outliers with drastic cost overruns. Such "black swans" with cost overruns over 200 % hit one out of six IT projects (Flyvbjerg and Budzier 2012). On the other hand, nuclear power plants and hydroelectric dams do consistently have extreme cost escalations. Sovacool et al. (2014a) have found an average cost overrun of 117 % in 180 cases of nuclear power plants. Ansar et al. (2014) have found an average cost overrun of 96 % for 245 cases of large dams. Other sectors, such as transmission lines, wind farms, and solar facilities, with average cost overruns of 8 %, 8 %, and 1 %, respectively, seem to have lesser problems with escalating costs and schedule slippage (Sovacool et al. 2014a).

Infrastructure projects show considerable variation as well. Transportation infrastructure has received a lot of attention in the literature because, for example, roads, rail, tunnels, and bridges are typically large and complex because they involve multiple stakeholders. Since the groundbreaking work by Flyvbjerg et al. (2003) based a comprehensive database on transportation infrastructure worldwide, scholars have started to explore the phenomenon of megaprojects more systematically. Applying large datasets, statistical analysis, and case study research, Flyvbjerg et al. (2003) focused on the difference between the projected costs and benefits of megaprojects and compared with the actual performance. According to them, the planning of transportation infrastructure has systematic problems worldwide (Flyvbjerg et al. 2003; Flyvbjerg 2007). In most recent years, research in megaprojects has surged, and

[2] An alternative definition is Frisk's (2008) "six Cs" to identify megaprojects. According to her, they are colossal, complex, and captivating because of their size, risk, funding, and design. They are controversial issues, they raise questions of control, and their costs are often underestimated.

Table 1.1 Existing research and average cost overruns

Category	Type of project	Average cost overrun (%)	Sample size	Study
Roads	Motorway, trunk roads, local roads, bicycle facilities, pedestrian facilities, park and ride, bus lane schemes, and guided buses	20	537	Cantarelli et al. (2012)
Rail	Metro rail, guided buses on tracks, conventional rail, and high-speed rail	34	195	Cantarelli et al. (2012)
Fixed links	Tunnels and bridges	33	74	Cantarelli et al. (2012)
Public buildings	Museums, signature architecture, hospitals, ministries, and maintenance works	51	51	Anzinger and Kostka (2016)
Industrial projects	Oil and gas production, refining facilities, chemical processing, LNG, and pipelines	24	318	Merrow (2011)
IT and ICT projects	National IT infrastructure (e.g. health or taxation), transportation IT, etc.	27	1471	Flyvbjerg and Budzier (2012)
Nuclear power plants		117	180	Sovacool et al. (2014a)
Thermal power plants	Coal-fired, gas-fired, and geothermal power plants	13	36	Sovacool et al. (2014a)
Large dam projects	Large hydropower, large irrigation, flood control, and multipurpose dams	96	245	Ansar et al. (2014)
Transmission lines		8	50	Sovacool et al. (2014a)
Solar facilities		1	39	Sovacool et al. (2014a)
Wind parks	Onshore and offshore	8	35	Sovacool et al. (2014a)
Olympic games		179	17	Flyvbjerg and Steward (2011)

researchers have also studied the phenomena of megaprojects in a highly interdisciplinary fashion.[3]

A key gap in the literature is lack of emphasis on national policy factors. Because previous studies (Flyvbjerg et al. 2003; Merrow 2011) have focused on transnational project data, the influence of the national policy context on policy and administrative capacity to choose adequate project governance and management arrangements has been insufficiently examined. By taking a look at Germany as a case study, we aim to find out where cost overruns in public infrastructure are most problematic and why. This is particularly intriguing in the case of Germany to which, viewed from abroad, a rather high political and administrative capacity is attributed. The study's focus on Germany allows for comparisons between sectors and between countries, a topic that has largely been ignored. An exemption is the study by Cantarelli et al. (2012), who compared infrastructure projects in the Netherlands with transnational data.

Chapter 2 looks at the variation across different sectors in Germany. Based on a database of 165 cases (115 finished, 50 unfinished projects) of projects between 1962 and 2015, the authors show that there are significant variations in infrastructure project outcomes across sectors in Germany. For finished projects, the ICT sector is especially facing significant cost overruns, with 131 % on average. Energy projects and defense acquisition are in the medium range with 91 % and 85 % on average per project. In the building and transportation sectors, average cost overruns are lower, at 51 % and 32 %. In the subsectors, there are even more variations. The case studies on the BER, the Hamburg Elbphilharmonie, and offshore wind power expansion in Germany shed additional light on the interplay between infrastructure project delivery and national policy features such as project governance and management. The authors of this book emphasize that there is no one-size-fits-all policy option for policy-makers and project planners to cope with this problem. Rather, different

[3] The literature draws on insights from various fields, such as economics, sociology, or psychology, including principal-agent relations (Flyvbjerg 2007), rent-seeking behavior (Flyvbjerg 2009), decision-making under uncertainty (Kahneman and Tversky 1979a), optimism bias (Flyvbjerg et al. 2003), contested information (De Bruijn and Leijten 2007), (project) governance (Miller and Hobbs 2005) and management (De Bruijn and Leijten 2007), as well as cost–benefit and multi-criteria analysis (Van Wee and Tavasszy 2008).

infrastructure sectors have different patterns of delivery and individual projects, though they can be compared with similar projects in the same sectors, are ultimately unique as well. A systematic investigation into different sectors of infrastructure can show how patterns differ and how to address sector-specific delivery problems by analyzing good and bad examples.

Causes of Delivery Problems

The different causal explanations for infrastructure delivery problems can be summarized as technological, psychological, and political-economic. Hirschman (1967) argued that the initial ignorance of the project risks—such as untried technology or the challenges of transferring known technologies to new places—leads not only to the problems observed but also to entrepreneurial learning. In addition, Sovacool et al. (2014b) suggested that some projects are easier to plan than others, comparing, for example, nuclear power plants and wind farms, because of differences in construction lead times (90 months on average for nuclear power plants, 13 months for wind farms), the level of technological standardization, and safety standards and regulations.

Flyvbjerg et al. (2003) and Flyvbjerg (2014) have criticized technology as an explanatory cause and focused instead on psychological and political-economic explanations. They explain systematic underperformance of project's forecasts mostly by the psychological factors delusion, appraisal bias, or optimism bias (Kahneman and Tversky 1979a; Kahneman 1994; Flyvbjerg et al. 2003; Flyvbjerg 2007, 2008). They showed that forecasts usually fail to account for reality because of cognitive biases to overestimate benefits of a project and underestimate risks.

Political-economic causes have also been influential in the literature. Such explanations include the problem of cost externalization to third actors (Sovacool and Cooper 2013), bad incentives for public institutions to choose the "cheapest" projects, leading firms to systematically underestimate costs (Flyvbjerg 2009) and strategic deception (Flyvbjerg 2008, 2012a, b, 2014, Flyvbjerg et al. 2009).

An emerging debate in the literature is the influence of national policy or geography on project delivery performance. Cantarelli et al. (2012) have found that, for example, planners in the Netherlands perform considerably better in rail projects than the rest of the world with 11 % average cost overruns compared to 34 % (this subject will be covered in Chap. 2 of this volume). This finding is significant, even though the causes for this difference are unclear, for example, whether they are found in geology, national- or state-level regulation, and planning capacity. The book is placed in this emerging research, finding that Germany also shows considerable differences with the rest of the world. To learn about the relevant causes of bad delivery performance for projects in Germany, this book looks deeper into selected cases.

Lessons for Better Delivery

How can policymakers and project planners improve the performance of infrastructure delivery? Nobel Prize Winner Daniel Kahneman (1994) has attempted to correct for cognitive biases by taking an "inside" versus an "outside view"—while the former is focused only on the project, the latter requires comparison of the forecast to similar projects. As a solution, forecasters need to take the "outside view" with a method termed "reference class forecasting" (RCF). The basis for estimation, instead of an isolated cost–benefit analysis, is a statistical distribution of characteristics of a list of similar projects. Forecasts for upcoming projects are then to be based on such distributions. Flyvbjerg et al. (2004) have applied RCF to public planning of infrastructure projects.

Beyond improving the methodologies for project planners, Flyvbjerg (2009) suggested improving forecasting precision through both public and private sector mechanisms, that is, transparency and public control, and competition and market control. The public sector–driven mechanisms would include measures such as peer reviewing of project proposals, including civil society in the formulation of proposals, and penalizing wrong forecasts. The private sector–driven mechanisms include measures such as inclusion of private capital in projects, to profit from the more efficient resource-allocating mechanisms and better risk management practices.

Another set of possible solutions concerns project governance. Miller and Hobbs (2005) argued that governance regimes need to be dynamic and progressively shape projects across their lifecycle, as well as be flexible enough to restructure the project when necessary to prevent failure. Regime design should clearly allocate risks and responsibilities. Expertise should be matched with according decision-making power and scrutiny. Other possible solutions for improved project governance include, for example, comprehensive front-end planning (Williams and Samset 2010), penalty-and-reward systems for good and bad forecasting by project planners (Taleb 2010; Flyvbjerg 2014), and comprehensive performance monitoring (McKinsey & Co 2013).

A key finding of this book is that many projects are so unique and transformative that a certain degree of "pioneer risk" is inevitable. While it is certainly desirable to select projects based on known technology and in smaller units, as Ansar et al. (2014) suggested, the large-scale use of new technologies mandate new project designs with yet unknown magnitudes of risk. Such projects are, for example, in the energy and ICT sectors that currently undergo rapid transformations. The case study of offshore wind parks shows that there are risk factors specific to an early period of industrial development, what we call "pioneer risks," but it is possible that learning takes place over time. To improve delivery performance in large infrastructure projects, our key recommendation is hence to try and enable learning. In the offshore wind industry, this is possible via competitive markets, technological standardization, and policy certainty. In other sectors, this can be done as well by attracting private capital, selecting appropriate governance models or innovative models of project delivery (such as PPPs), and various mechanisms to incentivize good planning. This will require a lot of effort, such as measuring the success and failures of new methods. But to cope with an endemic problem in infrastructure planning, it is certainly a worthwhile first step.

Structure of the Book

The book is structured as follows. Chapter 2 shows various patterns in the delivery of different infrastructure projects across sectors and illustrates how various factors such as governance, protests, and size of the project influence its performance. By examining a database of 165 large infrastructure projects, the authors provide a comprehensive investigation into the scale of the problem in Germany and find considerable differences between different sectors such as transportation, buildings, defense acquisitions, energy, and ICT. Drawing attention to the most successful and unsuccessful projects, the authors show in which sectors problems are most endemic and especially highlight that the pioneer character of uniquely challenging projects makes them particularly vulnerable to cost overruns.

Chapter 3 on the BER shows how a project that has experienced heavy difficulties right from project start can face a spiral of mistakes and an almost complete loss of control for the project management team. The BER is a high-profile failure that severely damaged the reputation of all actors involved—politicians, managers, planners, engineers, architects, and Germany as a whole. However, the author argues that failure was far from inevitable as numerous examples of successfully delivered airports show, but rather the result of bad project governance and management that had failed to identify risks appropriately.

Chapter 4 on the Hamburg Elbphilharmonie shows how unfinished planning at project start and an inappropriate project governance model can cause deception of the public, frequent delays, and escalating cost. With a multitude of actors involved, imbalanced risk and responsibility allocation, and driven by optimism bias, the planners of the Elbphilharmonie developed a destructive work relationship among each other. The authors examine to what extent project delivery problems of the Elbphilharmonie could have been avoided by choosing governance mechanisms more appropriate for project delivery challenges in the planning phase.

Chapter 5 on the German offshore wind power expansion shows how the separation between a private and a regulated party responsible for different parts of the project led to interface problems. While the construction and installation of the parks had comparatively low cost overruns for the private developers, problems with the regulated grid expansion led to considerable additional surcharges for consumers. The author shows that the delivery of privately owned projects such as offshore wind parks can face many problems at the intersection with public stakeholders, but also have a high potential of learning from experience through competitive markets and private sector-like risk management practices.

Chapter 6 concludes with specific recommendations how policymakers can help to enable learning and how project planners can improve delivery performance. The authors especially emphasize the need of institutional learning in planning of large-scale infrastructure projects, which will require substantial transformations, better coordination and better funding of public planning bodies, and openness toward new models of project delivery that attract higher private sector involvement and investment.

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Large Infrastructure Projects in Germany: A Cross-sectoral Analysis

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Introduction

Large-scale infrastructure projects are often finished late and over the initially planned cost. In Germany, this has been subject to heated controversy over the alleged waste of public money. The Elbphilharmonie in Hamburg, the Berlin Brandenburg Airport (BER), and Stuttgart 21 are prominent examples. This chapter examines large-scale infrastructure projects in different sectors, including buildings (construction, maintenance), energy (wind, nuclear), information and communications technology (ICT), defense acquisition, and transportation (airport, bridge, port, road, rail, tunnel, and waterway).

By taking a look at Germany as a case study, we aim to find out where cost overruns in public infrastructure are most problematic and why. A study investigating the reasons for time delays and cost overruns is a necessary start for developing solutions to the problem. The study's focus on Germany also allows for comparisons between sectors and between countries, a topic that has largely been ignored. An exemption is the study by Cantarelli et al. (2012), who compared infrastructure projects in the Netherlands to transnational data.

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Based on a database of 165 cases (115 finished and 50 unfinished projects) of projects between 1962 and 2015, this study shows that there are significant variations in infrastructure project outcomes across sectors in Germany.[1] The ICT sector is especially facing significant cost overruns, with 131 % on average for finished projects. Energy projects and defense acquisition are in the medium range with 91 % and 85 % on average per project, respectively. In the building and transportation sectors, average cost overruns are lower, at 51 % and 32 %. In the subsectors, there are even more variations, which will be addressed in this chapter.

By selecting specific examples and by drawing attention to the most successful and most unsuccessful infrastructure projects, the study summarizes possible explanations for this variation and offers recommendations for better management of large-scale infrastructure projects. In particular, with regulatory power, technical expertise, delivery capacity, and financing ability dispersed among a multitude of state and non-state actors, the findings suggest that effective governance of large-scale infrastructure projects requires the institutionalization of learning from experience to ensure completion on time, on budget, and sustainable.

Main Explanations for Time and Cost Overruns

Germany is, of course, not the only country that is facing significant additional costs when completing large infrastructure projects. The data collected allows some comparisons with transnational studies in the sectors of transportation (Flyvbjerg et al. 2003; Cantarelli et al. 2012), public ICT (Whitfield 2007), electricity infrastructure (Sovacool et al. 2014a), and buildings (Rigsrevisionen 2009). There are no comparable

[1] The numbers in this book slightly differ from the ones presented in a Working Paper in May 2015, published on the Hertie School of Governance website. A few projects were taken out of the database due to comparability issues and new ones were added. The most significant change affects the Toll Collect and the FISCUS project, which were originally listed as having had 1150 % cost overruns. After internal debates and a discussion with Toll Collect GmbH, we decided that the majority of cost overruns assumed were due to calculated economic damage (e.g. revenue loss from toll fees due to implementation problems), which should be excluded for comparability issues. Both projects are now listed as having had 100 % cost overruns, a number the Toll Collect GmbH confirmed.

studies on the sectors of airports, waterways, and offshore wind energy, on which data has been collected. As previously mentioned, the main three (or four) explanations are technological, political-economic, and psychological.

This study contributes to this debate in numerous ways: First, the existing studies are transnational. This can be a problem because variations in cost overruns, due to differences in geographic factors and national policy, are underexplored. Additionally, the data between different countries are sometimes problematic to compare, especially under different policy scenarios and regulatory regimes. Second, a variety of sectors and subsectors were included in order to better understand variations in the scale of cost overruns across sectors. Third, the analysis includes projects of different size categories and tracks additional variables such as citizen protests and public–private partnerships (PPPs). Especially with the current international boom in infrastructure investment, such as the Juncker-Plan in Europe, Germany serves as an illuminating case study.

Methods and Data Selection

Description of Database

The results are based on a database of 165 large infrastructure projects planned between 1962 and 2015, of which 115 are finished and 50 are still under construction. Our unit of analysis is the project case. A project was included in the database if it was based in Germany, was in public interest (taxpayer-funded or otherwise regulated), and was finished or is expected to finish (which excludes failed projects). The types of project delivery included are public procurement, PPP, or "semi-private," that is, subsidized and regulated industries such as electricity infrastructure (e.g. nuclear power plants, offshore wind parks, transmission lines). The majority of projects, 134 cases, were by public procurement, 13 were PPPs, and 18 were semi-private.

Projects differ in size. According to the US Federal Highway Administration, a "megaproject" is a project that costs more than $1 billion or has a high social or political impact. According to Flyvbjerg et al. (2003), "mega" is relative because a project considered small for a large city can be large for a small community. Hence, all projects were collected on which data was available. Project size is defined by its planned cost at the start of construction or execution.[2] The smallest project is the visitor and information center Grube Messel, which was planned to cost €4.4 million. The largest project is the acquisition and integration of the Eurofighter jets into the German military, which was planned to cost €14 billion in 1987 (adjusted for inflation during 1987–2014, it is now worth more than €23 billion).

This study grouped projects into sectors and subsectors. In total, 78 projects in the building sector (construction, maintenance), 50 in the transportation sector (airport, bridge, port, road, rail, tunnel, waterway), 15 in the energy sector (wind, nuclear), 10 in ICT (services, transportation), 8 in defense, and 4 in other sectors (events, science) were examined (see Table 2.1).

Data Sources

The cases were selected from publicly available sources, predominantly from state institutions (Bundesrechnungshof, state and federal ministries, parliamentary reports, etc.), the Bund der Steuerzahler e.V., a special interest group (taxpayers' lobby), documents by the construction company or architecture firm in charge, a financial auditor, project planner, or newspaper reports. When the numbers found were conflicting, by unreliable sources or partly unavailable, the researchers used the best estimate possible or deleted the cases.

Collected Variables

The key indicator for planning and forecasting performance is the cost overrun. By focusing on it, the study follows the methodology by Flyvbjerg et al. (2003), explained in more detail in Cantarelli et al.

[2] Projects are identified as "small" if they were planned to cost less than €50 million, "medium" if they were planned to cost more than €50 million and less than €500 million, and "large" if they were planned to cost more than €500 million.

Table 2.1 Number of cases across sectors

Sectors	Under construction	Finished	Total	Average project size (million €)
Building	**27**	**51**	**78**	**182**
Construction	17	44	61	201
Maintenance	10	7	17	113
Defense	**5**	**3**	**8**	**8149**
Energy	**1**	**14**	**15**	**2081**
Nuclear	1	6	7	3141
Wind		8	8	1154
ICT	**2**	**8**	**10**	**1619**
Service	2	5	7	2040
Transportation		3	3	638
Other		**4**	**4**	**1729**
Events		3	3	1972
Science		1	1	1000
Transportation	**15**	**35**	**50**	**1188**
Airport	2	4	6	2095
Bridge		2	2	99
Port	1		1	500
Rail	6	6	12	1501
Road	4	19	23	858
Tunnel	1	2	3	2460
Waterway	1	2	3	345
Grand Total	**50**	**115**	**165**	**1170**

Source: Infrastructure Project Database, 2015.

(2012).[3] A cost overrun is the difference between initially planned or estimated cost and actual cost at the end of the project, measured as a percentage of estimated costs. The initially planned or estimated cost is the number given by the responsible authority at the start of construction or execution of the project.[4] The study further collected data on the start

[3] Cantarelli et al. (2012), however, compared all projects if they were finished or "90 % finished." This was not possible to do for this study, because the data on schedule times was too imprecise across projects. Additionally, it is also possible to learn a lot from unfinished projects. This study hence strictly separates between finished projects and unfinished projects.

[4] To compare cost numbers at different points in time, we include inflation. We adjust the number value of the initially planned cost of a project for historical inflation for CPI2010 baseline for the period of planned construction. Inflation during unintended additional time of the project is considered part of the cost overrun percentage.

of planning time, start of construction, planned end of construction, actual end of construction, the federal state where the project was built, a variable for the type of project delivery (public procurement, PPP, semi-private), project size (small, medium, large), and if protests took place (0 = no, 1 = yes).[5]

Data Limitations

The case selection was limited by data availability. In Germany, there is no comprehensive database on a project-by-project basis, and this database is, to the knowledge of the authors, the first attempt to create one. Consequently, the availability of cost numbers is limited by factors such as public awareness and scrutiny, regulation, institutional capacity, and oversight that influence the cost reporting. In the process of data collection, projects were dropped when information was not available. Some of the problems with the definition of a project were listed in Chap. 1, which the researchers addressed in the best and most consistent way possible. The selection is hence skewed toward the building (78 cases) and transportation sectors (50). In other sectors such as energy, ICT, and defense, more data would be necessary to gain better insights. Nevertheless, this study is able to infer from a sample of 165 cases to the wider population of large-scale infrastructure projects in Germany.

Findings

The 165 large infrastructure projects in our database cover a total planned cost of €146 billion. When adding all the additional costs under real prices, the actual costs were more than €193 billion, or 32 % more total costs than planned at the start of the project (see Table 2.2). Table 2.3

[5] Based on whether or not the Google Search entry terms "(Project Name)" and "protest" yielded results after four pages.

Table 2.2 Total costs, in billion € (real prices)

Sectors	Planned costs	Additional costs	Total % increase
Building	**10.4**	**3.8**	**36**
Construction	8.9	3.4	38
Maintenance	1.5	0.4	28
Defense acquisition	**54.5**	**10.7**	**20**
Energy	**18.9**	**12.3**	**65**
Nuclear	11.5	10.5	91
Wind	7.4	1.8	24
ICT	**11.9**	**4.3**	**36**
Service	10.7	3.6	34
Transportation	1.2	0.7	60
Other	**4.7**	**2.2**	**46**
Events	4.2	1.7	41
Science	0.5	0.5	85
Transportation	**45.8**	**13.6**	**30**
Airport	7.9	4.7	60
Bridge	0.2	0	0
Port	0.3	0.2	80
Rail	12.9	5.1	40
Road	17.6	2.1	12
Tunnel	6.4	1	15
Waterway	0.6	0.5	88
Total	**46.9**	**146.2**	**32**

Source: Infrastructure Project Database, 2015.

summarizes the average cost overruns for all the projects and across sectors. The table differentiates between finished infrastructure projects and such still under construction. For finished projects, the actual cost figures are available, while for unfinished projects, the latest available estimated actual costs are used. Finished projects have a higher average cost overrun of 57 %, while unfinished projects are already at 39 %. It is to be expected that project currently under construction will face additional cost increases before completion. The lowest cost overruns are in the building and transportation sectors (51 % and 32 %). Cost overruns in the defense sector were at 85 %, while energy and ICT had cost overruns of 91 % and 131 %, respectively. This variation across sectors in cost overruns invites a more sector-specific analysis.

Table 2.3 Large infrastructure projects and sectoral distribution in Germany (1962–2015)

	Under construction		Finished		Total	
Sector	Cost overrun (%)	Sample size (*n*)	%	*n*	%	*n*
Building	**28**	**27**	**51**	**51**	**43**	**78**
Construction	34	17	47	44	43	61
Maintenance	18	10	75	7	42	17
Defense acquisition	**26**	**5**	**85**	**3**	**48**	**8**
Energy	**28**	**1**	**91**	**14**	**87**	**15**
Nuclear	28	1	187	6	164	7
Wind	–	–	18	8	18	8
ICT	**101**	**2**	**131**	**8**	**125**	**10**
Service	101	2	178	5	156	7
Transport			54	3	54	3
Transport	**56**	**15**	**32**	**35**	**40**	**50**
Airport	49	2	48	4	48	6
Bridge	–	–	11	2	11	2
Port	80	1			80	1
Rail	26	6	33	6	29	12
Road	15	4	28	19	26	23
Tunnel	364	1	34	2	144	3
Waterway	91	1	57	2	68	3
Other	–	–	**68**	**4**	**68**	**4**
Total	**39**	**50**	**57**	**115**	**52**	**165**

Source: Infrastructure Project Database, 2015.

Sectors with Lower Cost Overruns: Transportation and Building

Transportation

In the transportation sector, cost overruns average 32 % but hide variation among its different subsectors. Roads have cost overruns of 28 %, followed by rail with 33 % and airports with 48 %. Generally, transportation infrastructure is a key sector because projects are large (average project size: €1.2 billion) and are a demanding planning challenge.

Road (28 % Cost Overrun for Finished Projects)

Roads vary between 23 % below budget and 125 % above budget. An example for good planning is the Bundesautobahn 20 (Ostseeautobahn), a highway crossing four federal states and connecting the northwest with the northeast after the fall of the Berlin Wall. Planned to cost €1.6 billion in 1992, it finished on time, in 2005, and was below budget by 8 % when adjusted for inflation. Given that projects over €500 million in size had an average cost overrun of 49 % overall, the Ostseeautobahn was well planned. Overall, however, German road planners perform worse than the rest of the world with an average of 20 % (Cantarelli et al. 2012).

Rail (33 % Cost Overrun for Finished Projects)

Rails vary between 10 % below budget and 59 % above budget. A prominent case is Stuttgart 21, a rail-restructuring project (involving also a building project), which led to large public protests that received nationwide media coverage. Originally intended to cost about €4.1 billion, Stuttgart 21 already has an estimated cost overrun of 48 % and its completion has been delayed from 2019 to 2021. A similar case was the Cologne/Rhine-Main fast-rail track, which was also planned to cost about €4 billion in 1995. Because of economic complexity, legal issues, and problematic stakeholder relations, the project was delayed from a scheduled finish in 1999 to 2002 and increased by almost 44 % in cost.

Airports (48 % Cost Overrun for Finished Projects)

Airports have higher cost overruns compared with other transportation sectors, varying between −3 % and 148 %. A few airports, such as the Frankfurt Airport Landebahn Nordwest, a landing platform, were completed within budget and within time, while the majority of airports, such as the Kassel-Calden Airport or the Munich Airports 1 and 2, faced cost overruns. The BER is an extreme case in the transportation sector with current estimate of 99 % cost overrun and completion in 2017, 5 years later than originally planned.

Bridges, Waterways, Ports, and Tunnels

In the sectors of bridges, waterways, ports, and tunnels, average cost overruns for finished and still unfinished projects are 11 %, 68 %, 80 %, and 144 %, respectively. Of two bridges, one had a cost overrun of 25 % and one was 2 % below the planned budget. Two finished waterways have an average cost overrun of 57 %, while the currently constructed Jade-Weser-Port is already at almost double the initially planned €480 million costs, and the end of construction, originally scheduled for 2011, is postponed to 2016. Ironically, the smallest transportation project, the maintenance of the Alter Elbtunnel St. Pauli–Steinwerder, planned to cost €15–17 million, is a staggering 364 % over budget, while the largest one, the Tiergartentunnel in Berlin, planned to cost more than €5 billion, was finished with a cost overrun of only about 10 %.

Buildings

In the building sector, the average cost overrun for finished projects was 51 %, including the construction of new buildings and investments in maintenance of buildings. Projects included are the construction of ministries, public libraries, embassies, theaters, and museums. Rigsrevisionen, an independent Danish public auditor, looked at 49 public building projects in Denmark and found that 39 of 49 projects were within budget or not more than 10 % cost overrun, and 10 projects were more than 10 % over budget (Rigsrevisionen 2009). By comparison, projects in Germany have performed worse. Of 51 finished building projects, only 16 were below 10 % cost overrun, and the other 35 were between 10 % and 425 %.

Some public building projects received plenty of media attention, such as the Hamburger Elbphilharmonie, which became associated with bad public management. Another example is the new headquarter of the European Central Bank (ECB) in Frankfurt. The ECB was planned to cost €850 million in 2008 and end construction in 2011. In 2014, the building was finished with an estimated cost of €1.3 billion (FAZ 2014), a cost overrun of 48 % (inflation-adjusted). The project was blamed on complacent European politicians, as “oddly inappropriate” in the wake of European austerity policy (Der Spiegel 2013a). But there are also successful examples in the building sector. In 2014, for example, the new Ministry of Interior in Berlin was finished on time and almost 8 % below the €208 million budget.

Sectors with Medium Cost Overruns: Defense and Energy

Acquisition of defense equipment is generally in the medium range of cost overruns with 85 % for finished projects and 26 % for yet unfinished ones. However, only three out of eight projects in the sample can be considered finished. Cost overruns in this sector have become a controversial topic in Germany, because the increased total cost is massive. The average defense acquisition project in the database has a volume of €8.1 billion, with 23 % of total additional costs across all sectors for only 8 out of 165 projects (see Table 2.2).

When she took office in 2013, German Defense Minister Ursula von der Leyen intended to reform the German military (Bundeswehr) to deal with sunk costs and equipment shortages. A study by KPMG (2014) examined nine defense acquisition projects in Germany with a €50 billion investment volume and found the German bureaucracy was insufficiently equipped for the complexity of international defense contracts with big arms firms. The most costly of all the cases in this study is the acquisition and integration of the Eurofighter, a fifth-generation multirole jet, into the German military. It was estimated to cost €14 billion in 1987. Originally intended to acquire 250 fighter jets until 2014, the planners downsized the project to 143 fighter jets, scheduled to be fully delivered in 2018, with a cost overrun of 11 %.

In the energy sector, the average cost overrun is 91 %, divided into nuclear with 164 % and offshore wind parks at 18 %. Nuclear reactors, built supported by generous subsidies from the 1960 onwards, were technologically challenging projects, intended to substantially transform Germany’s electricity infrastructure. Six nuclear reactors had an average cost overrun of 187 %. In the wake of the “Energiewende” (energy transition), Germany intends to substantially reengineer its electricity infrastructure, with offshore wind intended to become a crucial pillar. Germany expanded its offshore wind capacity with 8 operational wind farms, 4 under construction, and 30 more planned or proposed. Offshore wind parks had particular problems of cost overrun and time delays because of technological challenges in grid construction and expansion. But the comparatively low cost overrun of 18 % shows that offshore wind parks are easier to plan because they are technologically more standardized.

Sectors with High Cost Overruns: ICT

The sectors with highest average cost overruns are energy and ICT, with cost overruns for finished projects of 131 %. Taleb (2010) and Flyvbjerg et al. (2011) have found this sector vulnerable to the "black swan" risk, that is, a cost overrun of over 200 % that hits one out of six ICT projects. The sample in this study found two "black swans" within a sample of ten projects as well. Mertens (2012) examined a number of cases in Germany and found that Germany seems to perform worse than its neighbors because of regulative barriers and the inefficient allocation of expertise due to the federal structure and underpaid public IT experts compared to the private sector.

An example for a "black swan" is the Gesundheitskarte, a nationwide electronic health service card. The card was intended by the federal government to make health-care provision more efficient. In 2005, it was scheduled to become effective in 2006 and cost €1.6 billion. After it became repeatedly delayed, its roll out was started in 2011 and already cost €5 billion. It is yet not fully rolled out and accepted by the German population, partly due to concerns about privacy. The key challenge was the step from development to implementation. Many doctors criticized the lack of a business model and unclear responsibilities (Mertens 2012).[6] Two tricky cases are Toll Collect, a truck fee system, and FISCUS, a failed nationwide taxation IT system. In the database, they are listed with cost overruns of

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[6] In addition, there are a few factors about the Gesundheitskarte that this study did not examine in depth. The key challenge was that the implementation clashed with many special interests that have to do with the particularities of the German national health-care system.

about 100 %, but their additional challenge was litigation charges that amount to €5–10 billion in economic damage. Because the outcome of the legal processes is yet unclear, and the estimates of losses vary, this study did not take into account what are likely significant further additional costs. But despite time delays and cost overruns, the Gesundheitskarte and Toll Collect were pioneering ventures that could turn out attractive. In the ICT sector, as well as in the energy sector, the German state took on transformative projects that entail first use of technology on a large scale.

Project Size

The conventional view is that time and cost overruns are a particular characteristic for very large projects, as the planning and management of such projects is difficult due to the complexity increasing with multiple stakeholders (Sovacool and Cooper 2013). The findings in Table 2.4, however, show that while finished "large" projects have on average a cost overrun of 49 %, "medium" projects had 45 % and "small" projects had 86 %. In other words, the scale of a project is influential, but not the only explanation for cost overruns, since smaller projects also have significant cost overruns.[7]

Table 2.4 Cost overruns and project size

	Under construction		Finished		Total	
Project size	Cost overruns (%)	Sample size (*n*)	Cost overruns (%)	Sample size (*n*)	Cost overruns (%)	Sample size (*n*)
Large	37	20	49	27	44	47
Medium	35	20	45	56	42	76
Small	53	10	86	32	78	42
Total	**39**	**50**	**57**	**115**	**52**	**165**

Note: Projects are "small" if they were planned to cost less than €50 million, "medium" if they were planned for more than €50 million and less than €500 million, and "large" if they were planned for more than €500 million.

[7] Data availability bias might explain this result. There seemed to less media coverage of smaller projects if they were not particularly problematic. Most of the data entries are hence from one publication, the "Schwarzbuch" by the Bund der Steuerzahler, while the sources are more varied for medium or large projects.

Table 2.5 Cost overruns and PPPs

Sector	Cost overruns (%)	Sample size (*n*)
Building		
Non-PPP	46	73
PPP	0	5
ICT		
Non-PPP	145	8
PPP	46	2
Roads		
Non-PPP	33	17
PPP	7	6

Public–Private Partnerships

PPPs often perform better than projects by public procurement.[8] However, a PPP is difficult to compare with conventional public sector projects. This study, if possible, applied the same standards to PPPs as to conventional projects. PPPs often face problems similar to non-PPPs. PPPs in the building, the road, and the ICT sectors perform significantly better than non-PPPs, with average cost overruns below zero compared to 46 % for public procurement, 7 % compared to 33 %, and 46 % compared to 145 %, respectively (Table 2.5).

Even large PPPs seem to deliver success. For example, Herkules is an IT system for the German military (Bundeswehr), the largest PPP project in Europe with a planned cost of about €7 billion from 2006 until 2016. Handelsblatt (2010) criticized Herkules as a "debacle" because they reported additional costs of €700 million. However, if adjusted for inflation, Herkules cost about 7 % less than originally planned. Despite this success, Defense Minister Ursula van der Leyen announced to cancel the contract with IBM and Siemens in 2017 because an internal solution would make "more sense economically" (Handelsblatt 2014).

[8] An OECD report (2012) defines PPPs as "long term agreements between the government and a private partner whereby the private partner delivers and funds public services using a capital asset, sharing the associated risks."

But PPPs can have particular problems as well, such as cost externalization. For example, the Warnowtunnel, a private toll road including a tunnel, was the first PPP in Germany. According to the plan, a consortium of banks was supposed to invest €219 million, including a 12 % subsidy by the European Union, for a duration of 30 years. During the construction phase, significant cost overruns occurred, because the contractor took advantage of unclear regulation and the contract allowed to externalize the cost to the public or by increasing the toll rate. In the end, traffic was 65 % below forecast and the consortium declared the project unable to repay the investment. To avoid insolvency, the consortium wrote off equity and extended the contract for 20 years before it will be transferred to the City of Rostock.

Citizen Protest and Impact on Cost and Time Overruns

Citizen protests are associated with a higher cost overrun of 69 % compared to 44 % in projects without protests, but to a lesser degree with a time overrun, 71 % compared to 66 % (Table 2.6). The causal relation is unclear, however. Protests predominantly took place in sectors such as energy (nuclear) and defense, which were particularly politicized. In the wake of Stuttgart 21, the journalist Dirk Kurbjuweit coined the term "Wutbürger" (angry citizen) for protest against government projects allegedly disregarding citizens' interests (Spiegel 2010). Apart from political issues, citizens usually protest if they see the project affecting their life (e.g. road projects close to local communities) or if the projects are present in the media as waste of taxpayer's money.

Table 2.6 Citizen protests and cost and time overruns

	Cost overruns (%)	Average time overrun (%)
No protests	44	66
Protests	69	71
Total	**53**	**67**

Table 2.7 Regional variation in cost overruns

Bundesland	Cost overrun (%)	Sample size (*n*)
North Rhine-Westphalia	108	19
Hessia	58	17
Lower Saxony	32	5
Brandenburg	34	5
Baden-Württemberg	33	9
Bavaria	34	24
Berlin	24	10
Thuringia	13	5

Regional Variation in Germany

Between the German regional states (Bundesländer), the cost overruns vary widely (see Table 2.7). For eight Bundesländer, the database had five or more cases of finished projects, excluding projects abroad (e.g. the German Embassy in Washington, DC) and projects where the regional jurisdiction is unclear (e.g. defense acquisitions). Because the responsibility (federal, state, local) for project planning was not a variable included in this study, this section does not depict planning *performance* of the federal states, but only the mere fact of *location*. Cantarelli et al. (2012) have done this previously, looking at regional differences within the Netherlands. The causal factors are unclear, but differences can probably be explained by either geographical differences (e.g. mountainous vs. flat) or differences in planning capacity.

The state of North Rhine-Westphalia had the highest average cost overrun of 108 % for 19 finished projects (see Table 2.7). By contrast Berlin has only 24 % average cost overrun despite its reputation as a city of bad financial planning because of massive mismanaged projects such as the infamous BER. As the capital city of Germany, cost increases such as the recent €93 million additional cost for the maintenance of the Staatsoper Unter den Linden, an opera house, receive plenty of media attention.[9]

[9] The Staatsoper, scheduled to finish in 2015, increased in cost at the time of the data collection. Like with other projects, it may have increased even further since this study finished data collection by the end of 2014.

The German South has lower cost overruns, with Bavaria at 34 % and Baden-Württemberg at 33 % from 24 to 9 finished projects, respectively. Baden-Württemberg has only 4 out of 13 total (including unfinished) projects with cost overruns of over 30 %, despite Stuttgart 21, the controversial rail-restructuring project. Bavaria seems to plan its transportation projects well: 17 such projects (including roads, rail, airport, and bridge) are at only 22 % compared to 40 % national average. In Thuringia, cost overruns were only 13 %, but all cases were roads, which has a comparatively low average cost overrun of 28 % across all Germany. An example is the fast-track highway Nürnberg-Ebensfeld-Erfurt shared with Bavaria (which is scheduled to finish in 2018), which cost €5.3 billion and had a comparatively low cost overrun of 13 %.

Top Outperformers and Underperformers

The top ten performing and underperforming projects offer additional insights. Table 2.8 lists the ten projects with the highest cost overrun. These flop ten projects alone account for 22 % of total additional costs of €47 billion. They include two ICT projects: Inpol (491 %), an ICT system

Table 2.8 Infrastructure projects with highest cost overrun

Flop ten projects	Cost overrun (%)	Additional costs (million €)
Schneller Brüter Kraftwerk Kalkar (nuclear)	494	2326
Inpol Neu BKA (ICT)	491	119
Bischofsresidenz Limburg (building)	425	25
Alter Elbtunnel St. Pauli–Steinwerder (tunnel)	364	71
Thorium-Hochtemperaturreaktor Hamm-Uentrop (nuclear)	336	3082
Bonner Kreuzbauten (building)	251	99
Bonner Schürmannbau (building)	245	497
Gesundheitskarte (ICT)	208	3376
Saarland Universität Bibliothekserweiterung (building)	142	18
Hamburger Elbphilharmonie (building)	136	499

for the Bundeskriminalamt (BKA), the federal anticrime agency, and the Gesundheitskarte (208 %), the electronic health card. The list also includes two high-technology nuclear reactors, the Schnelle Brüter (494 %) on top of the list and the Thorium-Hochtemperaturreaktor (336 %). A tunnel maintenance project and five buildings complete the list. For example, the Bischofsresidenz Limburg (425 %) was initially supposed to amount to 147 m^2 in size but ended up as a 2000 m^2 complex with additional features such as private rooms for the bishop, an atrium, and a chapel—which was blamed on the bishop's decadence and demands for luxury (Der Spiegel 2013b).

Some projects were planned very well. Table 2.9 shows that all of the top ten performing projects are in the building and road sector, which have comparatively low overall cost overruns. Five out of ten were PPPs. The best performer is an extension of the fast-track highway A8 Augsburg-München. It is a part of a larger project, the construction of the A8 Augsburg West–München Allach, and one of four first road-PPPs established by the German government.

Comparison with Transnational Studies

Compared with transnational studies of projects in the transportation sector, Germany performs a bit worse (see Table 2.10). Overall, Germany is 5 % points below the world average of 24 %. In the rail sector, Germany

Table 2.9 Best cost-performing infrastructure projects

Top ten projects	Cost overrun (%)	Additional cost (million €)
A 8 Augsburg–München, 6-streifiger Ausbau (road)	−23	−70
A 3 Autobahndreieck Würzburg-West (road)	−15	−13
B19 Immenstadt-Kempten (road)	−13	−15
Umweltbundesamt Dessau (building)	−11	−8
A5 Malsch–Offenburg (road)	−8	−84
Bundesinnenministerium Berlin (building)	−8	−17
Bundesautobahn 20 (road)	−8	−153
Klinikneubau Hochtaunuskliniken (building)	−6	−12
A8 Augsburg West–München Allach (road)	−6	−43
Bundespolizeifliegerstaffel und Polizeihubschrauberstaffel (building)	−5	−2

Table 2.10 Comparison of findings with relevant transnational studies

	Germany		The Netherlands		Northwest Europe		World	
	Average cost overrun (%)	Sample size (*n*)	%	*n*	%	*n*	%	*n*
Road	28	19	19	37	21	315	20	537
Rail	33	6	11	26	22	90	34	195
Tunnel/bridges	23	4	22	15	32	54	33	74
Total	29	29	17	78	22	459	24	806

Source: Infrastructure Project Database, Cantarelli et al. (2012).

is 1 % point below the world average with 33 %, but worse than the rest of northwest Europe[10] (22 %) and the Netherlands (11 %). In roads, Germany is 8 % points worse than the world average of 20 % (northwest Europe: 21 %, the Netherlands: 19 %). In tunnels and bridges, Germany is 10 %, 9 %, and 1 % points better than the rest of the world (33 %), northwest Europe (32 %), and the Netherlands (22 %). In the public IT sector, Germany has a very high 131 % average cost overrun compared with Britain's 31 % (Whitfield 2007). In nuclear energy, Germany is with 187 % average per power plant worse than the transnational average of 117 % (Sovacool et al. 2014a).

Explanations

In the literature, technological, political-economic, and psychological factors explain the phenomenon of time delays and cost overruns in large-scale projects in general. Many of these factors also help to explain some cases of poor planning and infrastructure management in Germany. For specifically the German case, three factors might be supplemental explanations: governance factors, geographical differences, and a pioneer risk attitude.

[10] Great Britain, Belgium, Ireland, the Netherlands, Luxembourg, northern Germany, northern France, Denmark, Norway, Sweden, and Iceland.

Governance factors lead to differences in the allocation of risk and competition for lower cost. Types of project delivery are a governance factor. For example, PPPs vary from non-PPPs; however, they still often have the same problems as conventional projects. This study suggests that more successful examples had a better allocation of risk of additional costs and incentives for good cost performance (see Koppenjan 2008). For example, the West Rail in Hong Kong was a completely public project, planned to cost €8 billion. It finished on time and 27 % below budget. Throughout the project stages between 1998 until its completion, the budget was continuously downgraded, because it had effective cost control, continued value engineering, and lower prices resulting from a competitive market (OMEGA 2007).

Furthermore, the results of this study confirm the finding of Cantarelli et al. (2012) that cost overruns vary across geographies. First, within Germany, the observed cost overruns in eight Bundesländer varied greatly between 13 % and 108 %. In addition, when comparing the Germany-based sector analysis with other countries, differences between Germany and the transnational data emerge. These findings suggest that infrastructure planning and management is influenced by the specific political-economic context in which the decisions are made and implemented. More research is needed to understand what the exact reasons are.

Finally, costs and time overruns seem to be high in sectors at the early state of technological development. As there is no benchmark for such pioneer projects, the pioneer takes a higher risk of cost overruns than second- and third-movers. In the energy sector, for example, Germany built a lot of subsidized nuclear power reactors in the 1960s and 1980s, while nuclear was an infant industry. While risky and costly, Germany pioneered nuclear technology and significantly reengineered its energy infrastructure. Currently, too, Germany has another transformative restructuring project of its energy infrastructure (Energiewende) with more large-scale, new technology projects to follow. More examples are in the ICT sector. Toll Collect and the Gesundheitskarte were pioneering ventures without previous experience that would substantially transform Germany's transportation and health infrastructure.

Flyvbjerg et al. (2003, 16) said that "no learning seems to take place" in planning of large-scale projects looking at the last 70 years. This study finds that the problem of public planning is that experience is not sufficiently institutionalized; therefore, each new large project planned is a new "pioneer" that does not build on previous experience. This study claims that pioneer risks are a problem and learning is possible if sufficiently institutionalized and incentives for public planners are right.

Recommendations

The key recommendation of this study for the governance of large-scale projects is "sector-based benchmarking." In the private sector, benchmarking means the comparison of industrial processes based on performance criteria to develop "best practices." The German government should do the same. The idea of benchmarking in public infrastructure planning entails three steps: a public megaprojects database, a reference class forecasting (RCF) model for different sectors, and a contract model based on microlevel risk allocation and cost control.

Introduce a Public Megaprojects Database

Germany should introduce a publicly available database about large-scale projects to provide transparency, intended to increase the incentive for the project planners to stay on budget, because of the higher chance of public scrutiny if they do not. The database should include all projects publicly financed and projects that receive direct or indirect subsidies and collect annual data on cost, status of completion, and other relevant metrics. Such a database should make benchmarking possible for private investors to properly plan project finance and enable learning curves in specific sectors. The UK has pioneered this approach by introducing the "Major Project Authority" (MPA). The MPA maintains a database of almost 200 infrastructure projects with a total volume of about €677 billion, regularly publishing reports and key data (UK Government 2015). It has the mandate to request information, evaluate planning, and intervene if deemed necessary.

Introduce Sector-Specific Planning Models

Public project planners should introduce RCF. RCF is a method intended to reduce optimism bias, developed by Kahnemann and Tversky (1979a, b) and applied to transport infrastructure planning by Flyvbjerg and COWI (2004) and Flyvbjerg (2008). On the basis of the aforementioned database, the MPA identifies relevant reference classes, categorized in sectors (e.g. road and rail) and subsectors (e.g. highways, trunk road, local roads). It then establishes a probability distribution based on past cost overruns and other metrics for the selected reference classes. New projects are then compared to those reference classes, and the MPA calculates "uplifts" based on the average cost overrun for the project class.

Microlevel Risk Allocation Contracts

A potential problem with RCF is that planners view the "uplift" as the real budget instead of the contingency, which they are not supposed to use. This could lead to bad incentives. Therefore, detailed risks assessments for each step in the project phase prior to project start are necessary. Such risks assessments involve comprehensive planning of each project phase and require the allocation of a risk for each microlevel project step, based on experiences of previous projects. The planning for additional, yet unforeseen, complications in large and complex projects need to be continuously updated to identify cost risks in advance. This helps to avoid that project managers simply convert additional risk allowances into their budget calculations. The key challenge for project planners is to be continuously on alert to mitigate cost escalations.

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3

The Elbphilharmonie Hamburg

Jobst Fiedler and Sascha Schuster

Introduction

The Elbphilharmonie scored ninth on a list of the ten most expensive skyscrapers ever built (MMO 2014). With its southeastern corner at 110 m, it marginally enters the skyscraper category but is in the prominent company of Taipei 101, Burj-al-Khalifa, or One World Trade Center. Alas, the city of Hamburg never desired a position in this ranking. When the city signed the construction contract in 2006, it planned for total project costs to be €351.8 million and to open the Elbphilharmonie in 2010 (Bürgerschaft der Freien und Hansestadt Hamburg 2014).[1] Over the following years, costs progressively escalated, while project progress was delayed. It became a planning disaster, with total project costs rising to €560.8 million by 2008 (Bürgerschaft der Freien und Hansestadt Hamburg 2008c, 5; B/PUA 2014, 25).

In 2011, the project was on the brink of failure, as several contract amendments had not successfully limited further cost escalations. Construction stopped for over 18 months. After a long, informal negotiation process, decision-makers achieved a complete project turnaround in 2013. For this

[1] Source from here on cited as B/PUA 2014.

G. Kostka, J. Fiedler (eds.), *Large Infrastructure Projects in Germany*,
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amendment, decision-makers did not only try to satisfy the construction company's run-up financial claims but also renegotiated the project governance setup. Project schedule and budget have remained stable since: As of Spring 2015, the Elbphilharmonie is planned to open in January 2017 at total project costs of €865 million (FAZ 2015; Neuordnungsvereinbarung 2013, 15).

As was pointed out in Chap. 1 in this volume, large public infrastructure projects often face time and cost overruns, and scholars have studied reasons for the "curse of the megaproject" in small- and large-sample studies (Flyvbjerg 2007, 2008, 2009). The Elbphilharmonie project represents an extreme case: It is a signature project that faced cost escalations of 145.9 %, up to a multifold of planned costs and an opening delay of 7 years.[2] This justifies an individual investigation.[3]

We find that the largest share of cost overruns was an unavoidable result of decisions and external influence factors in the projects development phase before construction contract signature in late 2006 (ex ante), with weak Hamburg-internal oversight enabling overoptimism and strategic deception. A lack of detailed planning, insufficient risk management, an overambitious tender schedule, and public pressure led to a premature lump-sum contract signature with unrealistically low cost assumptions when measured against the value of the envisaged building.[4]

We identify three intertwined project governance decisions partially made very late in the tender process as important drivers of further cost escalations: The external governance setup in which the city's project management agency served as main interface between the architects and the construction company, the choice of a forfeit model instead of an investor model to finance construction, and the parallel processing of planning and construction. Each individual decision's entailed risk was felt manageable, but project leaders drastically underestimated their interdependency. They impacted project performance devastatingly.

[2] As signature projects, we understand projects with unique characteristics: pioneering new technologies, combining functions in a special way, or symbolic meaning.

[3] This is a single-case, interpretative case study. Our sources are one interview conducted in Hamburg on 09.01.2015, one telephone interview conducted on 12.02.2015, newspaper reports, academic articles, publically available official documentation, and published expert opinions.

[4] Budäus (2013: 8) speaks of a "point of no return" for parliaments.

While we argue that cost escalations had after contract signature (ex post) been unavoidable, we also find that, through well-run project management, cost escalations could have been mitigated before the project turnaround in 2013.

This chapter proceeds as follows. We first describe the Elbphilharmonie's project planning phase from the idea in 2003 to contract closure in 2006, highlighting key developments, explaining decisions, and showing early path dependencies. We illustrate the role of public expectations and pressure in this phase, which led to flawed strategic decisions, embedded in an internal governance setup with limited oversight possibilities. We introduce the concept of Rightly Foreseeable Costs to distinguish between unavoidable cost escalations and potential for later cost mitigation.

We then select the mentioned three critical governance decisions and describe their impact potential in detail. After that, we portray the project developments until the turnaround in 2013, point out missed opportunities to mitigate cost escalations, and give an estimate for potential cost reductions through better project management.

We conclude by presenting lessons learned from the Elbphilharmonie project and give some recommendations for better large public infrastructure project management in Germany.

Project Milestones Until Contract Closure

2000–2003 Initial Idea and Early Path Dependencies

In February 2000, the government of Hamburg, the Senate, adopted the master plan for "HafenCity," an ambitious city development project around the harbor areal premises on the north side of the river Elbe (Hafencity Hamburg 2000). One of the prominent sites was Kaispeicher A, a post–World War II warehouse on a triangularly shaped land tongue in the middle of the river. As part of "HafenCity," an office tower was supposed to replace the old storehouse. Unrelated to the project, but around the same time, public figures in Hamburg identified the need for a new, large concert hall but were cautious to develop plans. As in the wake of the new economy crisis of the early 2000s, another office tower seemed one too much to the real estate developer Alexander Gerard, he designed a concept to build the new concert hall on top of the old warehouse at Kaispeicher A (Hamburger Abendblatt 2013, 2f).[5]

Gerard suggested finding a private investor to construct a double-use building at the Kaispeicher A. The core of the building would be public, consisting of a large and a small concert hall, necessary backstage areas, offices, and an open plaza. A "commercial envelop" would surround the core: investor-owned areas, consisting of a hotel, gastronomy, a parking garage, and private apartments. The commercial envelope should generate enough profit to satisfy the investor and simultaneously subsidize the core's construction. The city would endow the investor with the lot and collect private donations. Gerard envisioned that no further public funding would be required. In March 2003, Gerard requested a visualization study by Swiss architects Pierre de Meuron and Jacques Herzog from Herzog & de Meuron (HdM). The three had studied architecture together and were personal friends. While HdM worked on the study, Gerard secretly introduced his idea to selected politicians, artists, and prominent people of Hamburg. HdM, famous worldwide for ambitious projects, developed the design of a new glass-and-steel "wave" on top of the brick-and-stone warehouse. In June 2003, with a wooden-and-plastic model at hand, a construction cost estimate of €75.3 million, and a total project cost estimate of €116.3 million, Gerard called a press conference. The concept quickly gained wide support and enthused the city's public (Abendblatt 2013, 2f; B/PUA 2014, 21, 142).

In December 2003, the Senate investigated options for the newly called "Elbphilharmonie" project and subsequently dropped the original plans for an office tower at Kaispeicher A. HdM's design was informally accepted without an open bidding process. By the end of 2003, there were no construction plans or sound financial calculations, only a raw sketch of the building design. But Gerard had already created three key path dependencies for the project: First, the idea of a public core, cross-financed by a commercial envelope. Second, the desire to make it Hamburg's new landmark, designed by world-famous architects with a personal connection to Gerard, which would later have a significant

[5] From here on cited as Abendblatt 2013.

Construction Costs	This refers to the pure cost of construction of the Elbphilharmonie, which is virtually equal to the value of the construction contract and its amendments between Hochtief and Hamburg.
Additional Costs	These costs mark all non-construction related project costs, such as planning costs incurred by the architects, costs for the project management ReGe, financing costs, taxes, and fees.
Total Project Costs	These are the complete project costs, construction and additional.
Notes	Due to the cost misrepresentation in different estimates, the presented data cannot be verified beyond doubt, as strategically, project developers took different budget positions out at different times to reduce the cost estimates. Thus, cost estimates have to be taken with some precaution. Also, the final costs of the Elbphilharmonie and with that the burden on taxpayers cannot be marked before the sale of the commercial envelope in 2030.

Fig. 3.1 Clarification of different cost estimates

impact on the planning contract. Third, the belief that construction would not strain Hamburg's budget (Budäus 2013, 12f) (Fig. 3.1).[6]

2004—Project Development and Internal Governance Setup

Early in 2004, Gerard, intending to become the lead investor, asked Hamburg to install a project coordinator as a single point of contact on the city's side to smoothen project development and negotiation processes, instead of having to talk to the various partaking city agencies himself

[6] Budäus mentions that path dependencies can also be desirable to a certain extent, as they reduce complexity.

(Abendblatt 2013, 3). In May, Hartmut Wegener, an experienced project manager, agreed to do the job under two conditions.[7] First, he wanted to report directly to the First Mayor of Hamburg, Ole von Beust. He made the case this would enable a quicker, more flexible management outside of the sluggish city bureaucracy. Second, he wanted a private but publically owned company for project management—the Projekt-Realisierungsgesellschaft mbH (ReGe).[8] ReGe had already managed several construction projects for the city. It employed 22 personnel of which 6 staff members were dedicated to the Elbphilharmonie full time. As head of the firm, Wegener favored a LEAN approach to managing the project (Wegener and Uhl 2014, 55).[9]

Gerard tried to convince banks to invest in the project but could not provide substantial securities as a private investor. The Kaispeicher lot could have served as security, but Hamburg was unwilling to transfer ownership before having a guarantee for construction (B/PUA 2014, 21, 143–144). With such high risk resting with the investor, Gerard did not find a bank. Also, Wegener and Gerard were not able to work well together and repeatedly got into conflicts. Gerard finally gave up. In late 2004, Hamburg bought him out of the project and entered the existing contract with HdM (Abendblatt 2013, 4; B/PUA 2014, 144–145).

Thereby, ReGe's role increased dramatically. From the agency only managing the stakes of the city in a public–private project, it became its overall developer, planner, and manager. The core elements of the Hamburg-internal governance setup were determined. The public company, led by

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[7] While experienced in handling large construction projects, Wegener did not have special credentials in highly complex, multiuse, above ground-level projects.

[8] B/PUA identifies Wegener as the head of ReGe and project coordinator as one of the main decision-makers responsible for the Elbphilharmonie's cost and time overruns. Wegener denies these accusations. This chapter is not an investigation into ReGe's internal dynamics, nor is its aim to assign personal blame. We avoid attributing decisions to individuals, because from our goal to improve project management, focusing on individual's mistakes blurs the scope for analyzing systematic and systemic shortcomings. Budäus (2013: 10) also mentions that explaining cost overruns through personal factors limits the opportunities for general improvement.

[9] By LEAN management, Wegener meant a small core team working on the project, hiring external knowledge for specific tasks and outsourcing others. Unfortunately, the analysis of the impact of the LEAN management approach on project performance is not in the scope of this chapter. This would certainly be a useful endeavor, since it could be argued that this management style may not be suitable vis-à-vis an approach resting on constant management capacity.

a single, powerful project coordinator would hitherto develop the project. ReGe would report directly to the First Mayor and worked closely with his office but was only loosely linked to the city's administrative processes (Interview from 09.01.2015; Telephone Interview from 12.02.2015).

2005—External Governance and Tender Offer

Early in the year 2005, ReGe extended the contract with HdM, making them the Elbphilharmonie's general planner. The external governance setup, the relationship between the architects, the city, and the prospective construction company, was unusual: In complex construction projects, it is common to subject the planner to the construction company from the stage of execution planning on to ease communication and release synergies (B/PUA 2014, 114–115).[10] Construction companies then often intervene in the planning process, seeking rents from low-quality execution and limiting the architects' influence on construction. In this project, ReGe would serve as the interface between HdM and the construction company. By that, the city intended to satisfy the high standard of the world-famous architects (B/PUA 2014, 113–118).[11]

Hamburg invited Europe-wide tenders and started negotiations with six bidders on the basis of a feasibility study finished in July. The selected company should build the Elbphilharmonie and operate the commercial envelope (parking garage, hotel, and apartments). From lease and sale profits, it should cross-finance the concert hall, invoking minimal financial input from the city. The feasibility study predicted total project costs of €186.7 million. The commercial envelope, financed by the private investor, was estimated at €69.7 million and the public core at €117 million. The costs for the public core would mainly be provided by private donations (€30–35 million) and the city (€77 million). The private investor would be expected to cross-finance the remaining €10 million out of his profits (B/PUA 2014, 30). Private donations came quickly.

[10] Budäus (2013: 13) mentions that a separation of planning responsibility is a disadvantageous arrangement in a complex project.

[11] Neither the official report by the Parliamentary Inquiry Commission nor our interview partners could beyond doubt clarify whether this setup was desired by the city, the architects, or both.

In fall, a single donation by a renowned Hamburg entrepreneur provided €30 million, another €10 million each came from two different private sources. The city created the Stiftung Elbphilharmonie (Elbphilharmonie Foundation) to collect more private donations. With the sale of minted coins, auctions, and other public relations activities, the foundation generated over €67 million by 2008.

During the year, after the feasibility study (and continuing in 2006), the Elbphilharmonie still experienced some dramatic design changes. For example, deep into the tender process, the height between floors was reduced to enable more hotel rooms and apartments, thereby increasing a possible profit margin (Abendblatt 2013, 5; B/PUA 2014, 65–69). The public got confused, as newspapers reported repeated cost reestimations due to, sometimes fundamental, design changes. Some new estimates seemed to contradict previous ones. They suffered from a lack of clarity of what was actually included—was it total project costs, pure construction costs, or the city's share in these costs (Abendblatt 2013, 5)?

In 2005, the city introduced an external governance setup in which ReGe would take on an important interface function. The resolve with which wealthy citizens supported the project fueled public support, fostering path dependencies (Abendblatt 2013, 6). When the tender process began, design elements were again changed several times to satisfy Hamburg's and the investors needs in profitability of the project. As planning and tender process progressed, cost estimates repeatedly increased.

2006—Ownership Structure and Contract Closure

The tender process continued in 2006 with two remaining bidders. Estimated total project costs were at €228.6 million in April 2006, entailing €143.7 million for the public core and €84.9 million for the commercial envelope (B/PUA 2014, 31). In May, ReGe formulated a total project cost target of €210 million. With increasing cost figures, public support began to wane. Project leaders in ReGe and the Mayor's Office wanted to achieve a symbolic but significant cost reduction to ensure continued public support (Abendblatt 2013, 6f).

Construction company Hochtief suggested changing from the hitherto used investor model—in which the private investor would finance and operate the commercial envelope and give the concert hall to the public upon completion—to a forfeit model.[12] Here, Hamburg would take ownership of most of the commercial envelope—parking garage, gastronomy, and hotel (but not including the apartments).[13] The construction company would receive loans from the bank, bill Hamburg for construction progress, but sell this claim for compensation back to the loan-giving bank. This made Hamburg effectively the bank's creditor. As a public entity, it received better interest rates than a private firm. The resulting savings in interest payments reduced the projected cost by around €10 million (B/PUA 2014, 148–160; Budäus 2013, 42–43).[14] Hamburg, now the owner of the commercial envelope, planned to lease it to the construction company for 20 years after end of construction and use the income to cover interest payments. In 2030 (given a planned opening in 2010), the city would sell the commercial envelope and use the revenue to pay the remaining debt. The forfeit model seemed attractive not only due to the envisaged cost reduction but also since it promised higher control over construction execution and operation of a then city-owned commercial envelope. If, for example, a tenant in the commercial envelope went bankrupt, it would be Hamburg, not the private investor, who could select the new tenant. That promised a higher operational standard (Telephone Interview from 12.02.2015). With more control, less cost, and only changed timing and origin of cash flows, the forfeit model seemed convincing (Interview from 12.02.2015). Hamburg went for it.

In September, Hamburg awarded the project to Hochtief. Competing bidder STRABAG had not handed in a final offer but instead threatened legal action. They claimed that, due to the deficient planning stage, they could not make substantiated cost estimates and make an offer only if charging a considerable risk premium of about €100 million (B/PUA

[12] Hochtief represented the investor consortium Adamanta as the official bidder in the tender process. Apart from Hochtief, Adamanta included a financial investor and potential tenants for the commercial envelope. We speak of Hochtief instead of Adamanta, since it was the major representative of stakeholder interests on Adamanta's side.

[13] Apartments stayed under ownership of Adamanta's subinvestor Skyliving, whom Hamburg would charge for the apartment construction (B/PUA 2014:10).

[14] Simplified description.

2014, 75–76).[15] Hochtief handed in an offer and threatened legal action themselves if negotiations were not continued exclusively with them. Facing progress-hindering legal threats from both bidders, Hamburg resolved the situation by awarding the Elbphilharmonie contract to Hochtief, while promising other contracts worth €3 million to STRABAG (Interview from 12.012.2015). Still, Hochtief's offer of €257.4 million was considered slightly too high and revised again. The final package of contracts was signed in December. The lump-sum agreement for the construction costs was then worth €241.3 million, of which €142.3 million would be provided by the city; the rest was private donations and cross-financing (B/PUA 2014, 75–77). Adding to this the additional costs of €110.5 million, total project costs were at €351.8 million.

The decision for the forfeit model, increasing external pressure, and the hasty tender process were core developments of the project in 2006. The cost reduction achieved through the forfeit model was a signal to the public: The city was committed to building the Elbphilharmonie—at reasonable cost (Abendblatt 2013, 6–7). With contract signature, the mix of decisions made and influence factors had formed the setup that would lead to dramatic cost overruns (Fig. 3.2).

Ex ante Cost Underestimation

The weak oversight over ReGe's work and the specific project environment led to significant cost underestimation. It enabled optimism bias and strategic misrepresentation of costs in the form of insufficient risk management and unfinished planning. Both enablers and the form of cost underestimation deserve closer investigation.

Outside Pressure and High Expectations

Since Gerard in December 2003 had published his ideas for the Elbphilharmonie, Hamburg was eager to see the project realized. Project leaders and the public were willing to accept that a project as ambitious

[15] Since we do not see a change in the tender process to potentially having resulted in better project delivery, we do not analyze it closer. A detailed reconstruction can be found in B/PUA (2014: 63–82).

Cost Estimate	Construction Costs	Additional Costs	Total Project Costs	Comment
Project Description Gerard November 2003	€75.3 million	€41 million	€116.3 million	
Feasibility Study July 2005	€151.2 million	€35.5 million	€186.7 million	The building had been enlarged by around 50% from the previous estimate; the city's share of costs was estimated at €77 million
"Second Cost Estimate" April 2006	unknown	unknown	€228.6 million	
Contract December 2006	€241.3 million	€110.5 million	€351.8 million	The city's share of costs was estimated at €142.3 million

Sources: B/PUA 2014, 20-62; own estimates

Fig. 3.2 Selected cost estimates up to contract closure

as the Elbphilharmonie would not come free of charge, but in the run-up phase between late 2005 and late 2006, project costs seemed to explode. While project internals were aware that planning and design changes would lead to cost increases, those not involved could not understand why costs would escalate substantially.

With public support dwindling in the face of higher project costs, ReGe was determined to close the contract. Project managers in ReGe and the Mayor's Office saw pressure looming: For budget planning purposes, they wanted to close the deal in 2006 to be able to list the project in fiscal year 2007. Additionally, 2008 was election year, and ReGe wanted the contract signed before election campaigns started to keep the project out of a possible line of fire (B/PUA 2014, 69–72).

To ensure parliamentary approval, ReGe needed to maintain a certain proportion of costs between public areas and commercial envelope: under the forfeit model, the lease and sale of the commercial envelope should generate surplus used to subsidize the building's public areas—a principle called positive cross-financing. In the project status of late 2006, it was one of the few remaining elements linking the then publicly owned Elbphilharmonie to its 2003 public–private partnership origin. ReGe had to ensure construction costs for the commercial envelope would not reach a level above the projected income. Otherwise, construction of the commercial envelope would have needed public support—taxpayers would have subsidized a luxury hotel, not as planned the other way round. ReGe played with the internal allocation of costs between the public and private building areas, lease rates, and sale price to make sure this scenario of "negative cross-financing" would be avoided in the project planning phase.[16]

The external pressure led to cost underestimation—due to both overoptimistic risk assessment as a case of appraisal bias and against better knowledge. The described action imperatives could only take effect in a specific Hamburg-internal project governance environment. ReGe's special position in the city's administrative landscape enabled weak oversight over project managers' activities and enabled them to underestimate and miscalculate project costs without notice.[17]

Internal Governance Setup and Lack of Skepticism

As the project coordinator had wished when he came to the project in 2004, the Elbphilharmonie project was managed by an existing private company in public ownership. The head of ReGe and project coordinator reported directly to the First Mayor of Hamburg via the Mayor's Office,

[16] The potential worst-case scenario of a negative cross-financing was discussed within Hamburg's agencies before the decision for the forfeit model was made. Civil servants raised concerns over a public entity becoming the owner of a high-class hotel (B/PUA 2014: 149–155).

[17] It is not possible to attribute single decisions as either "delusional" or "deceptive," since both work together. We suggest that, for some decisions, the intentional aspect was stronger. Budäus (2013: 20) comes to similar conclusion regarding the effects of the "Elbphilharmonie-euphoria."

giving him a quasi-Senator status. The leading figures in ReGe and the Mayor's Office were the core team on the public side for the project until contract signature (Interview from 12.02.2015). This constellation was also a result of Hamburg's lack of capacity. The city had previously reduced its construction management capacity for aboveground projects (B/PUA 2014: 386–387). Appointing ReGe seemed a viable option. Public enthusiasm for the project contributed to this setup because it appeared high on the city's agenda and seemed perfectly suited to be managed on a high level. Rather than evolving through the administrative checks-and-balances process, the project circumvented the slow city bureaucracy (Interview from 09.01.2015).

Because of an information asymmetry, ReGe was able to deceive the Hamburg Senate and Bürgerschaft (Budäus 2013, 24). While the Senate requested expert outside opinions on critical project decisions, it tasked ReGe to gather this information. With that, possibly critical opinions would go through ReGe first before being presented to Senate or Bürgerschaft. Without engaging an external auditing entity for ReGe, both were dependent on ReGe's reports on project progress (B/PUA 2014, 398–400). ReGe could filter every external piece of information before presenting it to decision-makers. For example, the Senate requested external opinions on a potential sale price of the hotel after the lease cycle would end in 2030. €130 million were needed to pay back the construction loan. ReGe tasked two companies with a report. Both warned of market insecurities and concluded that achieving the desired price in more than 20 years ahead was highly insecure. ReGe, however, ordered them to rephrase their reports several times before presenting them. In the final reports, both companies suggested that achieving €130 million was likely (B/PUA 2014, 363–378).

In the beginning of 2007, the city added a board of supervisors as a more formal way of overseeing ReGe's work, replacing the direct reporting tie from ReGe to the First Mayor and the informal working process between ReGe and the Mayor's Office. ReGe had to report regularly and inform the board on important business developments. But the board was insufficiently equipped to establish effective control over ReGe. Board members mainly came from the senate. While various governmental institutions now received information on project progress, no Senate board member was a construction specialist but mainly came from the finance or culture department (B/PUA 2014, 441–442). The city agencies also did not try to engage more with the project. In parliamentary sessions and steering meetings, critical questions or raised concerns on cost assumptions were rare. The installation of the board of supervisors was to fulfill formal requirements rather to exert more direct control. Goodwill dominated (Interview from 09.01.2015). Hamburg's government had no reason to be skeptical against the project or the work done by the Mayor's office and ReGe.

With ReGe serving as the only point of contact for all other agencies of the city and the partaking companies, it could filter all stakeholder communication. This enabled the deception of decision-makers regarding projected costs before contract signature, the concealment of the project's negative development until 2008, and overoptimism, because the city would refrain from critically challenging the seemingly well-backed cost assumptions. While inside ReGe the true status of Hochtief's additional claims was well known, ReGe had the opportunity not to report bad news. It took the high cost escalation levels of 2008 until ReGe itself took the initiative to inform the board of supervisors on the true status of the project—being way behind schedule and with serious financial claims at hand.

Lack of Risk Contingencies

As mentioned, optimism bias and strategic deception significantly affected the project. For such problems, planners often use risk contingencies for unforeseen events, which are especially important for projects with high technological risks. There was no previous experience in some architectural designs and technologies used, like the ceiling of the main concert hall (White Skin) and the curved glass façade (Abendblatt 2013, 6; B/PUA 2014, 57–60, 574).

Furthermore, due to information asymmetry, project planners could underreport some risks to lower cost projections: For example, funds for bad weather days affecting construction were insufficient (B/PUA 2014, 243).

Neither was there enough information on the risk of installing critical and technologically challenging building elements. One requested expert opinion on the carrying capacity of the old Kaispeicher's foundation was still awaited at the time of contract closure. Only after construction had started, engineers found that, other than expected, the concrete poles under the Kaispeicher lacked carrying capacity. This required additional placing of hundreds of more poles, increasing costs (B/PUA 2014, 185–186; Abendblatt 2013, 10).

Similarly, planners underestimated the technological challenge of the Elbphilharmonie's façade. Until 2006, there was no subcontractor found capable of producing the unique façade consisting of thousands of individually shaped, differently curved, and laminated glass elements, and only rough cost estimates were available. In the contractual budget position, there were no reserves for possible production and delivery problems or damages during the installation process (Abendblatt 2013, 6).

In the cases presented, it would have been possible to improve the precision of cost estimates at the time of planning: by awaiting the report on the Kaispeicher's foundation and offers for the façade and by taking a more cautious stance on average weather forecasts. Again, both overoptimism and deception played a role.

Unfinished Planning

At the time of contract signature, the planning of the Elbphilharmonie was far from finished, which meant that planning continued parallel to construction. In large construction projects in the German system, the due process usually follows a sequence of nine phases (B/PUA 2014, 89–93, 113–130).[18] In the first phases, the relationship between client and architect is the dominant theme. After the client explains his functional needs and architectural taste, the architect drafts first sketches. Over a period of reciprocal interaction, the drafts become more detailed and planning for the building and its parts more specific. Ideally, the design plan phase is finished, and all necessary plans exist. They give a full description of the building and should enable precise cost estimation. At this point latest, a construction company joins the process. The design plans now need to

[18] This is a simplified description used for a vivid illustration of the process.

be transformed into execution plans—the actual building manual with which the construction company gets exhaustive information on when and where to place what. At this point, the client—architect relationship is replaced by a relationship between the architects and the construction company. The client rarely is concerned with the details of the execution planning, and often, the architect formally reports and works according to the construction company's guidance. If a lump sum has been agreed upon between construction company and client, the construction company is responsible of on-time, on-budget, and on-quality delivery of the building. Only changes to the original planning at the client's request should imply additional costs for him. Risks from the execution planning or construction lie with the construction company. According to the contract and the client's intentions, the client can hire the construction company either at the time when also the execution planning has been finalized—resulting in an overall longer process, but with a high precision of cost estimates, or he can chose to start constructing with the design plans and in parallel continue with construction and execution planning. This saves time but would trigger the construction company (in a fixed price contract) to charge a risk premium for a possible difference between design and execution plans. For highly standardized construction processes (like family homes, airplane hangars, or administrative buildings), the second option is a reasonable way forward, because technological and quality risks are seen as low and potential time savings are high (B/PUA 2014, 113–130). For a highly unique building, a fixed price contract can be dangerous due to the risks involved. Costly change requests may easily be triggered.

When the construction contract for the Elbphilharmonie was signed in December 2006, different parts of the building had reached various planning stages: few had reached the status of execution planning, the final step before construction. Many had reached a design phase planning status. Some crucial building elements, however, were not yet included in the detailed planning process. In the definition of the scope of construction (Bausoll), some of these parts were indicated with just budget positions, with no substantiated calculations underlying cost assumptions. ReGe and Hochtief primarily used these budget positions to cut cost estimates, because no detailed information backed the claims and could, therefore, barely be checked. Thus, the projected cost for individual budget positions later turned out to be unrealistic. Due to the weak internal oversight setup, some unrealistic assessments went unnoticed. This includes the main concert hall's stage machinery. During the negotiation process, the budget for this position had shrunk from €13 million to just €7.5 million (Abendblatt 2013, 7).[19] At no point had it ever been actually planned.

The unfinished planning of the Elbphilharmonie was a crucial factor for cost overruns. In the building contract, Hochtief agreed to build the Elbphilharmonie as defined in the Bausoll for a "lump sum" of €241.3 million. The Bausoll that was mentioned in the contract was enclosed as an appendix, yet it lacked a detailed level of planning for many parts of the building. When the Bausoll changed, Hochtief had a right for compensation, allowing them to claim remuneration in a formal process. ReGe and the Mayor's office were unaware that large construction companies like Hochtief had developed impressive "claim management" capacity not known in previous decades.[20] The incomplete definition of the Bausoll almost annulled the "lump-sum" agreement of the contract. ReGe drastically and self-delusively underestimated the incompletion of planning. This enabled an extensive claim management by Hochtief.[21]

Interim Result: The False Security of the Contract and Rightly Foreseeable Costs

The unrealistically low cost projections of the 2006 contract were possible because of weak oversight and the dynamics of public involvement and outside pressure. Measures ranging from contingency-cutting over recalculations of unsubstantiated budget positions to handwritten "corrections" in external, critical reports were elements of optimism bias and strategic cost misrepresentation which first seemed to have a successful output: The contract was approved by the Hamburg parliament.

[19] Under contract amendment four, the budget was increased to €16.2 million (B/PUA 2014: 57–60, 252f).

[20] As we will explain further.

[21] We explain claim management further.

It seemed to have fulfilled all expectations that the public, city government, and ReGe had created together. The contract promised the erection of a piece of architecture that would become Hamburg's landmark, uniquely combining its cultural purpose with a commercial envelope. A timely contract agreement had been achieved, as well as the goal of preventing negative cross-financing.

Hamburg was very satisfied with the impressive agreement project managers had reached with Hochtief. ReGe repeatedly declared publically and in a parliamentary questioning session that a guaranteed fixed price contract had been signed in which construction cost escalations would not lead to cost increases for the city (B/PUA 2014, 455–460). That was legally correct but misleading. Only construction cost escalation during execution (e.g. rising prices for steel and concrete, construction damages, mistakes) would be the construction company's risk. Other sources of cost increases, like change requests, were not covered by the lump sum.

Within the city government and ReGe, well-informed employees and managers should have known that the contract had no price guarantee, making costs increases in the construction process likely. In supervisory and working group meetings, employees had cautioned against the risks of unfinished planning (B/PUA 2014, 65–66, 70–72). HdM had warned they needed more time to deliver a more detailed level of planning and insisted that, on the plans enclosed to the contract, a note was added reading "Not appropriate for constructing" (B/PUA 2014, 110–113).

While knowing that the project was worth more than the €351.8 million of the lump-sum agreement, decision-makers nevertheless underestimated the difference between the value of the contract and the value of the planned building (Interview from 09.01.2015). Given that, the ferocity with which they insisted on having reached a fixed price agreement with no chances of cost increases seems surprising. They hoped it would send a message to HdM and Hochtief to stick to the agreed contract and the lump sum (Interview from 12.02.2015). But this strategy did not work out. Hamburg underestimated Hochtief's dedication to increasing its profit margin (Interview from 12.02.2015). But with its public evocation of cost security, the public was even more shocked when cost escalations arose.

The cost escalations described so far, resulting from unfinished planning and weak oversight, do only partially explain total cost overruns. Instead, the 2006 cost miscalculations ex ante hid the actual costs of the Elbphilharmonie. If due diligence had been applied to supervision, a more detailed planning level had been reached, and more realistic risk contingencies had been included in the contract, planners could have presented a more precise estimate of the total project costs.

The 2006 contractual price did not mirror the value of the envisaged building (even if in an unfinished planning stage). Years into the construction process and with a finished planning stage, the hidden costs—the difference between the 2006 contractual sum and the real value of the envisaged building—have mostly been revealed, thus ex post presenting the rightly foreseeable costs (RFC). We define them as *those total project costs that could ex ante have been disclosed before contract closure if planning had reached a full design status, all available and requested information on technological risks had been included in the calculation process, and effective compliance had been carried out by Hamburg's government*.

This is a counterfactual concept, albeit useful despite limitations.[22] We lack information on future sale price and lease of the commercial envelope and the resulting intertemporal cash flow (debt service requirements vs. timing of income). Additionally, the monetary equivalent of single decisions in the interdependent project environment is hard to measure. But they could have been approximated if ReGe had made cost security its primary directive, giving planners the time they wanted to finish the planning process.[23] Though speculative, available data allow for an extrapolation of RFC.[24] They are identical to the value of the Elbphilharmonie envisaged at the time of contract closure (e.g. ex post change requests are not covered by RFC). To approximate RFC, we have established lower and upper boundaries:

RFC must be above the 2006 total project costs of €351.8 million because (a) most later planning changes and budget increases would have

[22] Though not using the concept, Budäus (2013: 6), tasked with an economic investigation into the Elbphilharmonie's problems, similarly speaks of the lack of transparency of ex ante cost estimates.

[23] Naturally entailing a longer planning and negotiation process, resulting in additional costs.

[24] Hamburg's government tried to estimate RFC but stopped the process because of its difficulty and its ex post limited practicability for project delivery (Interview from 09.01.2015).

been necessary anyway, (b) the construction schedule was overambitious—a longer construction phase would have been necessary, and (c) an extended planning phase would have been necessary. RFC must be below the 2013 total projects costs of €865 million because (a) many construction interruptions could have been avoided, (b) transaction costs could have been mitigated before contract closure (synchronization of planning, etc.), and (c) project cycle extensions (construction interruptions, negotiation phases, etc.) entailed recursive cost overruns (opportunity costs, holding construction capacity ready, planning, and management capacities, additional synchronization effort).[25]

Out best estimate for RFC is €550–650 million. The RFC concept does not necessarily imply that the project could have been realized at a lower price. But in 2006, decision-makers had necessary information to give a better estimate for the final price. They could have known realizing the Elbphilharmonie would have cost at least €550–650 million, not €351.8 million.

There remains a gap between RFC and the 2013 total project costs of €865 million that deserves explanation. During the development phase, the city made three fundamental decisions regarding the project's governance whose consequences could barely be foreseen at the time they were made, since they were fundamentally interdependent with the projects general development and especially its unfinished planning status. Decision-makers hoped they would result in cost reductions and more direct control over the Elbphilharmonie, ensuring the project's high quality standards. All three decisions loaded ReGe with tremendous additional work and management effort to hedge the entailed risk. Their entanglement and ReGe's inability to manage their impact worked devastatingly on the project's performance, causing dramatic cost and time overruns. It is also here that the city missed opportunities to mitigate cost overruns.

[25] The role of transaction costs is, for example, explained by Budäus (2013: 26).

Fundamental Flaws in Project Governance: Door Opener for Additional Costs

Forfeit Model

In summer 2006, Hamburg agreed to forego the investor model for a forfeit model, amid the running tender process and not long before contract closure. ReGe hoped to achieve cost reductions by lower interest payments. Taking full responsibility for the commercial envelope eliminated many interfaces between previously public and private areas of the building. With full control over the planning and construction process for the whole Elbphilharmonie, conflict potential between investors and the public side seemed drastically reduced, which should have ensured the Elbphilharmonie's high quality standards. But the projected savings in future interest payments of around €10–15 million stood against a tremendous amount of risk shifted from the private investors to the city.

Hamburg first took over the full construction risk for the commercial envelope. Second, responsibility for finalization of planning for the commercial envelope shifted from the previous investors to the city. Third, Hamburg took on financial risk: If construction was delayed, lease of the commercial envelope could not start in time to cover the debt service (B/PUA 2014, 152–156). Finally, Hamburg needed to integrate the existing plans for the private areas, done by the investor, into the overall plans (Interview from 09.01.2015; B/PUA 2014, 192–207).[26] The shift in planning responsibility increased ReGe's workload, because it added up the pile of plan transfers they needed to coordinate between HdM and Hochtief.

ReGe underestimated the risk and potential impact this decision would have on project governance and costs but tacitly accepted future cost increases. It was highly delusive. It was also questionable how the decision

[26] The integration of the investor planning was the first big fight between ReGe and Hochtief—ReGe took the position that the integration of investor's planning was included in the contract, Hochtief argued it was not. After receiving extended legal advice, ReGe gave up its position and accepted Hochtief's claims.

came about: It was agreed on in an ad hoc meeting between ReGe's core team, the Mayor's Office, and the Mayor himself, and no protocol has been made in an otherwise well-documented project (B/PUA 2014, 148–160). Assuming ReGe has deliberately pursued this decision against better knowledge, this is a case of strategic deception.

Additionally, taking ownership for the commercial envelope multiplied the available scope for optimism bias and cost misrepresentation, because it increased the space of the Elbphilharmonie under the city's managing responsibility. With insecurity about the future income generated by the lease and sale of the commercial envelope, the total impact on costs triggered by the forfeit model is speculative. For the finalization of planning, the integration of investor planning, additional workload, interim financing, construction interruptions, and realized construction risk, this decision created a multitude of additional costs vis-à-vis the realized savings in interest of €10–15 million.[27]

External Governance Setup

In the contract signed between ReGe and HdM, when Hamburg took over the project from Gerard in 2004, they agreed to leave the main responsibility for most of the execution planning with the architects. They would deliver the plans to ReGe, who would verify them and pass them on to the construction company. This arrangement did not count for the detailed planning of the supporting structure and technical building equipment (light, air-conditioning, etc.), which remained with the prospective construction company (B/PUA 2014, 115–129). In this external governance constellation, almost all interaction between the architects and the construction company would happen through ReGe. The setup had two goals: first, to keep the architects as the city's advocate with monitoring power over Hochtief's activity, and second, to ensure the realization of HdM's top standards in execution of the Elbphilharmonie (Interview from 09.01.2015; B/PUA 2014, 114). But

[27] Our interview partner suggested that the necessary renegotiation of the loan payment schedule in the face of the opening delay alone has cost more than €15 million (Interview from 09.01.2015).

as we have described earlier, this agreement can be dangerous for complex construction projects.

The setup came with complex interfaces that needed to be managed by ReGe. With divided planning responsibility, ReGe had to coordinate both Hochtief's and HdM's plans and delivery schedules. This was a complex undertaking as each plan needed several transfers between the firms.

ReGe underestimated the effort and was overburdened with planning coordination shortly after construction start. As a result, the architects and Hochtief lost confidence in ReGe's work. Additionally, their work relationship worsened, as they began accusing each other of delaying construction by withholding plans or not delivering them on time. Hochtief began sending construction interruption notifications to ReGe, claiming compensation for holding capacities ready without being able to build (Abendblatt 2013, 6; Interview from 09.01.2015; B/PUA 2014, 129–130). Overcoming the destructive working relationship posed as the main challenge in negotiating the 2013 project turnaround (Interview from 09.01.2015).

By positioning itself as an interface between HdM and Hochtief, ReGe got better monitoring power and control over planning and construction execution. But ReGe's underestimation of the resulting effort led to large cost escalations and time overruns. Furthermore, ReGe's weak compliance with oversight requirements contributed to this growing backlog remaining hidden until 2008 (Fig. 3.3).

Parallel Processing of Construction and Planning

The decision to parallel process construction and planning was motivated by two aspects. First, ReGe had some experience with this procedure from some previously managed projects and thought the coordination effort was manageable (B/PUA 2014, 69–75). The Elbphilharmonie, however, was far more complex. Second, ReGe did not desire a finalized planning before construction start. The architects repeatedly warned they needed more planning time before construction start, because unfinished planning could result in substantial cost overruns. ReGe decided to continue despite the warnings for two reasons. The project coordinator

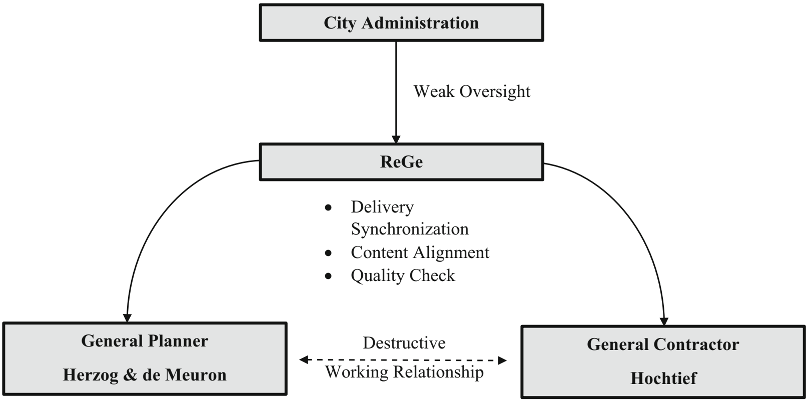

Fig. 3.3 External governance setup

argued that architects would have a natural incentive to plead for more planning time. They would use it for more than just finer planning. He feared that, in this signature project, planned by world-famous architects, HdM would incur costs by including extravagant elements. By pressuring them, he hoped they would focus on standardized execution planning rather than including "dream material" (B/PUA 2014, 69–75). Finally, ReGe itself worked under the pressure of possible project cancellation. The more detailed the plans got before contract closure, the higher the projected costs got, possibly approaching the RFC. As mentioned, ReGe was incentivized to secure the project and feared a political veto if costs estimates got too high, so they worked toward a swift contract signature at the risk of later cost escalations.

The decision was driven by perceived necessity and outside pressure. It was deceitful because the unfinished planning allowed a quick lump-sum agreement. But it was also subject to optimism bias, since ReGe once more underestimated the decision's impact. ReGe lacked the expertise to reliably assess the planning status at contract closure, and the internal governance setup hindered the flow of critical information, such as the architects' warnings.

With the key decisions in favor of the forfeit model, the external governance setup, and parallel processing, ReGe found itself in a unique position as the projects primary interface between all actors involved, in a project with unfinished, unsynchronized, and barely coordinated planning as well as divided planning responsibility. Due to self-overestimation of its capabilities—mainly by the project coordinator—it had taken on not only all of the city's stakes in operational management but also important parts of project management that would have been directed to HdM and Hochtief under a standardized governance setup. ReGe became the bottleneck, resulting in the late delivery of barely checked construction plans to Hochtief, which enabled them to realize a massive amount of financial claims. In the next section, we will describe a simple version of claim management with which cost escalations realized.

Cost Escalations: Change Requests and Claim Management

After contract signature, user change requests quickly caused cost escalations. They did not result from planning continuation but were external wishes for, sometimes fundamental, functional changes. Change requests came from Hamburg's government, such as the cultural authority, or the Bürgerschaft. They wanted to include a third, smaller concert hall to serve as a choir rehearsal room, a larger ticketing area, and an additional cafeteria (B/PUA 2014, 53–54).[28] ReGe or the board of supervisors cannot be blamed for cost overruns stemming from these change requests, as they were the choice of the city's political representatives.[29] Change implementation required rescheduling of many areas, which altered the scope of construction (Bausoll), the heart of the Elbphilharmonie's contractual lump-sum agreement. Their costs for planning and construction were, therefore, not part of the contract and were claimed by Hochtief.

User change requests were not the main driver of cost escalations, though the devastating effect of ex post change requests on cost schedules has been highlighted for other projects, such as the Berlin Brandenburg Airport

[28] The report claims user change requests were made one month before contract closure. This would still be insufficient time to include such drastic changes in an ongoing planning process.

[29] Cost escalations due to user change requests are investigated in B/PUA (2014). They assess them to be at €0.1 million, pointing at additionally necessary shell construction prices. But shell construction is only a small share of overall construction costs, since changed areas also need equipment, interior fittings, and rescheduling of plans. The assessment is unrealistic.

(see Wendler 2014 or Chap. 4 in this volume).[30] The unfinished planning status had a drastically higher impact, because it enabled Hochtief to carry out an extensive claim management.

Claim management means the systematical demand for financial compensation by taking the legal position that more detailed plans deviated from the Bausoll (B/PUA 2014, 171–172).[31] This became possible because Hochtief, in its lump-sum offer, estimated costs based on experience in similar projects and standard unit prices, while HdM made high-level quality standard plans. Under parallel processing of planning and construction, this opened up the floor for legal arguments on what distinguished a *more detailed* from a *different* plan—is a detailed high-quality execution plan qualitatively different from the imprecise standard-quality design plan that would justify additional compensation for Hochtief? Or is it just a plan refinement included in the lump-sum agreement?

What commonly happened after contract signature was that, when execution plans arrived, Hochtief argued they deviated from the Bausoll covered by the fixed price agreement and claimed compensation. ReGe would counterargue that the execution plans were merely more detailed descriptions of the agreed Bausoll, and thereby part of the lump sum. Even if construction costs were above budget, additional costs would be at Hochtief's risk. In the first step of the claim management process, the construction company sends a Projektänderungsmeldung (Project Change Notification, PÄM), informing the client of additional costs due to changed planning. Clients then have three options.

First, they could veto the PÄM (under the argument described above), potentially leading to a long, costly, and complex legal process with an uncertain verdict. Second, they could accept the PÄM and pay the additional price. Third, they could accept the PÄM, but try to reduce its price tag. This may be possible because a construction company is not obliged to search for the lowest available price of the changed plans but just has to make a detailed, written, substantiated offer. If the client successfully shows there are cheaper offers available, the construction company must

[30] Though we can assume a correlation between unfinished planning and change requests, if planning had been finished at the expense of a longer planning process, probably all stakeholders could have voiced their requests in time.

[31] Simplified description of the claim management process. More detail in B/PUA (2014: 170–269).

take those. Due to information asymmetry, disproving the construction company, however, can be difficult.

For ReGe, due to their unique interface position, a fourth option existed to prevent claim management in the first place. They could have precisely checked all execution plans before handing them to Hochtief, compared them to the Bausoll, and anticipated arising PÄMs. If they found potential problems, they could have returned the plans to the architects and demanded revision.

Extensive claim management has been called a structural element of the German construction business (Handelsblatt 2005). Since public entities must agree to the cheapest offer for a project, companies are incentivized to underbid each other below a profit margin during tenders, to then increase revenue after project start through claim management. Some firms back up their claims by an advanced legal capacity, making a legal confrontation expensive for the client (Interview from 09.01.2015). Hochtief's drastic form of claim management can be explained by its bad business situation: the company had lost profitability and was under risk of being taken over. To its disadvantage, Hamburg seemed unaware of Hochtief's claim management capacity (Interview from 09.01.2015).[32]

To effectively counter claim management, clients need to establish an anti-claim management. This requires either a potent legal service to counter PÄMs or an experienced civil engineering department capable of renegotiating their price tags. Chances for claim management can be minimized by starting constructing with finalized execution planning or by having the construction company do it.

Developments Until Project Turnaround 2013

2007–2008: First Contract Amendments

In the 4 months between contract signature and the foundation stone ceremony on April 1, 2007, several events hit the project. In early March, interruption notifications by HdM and Hochtief reached ReGe, and

[32] Budäus (2013: 20ff) gives a game theoretic account of claim management.

the first PÄMs dropped in. The first contract amendment was agreed between ReGe and the construction company (about construction interruptions due to missing plans). It costed an additional €1.657 million (B/PUA 2014, 48). One day before the ceremony, ReGe's second in charge, project manager Heribert Leutner, resigned (Abendblatt 2013, 10).

ReGe faced limits in operational management. It failed to synchronize plan delivery, resulting in costly interruption notifications.[33] PÄMs arrived in ReGe's offices often on a daily basis (Abendblatt 2013, 10). They originated in user change requests, a lack of planning precision, realized risks (as in the case of the concrete poles), or changes necessary due to EU-wide requirements on fire and flood protection (B/PUA 2014, 564). ReGe did not have the capacity to verify the PÄMs. For some, the "verification process" meant that the project coordinator refused payment by a handwritten annotation on the margins of the document (B/PUA 2014, 185–187).[34] ReGe could not build a substantial anti-claim management.

On June 18, 2007, the integration of the investor planning was finished. By then, PÄMs totaled around €10 million. ReGe reacted but potentially made things worse. In October 2007, it ordered to pass HdM's plans on to Hochtief without checking to secure a timely delivery and stopped verifying individual PÄMs in favor of a packet solution, paying Hochtief a lump sum for all backlogged PÄMs. But this may have incentivized Hochtief to create even more PÄMs in order to increase the bargaining sum. Also in October, the second amendment to the contract was agreed, which rescheduled the loan payment plan. It resulted in €0.5 million additional costs due to rising financing expenditures (Bürgerschaft der Freien und Hansestadt Hamburg 2007a, 2; B/PUA 2014, 49).

The city government was informed of the first two contract amendments, but both did not point at further project-internal problems. The critical developments regarding rising PÄM demands and construction interruption notifications, ReGe's lack of resources, and the destructive

[33] Our interview partner suggested this was the single most expensive mistake (Interview from 12.02.2015).

[34] Mr. Wegener's personal style of anti-claim management seemed sometimes successful. When notified that Hochtief claimed over €5 million for the additionally necessary concrete poles founding the Kaispeicher, he sent back the document, commenting "We are not paying for this unsubstantiated impertinence!" The city finally paid around €1.35 million.

work atmosphere between all parties were not reported to the board of supervisors, the First Mayor, or the Bürgerschaft.

The Hamburg general election of early 2008, resulting in the Mayor's reelection, led to some adjustments in the internal governance setup. The administrative supervision shifted from the city development department to the cultural department, and key personnel in the First Mayor's Senate Chancellery changed. The cultural department, under the impression that project control had not been exercised well enough before, and tipped off by some informal communication, decided to delve deeper into the project's status (Interview from 09.01.2015). Under the new setup, and with different members, also the board of supervisors started to pay closer attention to project progress.

In the summer of 2008, enough information on the project's critical status had reached the First Mayor, who saw major steps necessary. The claims in PÄMs totaled over €60 million. Additionally, Hochtief informed ReGe of a €90 million claim for total construction interruptions. Wegener met confidentially with high-ranking members of Hochtief to negotiate contract amendment three, the envisaged package agreement on all run-up claims. But members of ReGe and the city government lost trust in his steering capability and dissociated themselves from him. The Bürgerschaft remained uninformed of the problems, depending mainly on rumors and incomplete newspapers information. When questions on the project status were officially raised, they were answered evasively or not at all.[35] Because Wegener's negotiations seemed unsuccessful, he was asked to resign in early September 2008 (B/PUA 2014, 292–310). Former ReGe project manager Heribert Leutner, who had left in March 2007, became ReGe's new head shortly thereafter. His negotiations were now labeled contract amendment four. The city wanted more direct control over ReGe's activity and installed a construction committee alongside the board of supervisors. It was staffed with construction experts and provided the board with expert opinions unfiltered by ReGe. Its influence remained limited (Interview from 09.01.2015).

[35] ReGe argued that it could not give information to the parliament pertaining the progress of negotiations with Hochtief, because they would get published and thereby weaken ReGe's bargaining position. See, for example, Bürgerschaft der Freien und Hansestadt Hamburg (2007b, c, d, 2008a, b).

On November 26, 2008, an agreement was reached and contract amendment four was signed (B/PUA 2014, 50–61). The additional construction costs of €137 million consisted of €48.2 million for run-up PÄMs, €22 million for budget increases for still unplanned positions, €36.8 million for construction interruptions, and €30 million as an agreement sum. With that agreement, all financial claims had been settled. Hamburg again was convinced to have reached a sustainable agreement, based on near-finalized planning. Internal memos pointed out that planning was still unfinished—highlighted by the increase in budget positions of €22 million. The city discarded thoughts on a change of the external governance setup, because it did not want to give up control over quality after already having lost control over costs and schedule (Interview from 09.01.2015). There was no cost security and no robust completion date. With still unfinished planning, it was still a matter of time before the circle would start again.

2009–2013: Hardening of Positions and Turnaround

As interruption notifications and PÄMs started coming in again in 2009, the insufficiency of contract amendment four became obvious. Hamburg's frustration now started turning against Hochtief. After the devastating developments of 2008, the city government exerted control over the project wherever possible, and it remained on top of the agenda. The parliament installed an inquiry commission to investigate the 2008 events and the run-up phase before 2006, trying to identify a responsible actor (B/PUA 2014, 1–2). To counter newly arising claims, ReGe's staff was doubled to build better anti-claim management. But this could barely stall new claims and contributed to the poisoned work atmosphere as Hamburg and Hochtief continuously threatened each other with legal action (Budäus 2013, 23).

Between 2010 and 2011, the project started damaging HdM's and Hochtief's professional reputation. Also, important actors left the scene. On February 20, 2011, a new First Mayor was elected who quickly familiarized himself with the project. Within Hochtief and HdM, key personnel changed. But before a new approach could become effective, tensions increased. A first attempt to negotiate another contract amendment targeting the project governance setup (suggested by Hochtief) failed, because it did not provide a solution for a new area of conflict: Who was responsible (and would pay) for construction damages? Were damages a result of faulty execution by Hochtief or unrealistic planning specifications by HdM? In October 2011, disputes over construction and planning shortcomings became public. Construction stopped. Hochtief argued that, due to concerns over the structural capacity of the building, it would be dangerous to lower the roof.[36] Hamburg and HdM vetoed and demanded lowering. Until the summer of 2012, several offers for contract amendments including a new governance setup were exchanged between Hamburg, HdM, and Hochtief, but no offer included a settlement for claims on execution quality and risk ownership appealing to all sides. Legal threats and ultimatums still abounded.

While contract termination and legal scenarios were drafted and discarded on the operational level between all project parties, the new city government started to engage in informal meetings with high-ranking members of HdM and Hochtief—ReGe was mainly left out of the process, since an agreement on project level seemed unachievable. All sides expressed their willingness to successfully carry out the project. The city was convinced that the most important goal was to reestablish trust between HdM's architects and Hochtief's engineers. The negotiations continued through 2012 and gradually showed effect. On December 12, 2012, the mayor presented the cornerstones of a new agreement with Hochtief during an extended press conference.

On April 9, 2013, contract amendment five was signed—with far-reaching concessions made by Hochtief (Abendblatt 2013, 14–15). For a new total of €575 million in construction costs, Hochtief agreed to take on all liabilities for already constructed and still to be constructed parts of the Elbphilharmonie. The architects were subjected under the direction of Hochtief, planning was to be finalized according to Hochtief's guidance, while HdM kept creative leadership. A fixed schedule with contractual penalty arrangements was included as well as Hochtief's

[36] For details about the construction stop, see Abendblatt (2013: 14).

Contract Amendment	Value of Amendment	Construction Costs	Additional Costs	Total Project Costs	Comment
Contract Amendment 1 March 2007	€1.6 million	The amendment was necessary due to a six week long delay in construction. The amendment sum was agreed upon only together with amendment 4.			
Contract Amendment 2 October 2007	€0.5 million	Increase in financing costs due to a reorganization of the payment schedule and an agreement on the final loan interest (4.85% p.a.) for the forfeit loan.			
Contract Amendment 4 November 2008	€137 million	€378.3 million	€182.5 million	€560.8 million	
New Contract 2013		€575 million	€290 million	€865 million	No amendment value - new contract

Sources: B/PUA 2014, 20-62; own estimates

Fig. 3.4 Contract amendment overview

guarantee to refrain from further claim management if the city stopped change requests. Since April 2013, no new financial claims have been asserted. The current construction progress is before schedule. In mid-January 2015, the city announced the opening of the Elbphilharmonie on January 11, 2017 (Fig. 3.4).

Missed Opportunities to Hinder Cost Overruns

Six years after project start, Hamburg reached a contract amendment including a new project governance setup. Expert see it as a highly beneficial and secure contract for the city, and it seems to have successfully locked costs—but at €865 million—at least more than €200 million above the RFC (Abendblatt 2013, 14–15). As we have shown, cost overruns up to the level of RFC have been unavoidable ex ante, but Hamburg missed opportunities to limit further cost overruns, especially to hedge the impact of the trio of underestimated governance decisions.

Decision-makers of course tried to adapt to the circumstances after construction start, but their attempts to solutions within the existing governance setup failed: neither a change of ReGe's leadership nor the PÄM packet solution or the increase in oversight activity put a stop on cost escalations. The turnaround became possible through an informal, top-level negotiation process outside of normal project governance and involving changed partners on all sides.

We see several other options with which Hamburg could have tried to get the project back on track, of which we want to outline four. First, ReGe could early on have increased its operational capacity and drop Wegener's LEAN management approach (which happened only in 2010). Additional staff could have worked on content verification and synchronization of planning and/or build up an anti-claim management. This could have reduced cost escalations in the existing governance setup while only increasing ReGe's operational costs in an acceptable amount. When ReGe did increase its capacity in 2010, it focused on an anti-claim management driven by threats of legal action. The effect on cost mitigation then was low. However, it contributed to a hardening of fronts and thereby the construction stop. This signaled to all parties that, without a final settlement, a long and costly legal process was lurking, in which a clear winner was unlikely.

Second, ReGe could have tried to reach an agreement on a preliminary construction stop to finalize planning before further construction. This would have incurred costs and delays, but a finished planning would have limited PÄMs, further ad hoc interruptions, and helped avoiding alteration of already constructed areas.

Third, the city government could earlier have insisted on a renegotiation of the external governance setup, modeled after the 2013 solution. This could have triggered a significant additional risk premium and long negotiations but would have hindered construction interruptions, PÄMs, and reduced ReGe's operational costs.

Finally, ReGe could have urged the city not to bring in user change requests after contract signature and only include changes caused by altered regulatory requirements.

It must be noted that all measures would have influenced the Elbphilharmonie's design, as they would have impacted the process of plan exchange between HdM and Hochtief, which would probably have reduced HdM's highest-quality standards. We cannot say whether the current execution standard was worth the final extent of cost overruns.

We disagree with the view that Hamburg missed an opportunity to reduce costs by not re-opening the tender process after the penultimate bidder had dropped out in 2006 (B/PUA 2014, 77–79). ReGe was incentivized to present the contract with the costliest offer still acceptable to the parliament, and construction companies were incentivized to present the lowest possible offer. With a reopened tender process, competitors may have continued to underbid each other but mainly through more strategic cost representation with the opportunity of an extended claim management ex post. A realistic cost assessment would have decreased their chances to win the tender. Therefore, a reopened tender process would have led to offers looking better on paper, not to cheaper offers.

Lessons Learned

As shown, the cost and time overruns occurred due to a unique interplay of internal and external governance decisions, optimism bias, and strategic cost misrepresentation. The lessons we can draw from the Elbphilharmonie case are confirming previous research but also point at the specifics of the German system. A finished planning process should lie at the heart of any contractual agreement in complex projects. Unfinished planning is an invitation for ex ante miscalculations of costs which later lead to cost escalations.[37]

Change requests after project start are an important driver of cost and time overruns. With thorough, finalized planning, they should automatically become superfluous. Change requests—if not required by changed

[37] Also in Budäus (2013: 8f).

regulation—should be neglected from a cost overrun perspective. From a wider project perspective, they may very well bring value in a addition. A strong supervision over project managers' assumptions and calculations should be established. External, expert oversight over the project status is necessary. A realistic risk management is needed, especially in the negotiation phase, where contingencies offer an easy option of cutting predicted costs. Unrealistic risk assessments lead to costs escalations.

Some of the above lessons have been challenged. Repeatedly, public megaproject internals in Germany have argued that strategic cost misrepresentation would be necessary to start projects (Der Spiegel 2013).[38] If projected costs would be assessed more realistically, their political approval became improbable once costs reached a critical level. Therefore, project managers would have an incentive to avoid strong oversight and start projects in phases of unfinished planning, knowing that costs will escalate. Once a political will to realize a project had formed, a later cancellation of the project, even if costs rose substantially, was unlikely.[39] Unfinished planning and change requests, by that argument, would be necessary parts of public projects.

By a similar interpretation, the demand for better risk provision may be unrealistic. If the public side included higher contingencies to make up for optimism bias and potentially arising planning changes, it would be very unlikely that a profit-driven company would not find a way to argue the risks had realized, claiming the full sum. In a public–private contractual setting, risk contingencies tend to get used if no mechanism is found to circumvent it.[40]

Cost and time overruns in public megaprojects seem to be innate in the system. But even if we accept that deception was a necessary element in project planning and that many beloved buildings across the world would never have come to life if decision-makers had known

[38] Stated by architect Gerkan in an interview together with de Meuron.

[39] While this is a common belief of decision makers and can serve to justify deception, we have not found any example of a large public infrastructure project that has been cancelled in a political process because pre-contractual cost estimates got too high. Bent Flyvbjerg on several occasions picked up similar arguments and highlights that misrepresented projects may have blocked the way for actually better projects (Flyvbjerg 2009: 348f).

[40] This is an idea developed during an informal talk in the German Ministry of Finance.

ex ante what they would cost, there is no point in fatalism. While public project managers and private contractors may be incentivized to ex ante hide true costs of projects, they are not incentivized to let projects fail or almost fail, inflicting damage on their reputation, or damaging their careers. There is an incentive for well-done project management under operational conditions, in the Elbphilharmonie case, ReGe unfortunately failed to run operations well.

Apart from generally applicable, yet potentially hard to implement lessons in the current system, we can derive additional lessons from the Elbphilharmonie case.

Project managers should early on try to manage public and political expectations into what a project can achieve, by measures of strategic communication and participatory governance. With public stakeholders expecting first a cost-free and later at least “cheap” Elbphilharmonie, frustration was almost sure to follow. This was exacerbated by ReGe’s insistence that the 2006 contract offered cost security. The continued attempt to hide the project’s status increased the 2008 shock.

Project managers must pay more attention to the potential interdependencies and consequences of governance decisions made at different times. Parallel processing of planning and construction and the chosen external governance setup each alone had dramatic potential impacts, but it was their entanglement that caused ReGe’s capacity overload. An early, holistic analysis of each decision could have paved the way for a necessary readjustment of the project management approach.

Executives must quickly adapt to changed circumstances. ReGe knew that costs would escalate after contract signature, but the intensity of Hochtief’s claim management surprised the firm, as ReGe was unaware of the cultural change in large construction companies. The governance setup’s consequences became visible then, but ReGe failed to react strategically, and instead continued its management style with only minor, finally futile readjustments.

Project managers must escalate the negotiation process if necessary. ReGe’s decision to proceed with project management on an operational level, hiding the problems, only contributed to the 2008 shock. Escalating project steering to the politically responsible level in time may have resulted in an agreement before 2013.

Conclusion

Optimism bias and deception lie at the heart of cost and time overruns in the Elbphilharmonie case. They were fostered by public and political pressure and high expectations; they manifested as insufficient risk management, unfinished planning at construction start, weak oversight, and three critical governance decisions whose impact was devastatingly underestimated: An external governance setup with ReGe as an interface between HdM and Hochtief, parallel processing of planning and construction, and the forfeit model. ReGe was overwhelmed by the coordination effort resulting from the decisions' interdependency, but problems remained hidden until 2008. Change requests added to rising costs.

All flaws were codified in the 2006 contracts and cost escalations up to RFC unavoidable. Nevertheless, Hamburg missed chances to mitigate further cost escalations through a mutually agreed construction stop, anti-claim management or an attempt to renegotiate the governance setup. Even after cost escalations had shocked the city in 2008, project management was not significantly altered, nor did Hamburg try to reach a new governance setup. The city decided potential savings were not worth risking the loss of control over execution quality after already having lost control over time and cost schedules. Project managers underestimated how much Hochtief was dependent on claim management to make the project profitable and what pitfalls still laid in unfinished planning. The mistakes of 2006 were repeated in 2008, since optimism still reigned. As the project continued and another round of cost escalations followed, Hamburg saw the necessity to either renegotiate the governance setup or cancel the project. Due to the slim chances of clearly winning legally, a new governance setup was the preferred option. After almost all personnel on operational and politically accountable level had changed in Hamburg and Hochtief, an agreement was reached. While legal threats were continuously exchanged, a long process of informal negotiations took place which succeeded in reestablishing trust, and finally, the new contract could be signed in 2013.

Hamburg is to blame for the flaws of the 2006 contracts with the initial governance setup, the repetition of mistakes in 2008, and for missing further cost mitigation opportunities, even if it has to be respected that as a public entity with its legal constraints and process-driven environment, Hamburg suffered from disadvantages in negotiations vis-à-vis the relative freedom of a private company. Using the concept of RFC, it becomes clear that decision-makers could have known ex ante that the Elbphilharmonie project was worth at least €550–650 million. While we cannot exactly determine the value of the detours the project took, somewhere between the RFC and the 2013 price of €865 million is the sum of avoidable cost overruns. For future projects, among other things, decision-makers need to pay closer attention to the interdependency of governance decisions, finish planning before construction starts, and continuously review project's status to be able to strategically react to changed circumstances.

Appendix 3.1. Project Timeline

1997	The "HafenCity" project starts.
2000	Previous plans for the Kaispeicher A premise to host a cultural site are dropped in favor of plans to erect the "Media City Port," an office tower.
2001	The investor and project developer Alexander Gerard and his wife, Jana Marko, start to develop the idea of a concert hall at the Kaispeicher A site.
September 23, 2001	A coalition of CDU, FDP, and the Schill-Party win the Bürgerschaft election; Ole von Beust becomes Hamburg's First Mayor.
October 31, 2001	Patrick Taylor, old and new business partner of Alexander Gerard, sends a letter to the Mayor, bringing up the idea of a concert hall in the Kaispeicher.
December 21, 2001	The first meeting between Gerard and HdM takes place, in which the architects craft the idea of a "wave" atop the Kaispeicher.
2002, Fall	Hamburg's government looks into the possibilities of a new concert hall for the city and plans for an "AquaDome" concept at Magdeburger Hafen. Gerard counters by publishing his concept of a cultural use for the Kaispeicher and an office tower next to it to receive cross-financing.
March 2003	Since the project does not get hold, Gerard tasks HdM to develop a project study including visualization.

(*continued*)

June 6, 2003	First press coverage of Gerard's project.
June 26, 2003	Gerard and Marko hold a press conference introducing the Elbphilharmonie concept, using a wooden-and-plastic model made by HdM and elates Hamburg with the Elbphilharmonie idea. The public concert hall in the center of the building is financed by a private envelope around it, consisting of gastronomy, apartments, a parking garage, and a hotel. The city should not provide funding and just present investors with the premise.
August 21, 2003	Open letter by renowned Hamburg architects to the Mayor, pleading him to enable the Elbphilharmonie and to select the HdM sketch.
September 26, 2003	The SPD opposition requests the Senate to drop the "AquaDome" project and concentrate on the Elbphilharmonie project. AquaDome is dropped on October 24, 2003.
October 7, 2003	Patrick Taylor, previous business partner of Alexander Gerard, leaves the project. Gerard's new partner would be Dieter Becken.
December 16, 2003	The Senate officially announces to continue investigating the possibilities of the Elbphilharmonie project.
December 30, 2003	Following the Schill-Scandal, the Bürgerschaft decides for new elections.
February 29, 2004	Elections for the Bürgerschaft, a new CDU-only government emerges; Karin von Welck becomes the new Senator for Cultural Matters.
May 3, 2004	Alexander Gerard and Jana Mako meet Christoph Lieben-Seutter in Vienna.
May 4, 2004	Meeting between Ole von Beust and Hartmut Wegener. Following that, Wegener becomes the Project Coordinator, and the Realisierungsgesellschaft Hamburg (ReGe) is tasked with project lead. Soon after, Wegener hires Heribert Leutner as ReGe's second and Düsseldorf-based lawyer Ute Jasper to accompany the project. On the city's site, the city-development agency is responsible for the project.
2004, Summer	Yasuhisa Toyota is tasked with the acoustics of the large concert hall.
November 3, 2004	Hamburg buys Alexander Gerard and Dieter Becken, the original investors, out of the project for €3.48 million.
January 19, 2005	ReGe signs the general planning contract with architects HdM.
January 20, 2005	The Senate decides to pursue the project under the proposed investor model.
February 25, 2005	The Europe-wide tender process starts.

(*continued*)

April 22, 2005	The architects finish their predesign planning and estimate the constructions costs at €196.7 million.
April 25, 2005	The first phase of the Europe-wide tender process ends, 25 bidders have participated, 6 get selected for round two.
July 12, 2005	The Hamburg Senate receives the feasibility study, which estimates construction costs at €186.7 million.
August–October 2005	Three large private donations contribute €50 million (a single €30 million donation and two €10 million donations) to the project.
October 31, 2005	The Elbphilharmonie Foundation starts working.
October 26, 2005	The Bürgerschaft formally agrees to the tender process.
December 8, 2005	The NDR-Sinfoniker is selected as the orchestra-in-residence for the Elbphilharmonie.
January 6, 2006	The second phase of the tender process ends.
April 12, 2006	ReGe selects STRABAG and IQ2 (consortium consistent of Hochtief, Commerzleasing, ArabellaSheraton, APCOA, Nordmann, Gartner, HSH Nordbank, Bayerische Landesbank, and Quantum) as the final bidders.
April 2006	The architects deliver the design phase plans and estimate construction costs at €228.6 million.
June 2006	ReGe formulates its cost goal of €210 million for the project.
June 2, 2006	The designated general director of the Elbphilharmonie, Christoph Lieben-Seutter, arrives in Hamburg.
June 16, 2006	The architects warn that a premature construction that begins with unfinished planning in this complex project could easily entail large financial claims.
June 27, 2006	ReGe receives an email from the cultural department listing all ongoing change requests: integration of a cafeteria, different partition of offices and backstage area, enlargement of the ticketing area, and integration of a third concert hall.
June 28, 2006	Hamburg decides to forego the previously favored investor model for the forfeit model.
September 15, 2006	Within the deadline, only one remaining bidder, Hochtief (IQ2), delivers a proposal—with construction costs at €274 million.
September 29, 2006	Following a meeting with the First Mayor, it is decided to adapt Hochtief's proposal to ensure "positive cross-financing." Postnegotiation talks begin the following day.
November 24, 2006	Hochtief delivers their final offer; construction costs are at €241.3 million.
November 28, 2006	ReGe finds an agreement with STRABAG to settle the claims against the tender process.

(*continued*)

December 18, 2006	Hamburg signs the contract with construction company Hochtief. The Senate agrees to the contract 1 day later.
January 16, 2007	A parliamentary information session takes place in which the members of the Bürgerschaft are informed about the contractual setup.
February 2007	The city establishes the Bau KG, with which it installs a board of supervisors to oversee ReGe's activity.
February 28, 2007	The Bürgerschaft unanimously agrees to the Elbphilharmonie contracts.
March 8, 2007	The first PÄM arrives at the ReGe office.
April 1, 2007	Project Leader Heribert Leutner leaves ReGe.
April 2, 2007	Foundation stone ceremony.
May 31, 2007	A 2-day teambuilding exercise with participants from HdM, Hochtief, and ReGe takes place.
June 1, 2007	Annette Kettner is hired as a replacement for Heribert Leutner as Project Lead.
June 18, 2007	PÄM 75 arrives; Hochtief's claim sum up to just under €10 million. The same day, The integration of the investor planning is finished, which will turn into PÄM 100.
June 19, 2007	First meeting of the Bau KG's board of supervisors.
September 2007	The project receives a private donation equivalent to €2 million for the main concert hall's organ.
October 25, 2007	Hartmut Wegener decides to pass on architect's plans to the construction company without checking them.
November 7, 2007	The Elbphilharmonie Foundation holds a charity auction to raise money for the project.
November 26, 2007	The second meeting of the board of supervisors takes place.
December 2007	Between December 10 and 18, a series of letters between ReGe and HdM is exchanged with which ReGe wants HdM to clarify whether arriving plans are continuations or changes. HdM refuses and declares about 4 months later that they cannot clarify the planning situation for the city.
December 21, 2007	ReGe hires law firm "Heiermann Franke Knippe" as a legal consultant.
January 24, 2008	The culture department asks Wegener to correct a meeting protocol in which Wegener acknowledged that the tender process' schedule was chosen because of upcoming elections.
February 1, 2008	A protocol of a Jour-Fixe meeting reveals the destructive work relationship between HdM and Hochtief.
February 24, 2008	Elections for the Bürgerschaft. CDU loses the majority but stays in power, forming a coalition with the Green Party.
March 7, 2008	First handwritten note of Wegener to the Mayor mentioning possible cost overruns (around €50 million).
June 2008	The city-side responsibility shifts from the city development to the culture department.

(*continued*)

June 19, 2008	Meeting of the board of supervisors, the day before, Hochtief informed ReGe of their €90 million claim for construction hold-ups, which ReGe delivers at the meeting.
July 1, 2008	A first summit including HdM, ReGe, and Hochtief take place chaired by the First Mayor.
July 29, 2008	A second summit including HdM, ReGe, and Hochtief (with Hochtief and HdM in different sessions) takes place chaired by the First Mayor.
August 8, 2008	Wegener declares the negotiations for contract amendment three to have failed.
September 10, 2008	The board of supervisors allows Wegener a negotiation mandate of €75.2 million, provided a synchronized schedule between Hochtief and HdM exists.
September 11, 2008	A meeting reveals there is no synchronized planning but only a Letter of Intent to establish one.
September 12, 2008	Wegener and Henner Mahlstedt (Hochtief board of directors) meet for another (second) informal negotiation of contract amendment three. The scheduled official meeting on September 17 does not take place.
September 2008	Harald Wegener leaves ReGe; Heribert Leutner returns as the new head of ReGe.
October 9, 2008	Johann C. Lindenberg, former CEO of Unilever Germany, becomes the new head of the board of supervisors. The board members are rotated.
November 10, 2008	HdM project leader David Koch warns in an email of a premature closure of contract amendment four; he renews the warning on November 19 and November 20.
November 26, 2008	Contract amendment four is signed, worth €137.8 million.
January 6, 2009	Wegener writes a letter to von Beust, claiming the expensive contract amendment would not have happened under his leadership.
January 23, 2009	Karin von Welck claims that contract amendment four was a success.
March 4, 2009	Within the Bürgerschaft, the contract amendment four passes against the votes of SPD.
December 19, 2009	The first element of the glass façade is installed.
January 12, 2010	In a concerted visit to the construction site, HdM, Hochtief, and city acknowledge that construction is 8–10 weeks behind. The same day, Hochtief sends a message claiming the opening must be delayed another year.
January 18, 2010	Parliamentary party leaders are informed of the current claim status in a closed session.
2010, Spring	The city files a lawsuit against Hochtief, claiming the delivery of a fixed construction schedule to determine the party responsible for delays.

(*continued*)

May 5, 2010	A Parliamentary Inquiry Commission is installed.
May, 2010	HdM delivers a report claiming 4494 lacks in construction quality.
May 28, 2010	Roofing ceremony.
July 18, 2010	Ole von Beust announces his resignation, so does Karin von Welck and other project participants.
August 25, 2010	The Bürgerschaft votes for Christoph Althaus (CDU) as new First Mayor. Reinhard Stuth returns as new head of the cultural department.
November 28, 2010	The Green Party cancels the coalition. The Parliamentary Inquiry Commission, therefore, only publishes a status report.
February 20, 2011	The SPD wins the election with a majority; Olaf Scholz becomes the new First Mayor. New Senator for the cultural department is Barbara Kisseler. The Inquiry Commission is reinstalled.
April 19, 2011	Mahlstedt and Lindenberg agree to a settlement through an arbitrating body, but Hochtief cancels the agreement shortly thereafter.
June 2011	Hochtief conveys to the city that construction would only be finished in April 2014.
June 29, 2011	ReGe presents a document including possible scenarios for a contract termination.
July 13, 2011	Mahlstedt presents to Kisseler the cornerstones of suggested options, including a restructuring of the governance setup and contract termination.
September 20, 2011	Hochtief announces it will stop the work on the concert hall's main roof in mid-October, due to concerns over the calculated statics.
September 30, 2011	Hochtief announces it will stop its share of planning.
October 2011	The Senate informs the public of the current status, ReGe starts talks with subcontractors to see if they were willing to continue working for the city outside of the Hochtief contract.
November 2011	Hochtief corrects the envisaged construction finish from April to November 2014. The city claims €40.6 million from Hochtief for hold-ups.
January 16, 2012	ReGe threatens Hochtief to withdraw the right for planning shares for the technical equipment, if not provided by February 28.
February 2, 2012	Ole von Beust, questioned by the Inquiry Commission, takes full responsibility for the project.
March 2012	Leutner and new Hochtief-Europe CEO Rainer Eichholz develop ideas for a restructuring but drop them again.

(*continued*)

April 12, 2012	The city threatens contract termination if the roof was not lowered by end May. Hochtief answers it will prepare working continuation.
June 13, 2012	Eichholz cancels the previous formal agreements in a letter.
June 14, 2012	A meeting between Kisseler, Leutner, Margedant, Hill, and Eichholz fails to deliver progress.
June 21, 2012	Hochtief receives a third ultimatum: The agreed cornerstones should be signed by June 28 or negotiations would be cancelled. Hochtief asks for a prolongation until July 5.
2012, Spring	Spanish construction company ACS, who has previously taken over Hochtief, makes Marcelino Fernández Verdes as CEO of Hochtief Solutions AG.
May 2012	Verdes and David Koch, HdM's partner in charge of the Elbphilharmonie, meet in Hamburg.
July 3, 2012	Following his call from July 1st, Kisseler and Fernández Verdes meet in Hamburg.
July 5, 2012	A first agreement paper is signed: According to the text, the roof will be lowered, HdM and Hochtief continue planning together, construction will finish in Mid-2015, and cost claims will be settled by an arbitration body.
August 21, 2012	The Senate gives a status report, highlighting that the construction stop was ongoing for 11 months.
August 27, 2012	Kisseler, Hill, Margedant, Fernández Verdes, and Koch meet in Venice. They agree that the July 5 paper is not a viable solution, as long, mutually unsatisfactory arbitration processes would be necessary to settle all cost claims. Kisseler, nevertheless, requests the roof to be lowered as a sign of good faith. In the evening, Kisseler meets with de Meuron, who makes clear that only a complete restructuring including Hochtief is a viable option for HdM—both meetings take place without ReGe and the public knowing.
August 29, 2012	Scholz and Fernández Verdes meet, together with Kisseler, Hill, and Koch. Scholz requests the lowering of the roof. Thereafter, Hochtief allows the city review their accounting statements to clarify on their financial situation.
September 17, 2012	The lowering of the roof begins.
September 19, 2012	ReGe asks for permission to start a contract termination. They put projected €349 million costs in project continuation without Hochtief against €346 million continuing with Hochtief. In a termination scenario, they calculate with a 50–80 % success chance in claiming up to €244 million.
November 2012	Fernández Verdes becomes CEO of Hochtief Solutions AG.

(*continued*)

November 23, 2012	Hochtief announces the successful lowering of the roof.
December 4, 2012	A Hamburg-intern summit chaired by Scholz assesses the risk of the alternatives. In the following weeks, several new offers by Hochtief come in.
December 14, 2012	The board of supervisors discusses the final Hochtief restructuring offer but comes to no conclusion.
December 15, 2012	During a special session of the Senate, Scholz receives a message from Hochtief giving in to the last of the city's demands (the right to contract termination and immediate access to the construction site if the new contracts would not be ready by February 28). The Senate agrees.
January 7, 2013	Leutner resigns.
March 1, 2013	The Senate announces the finish of contract negotiations, only appendices would remain unfinished. They are finished on April 9.
June 19, 2013	With only the votes of the SPD, the contract amendment five passes the Bürgerschaft.
November 2013	Shell construction is finished.
December 2013	Fitting of the "White Skin" starts.
January 2014	The glass façade is finished.
August 2014	The roof is rain-proof.
January 12, 2015	During a press visit to the large concert hall, Olaf Scholz announces that January 11, 2017, is envisaged as the date for the first concert. The Plaza should be opened in November 2016.
April 14, 2015	Following the elections in February, the new SPD–Green coalition is formed.
April 30, 2015	Projected finishing time for the fitting of the White Skin.
January 31, 2016	Projected finishing time for the large concert hall.
October 31, 2016	Projected transfer to the city.

Sources: B/PUA (2014), Abendblatt (2013), elbphilharmonie.de.

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4

Berlin Brandenburg Airport

Jobst Fiedler and Alexander Wendler

Introduction

> The one who can successfully operate airports is not necessarily the one who can build them too. … There was an overconfidence to achieve what better would have been left to professionals to do.
>
> Hartmut Mehdorn, CEO FBB from 2013 to 2015 (Der Spiegel 2014)

High-Profile Failure in Large Infrastructure Projects

“Infrastructure” is a term used for physical assets that “enable, sustain or enhance societal living conditions” (Fulmer 2009, 32). With regulatory power, technical expertise, delivery capacity, and financing ability dispersed among a multitude of state and non-state actors, infrastructure is a case in point of coproduction of statehood that relies on coordination and effective governance. This is exacerbated in cases where the infrastructure

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is complex, costly, and attracts a high level of public attention or political interest—large-scale infrastructure projects or megaprojects.

When such projects fail, the damage to the governments in charge, the private sector service providers, the financiers, public or private, and the users can be enormous. Berlin Brandenburg Airport ("BER" or the "Airport Project") currently under construction in Schönefeld, Brandenburg, is such a high-profile failure being more than 5 years behind schedule and at least 70 % above budget. The official opening date of BER has been moved a number of times, from originally October 2011 to dates in mid-2012, early and then late 2013. Since the last cancellation of a firm opening date in January 2013, the developer of the Airport Project, Flughafen Berlin Brandenburg GmbH (FBB),[1] has not been able to name a new opening date given the complexity of the ongoing technical issues faced until December 2014. Only then the last quarter of 2017 as the targeted time window for the opening date was announced.

Cost overruns and schedule delays are the quintessence of failure, as succinctly formulated by Holgeid and Thompson (2013, 221):

> Project Success: The project is completed on-time and on-budget, delivering the expected value; Project Failure: The project is either terminated or not completed on-time, or not on budget, or not providing the value aimed for.

The failure of the Airport Project has led to several parliamentary hearings and full-scale investigations. Documents and minutes made available by these ongoing investigations point to serious flaws in the governance structure as being at the heart of the disaster. Innumerable change requests by FBB, deficiencies and mistakes in general planning, and failures in construction and interface management are clearly documented and not in dispute. These issues lead inevitably to questions about steering of and by FBB, ranging from the suitability of planning processes, over project organization to the contractual allocation of construction risks.

[1] The airport company underwent a number of name changes before becoming FBB. In this book, "FBB" is used throughout where possible.

This study analyzes BER's governance failures with regard to issues identified by research studies of other large-scale infrastructure projects and attempts to draw lessons. Intriguingly, the BER disaster is neither unique in its failings nor therefore unexpected. The poor experience globally of providing publicly funded megaprojects in infrastructure on time and budget should have heightened the caution of the decision-makers responsible for the Airport Project. But more importantly, if BER's mistakes follow a global pattern, they not only could have been avoidable but also can be the basis for lessons for future projects.

BER is a high-profile failure that did and continues to damage severely the reputation of all actors involved, from architects and planners to engineers, managers, politicians, and Germany as a whole. But while failure was not totally unexpected, it was not predestined either, as large airport passenger terminals can be developed and delivered successfully. Recent examples for successful developments are Munich Airport's Terminal 2 or Hamburg Airport's Terminal 1.

Three broad reasons of why the BER failure is worth exploring are as follows:

(a) Whereas a body of international research exists that explains common mistakes in planning and executing large infrastructure projects, BER and other current projects still have been executed with faulty governance structures. This exacerbates the public outcry and highlights the need for clear and founded lessons such that "this never happens again."
(b) While benefiting from the information made available by the several parliamentary hearings and investigative committees, the study aims at a different outcome. The committees focus on identifying fault and political responsibility instead of drawing general lessons. Their conclusions are also influenced by party political considerations.
(c) There is ongoing innovation in the field of governing large-scale infrastructure projects, in particular in the UK. Assurance and management concepts and contractual arrangements developed for or used by public projects in the UK are available for the analysis.

Research Question and Limitations

The definition of the research question is based on the understanding that governance is at the heart of success or failure of undertaking a megaproject. This logic also applies to BER that shows the full list of symptoms of ineffective project governance, as developed by Greiman (2013, 138):

- owner and sponsor conflicts;
- cost overruns and schedule delays;
- quality control and assurance issues;
- increased project incidents; and
- escalating claims and risk problems.

In order to formulate improvements to the governance of megaprojects based on the specific experiences of designing and constructing BER, the following research question needs to be answered: What were the major mistakes made in the governance of the Airport Project that contributed to the significant time delays and cost increases, and what lessons can be drawn from the BER experience to strengthen the governance of publicly provided megaprojects? Answering this question will have regard to a number of studies undertaken by scholars and practitioners on the different factors for success and failure. Also, new developments in the interplay between public and private sectors that are being applied to mitigate time delays and cost increases in large-scale infrastructure projects will be considered. In order to contain the scope of this study, a number of limitations, time-wise and related to the subject matter, were chosen:

The analysis focuses on the time between the decision to deliver the Airport Project as a public project and the last cancellation of a firm opening date, that is, a period stretching from 2003 to 2013. It focuses further on the delivery of the passenger terminal building. The ancillary buildings or the runway system were excluded since here only few cost and financial issues occurred.

As a consequence, the study does neither touch on the questions of why the privatization process in the late 1990s and early 2000s failed, nor on the possibility of a future privatization of BER. Also excluded are the political decisions to build BER and to locate the airport in Schönefeld and decisions relating to the current airport system in Berlin. On the back end, the analysis focuses on the "original" delivery process and its governance, not the current remedial actions since the arrival of Hartmut Mehdorn as chief executive officer (CEO) in 2013 and his sucessor in 2015 that "try to put humpty back together again." Further, the study sidesteps the much-debated question of comparing public and private ownership and operation of infrastructure assets on the criteria of efficiency or equity but rather draws lessons in order to increase the likelihood of success of projects that for one reason or the other are decided to be undertaken by public entities.

Hypothesis

As mentioned above, the basic understanding of this study is that the significant time delays and cost increases in the construction of the Airport Project are attributable first and foremost to mistakes in designing the governance of the multi-billion-Currency project. Specific problems like the insolvency of designers, design changes due to new EU guidelines, project interface issues, and significant quality problems are mere symptoms of such mistakes.

The problems at BER are, therefore, not based on unique or unprecedented problems or incidences but rather on aspects of governance of megaprojects that have been the subject of research for at least two decades and have been identified and outlined in a number of publications. Building on that basic understanding and recognizing total disregard for best practice by the owners and sponsors of BER, the hypothesis of this thesis is composed of the following parts:

- The literature on megaprojects contains several potentially significant ideas and concepts that have direct relevance for BER.
- Based on a literature review, a set of relevant success criteria can be elaborated which can guide through the vast amount of case-specific information.
- Mistakes were made at BER on both the design and setup of the governance structure and the undertaking of key processes within that structure. Two key issues warrant mention at this point: First, that the megaproject was "squeezed" into an existing corporate governance framework designed for a going concern. Second, that ongoing changes

to size and layout are less a valid explanation for the cost increases (as argued by Hartmut Mehdorn) but rather a cause of the many problems.
– It is believed hthat, built on the foundation laid by the foregoing points, lessons can be drawn to be applied to other large-scale infrastructure projects.

Methods of Inquiry and Sources

The research strategy applied is the case study approach, which is supported by a literature review. The literature review is utilized to build a framework for the case study by crystallizing governance factors important for the success of such undertakings as developed by research. These factors then guide and organize the buildup of the case study, validate the assessment, and inform the drawing of lessons.

A case study is an approach that focuses on "understanding the dynamics present within single settings" and can include the analysis of multiple cases or various levels within one case (Eisenhardt 1989b, 534). The case study of BER is based on a combination of primary and secondary sources. Some of the primary sources relate to parliamentary investigative committee hearings, like written minutes of selected hearings about BER or written Questions and Answers as part of such investigations, or have been made public in connection with such investigations. In particular, the leaders of the Piraten Partei in the State Parliament of Berlin, the party that chairs that parliament's investigations into BER, have proven to be promoters of transparency by making a large number of primary sources public. Such sources include internal documents and reports by FBB and by their expert advisers, as well as project-internal correspondence.

These sources have been supplemented with other public primary sources including reports by audit offices, media releases by FBB, media interviews of key actors, and the project's architect even published his own book. Secondary sources for the case study include a wide range of media reports (newspapers and television), some accounts of statements made during the hearings and other outsider critiques, and non-academic descriptions in book or report form.

Interviews were not conducted. The reasons for this are threefold. First, there is sufficient inside evidence accessible, including accounts and explanations by key actors, to draw a good picture of what happened. Second, the accessibility of key actors is restricted given that the project is still ongoing, is considered a big failure, is politically charged, and parliamentary investigations are current. Third, a clear pattern of "blaming someone else" has emerged that does not much enlighten the issue. The Federal Republic blames the other shareholders, the State of Berlin blames the architects, the architects blame the FBB management, and so on.

The literature review accessed research by scholars and practitioners into success and failure of megaprojects. This research ranged from broad and well-known academic research of Flyvbjerg or Miller and Lessard, over published reviews of specific projects, to a popular account of practitioners backed by Deloitte.

Megaprojects and Their Inherent Problems

Large-Scale Infrastructure Projects—An Introduction

Megaprojects are simply "very large" projects; beyond that the term is open to interpretation and definition. Large-scale infrastructure projects are characterized by high levels of complexity, which can be explained "as a set of problems that consist of many parts with a multitude of possible interrelations and most of them being of high consequence in the decision making process that brings about the final result" (Brockmann 2009, 3). Brockmann highlights that this complexity does encompass not only task complexity but also social and cultural complexity, based on the number of individuals and organizations involved and their different historical experiences (Brockmann 2009, 3–4). Underscoring the multidisciplinary complexity, Hassan et al. (1999, 21) put the following attributes on megaprojects:

- "high" capital costs;
- long duration but program urgency;
- technologically and logistically demanding;

- requires multidisciplinary inputs from many organizations; and
- leads to "virtual enterprise" for the execution of the project.

Drivers of Project Performance

Over the last 10–15 years, the general performance and the underlying performance drivers of megaprojects have been the subject of academic research. However, the continuing troubles with megaprojects can be seen as sign that to date the lessons from the past have been mostly lost and an accessible way to share acquired insights with key actors has still to be found.[2]

This section summarizes the reasoning of several studies of the root causes and the solutions proposed. It also outlines relevant and applicable lessons drawn from a "lessons learned" study of the 2012 London Olympic Games as well as a popular book on "getting big things done in Government."

National Research Council (US Department of Energy)

Given the bad performance of the US Department of Energy in undertaking its complex, very expensive, and sophisticated projects, the National Research Council provided in its report a number of recommendations aimed at lifting the department's performance to the standards of better performing agencies and the private sector (National Research Council 1999, 3–9).

On governance, the council found that there was a lack of comprehensive project organization that covered all parties involved and set out the roles and responsibilities of these parties. In particular, no single authority was responsible, with lines of authority unclear. On risk assessment and mitigation, the report recommended setting contingency levels for each project having regard to the risk appetite, degree of uncertainty, and confidence levels. On project reviews, the report found that inde-

[2] Compare with Concerns in Haynes (2011: 197)

pendent project reviews were essential and recommended the formalization of procedures for independent reviews that are continuing and non-advocate. Finally, on the field of contracting methods, the report pointed to the need for the development of guidelines for structuring and managing performance-based contract, in particular with the view of an appropriate allocation of risks (National Research Council 1999, 3–9).

Miller and Lessard (IMEC Study)

Based on the IMEC Research Program, Miller and Lessard see large-scale infrastructure projects primarily as managerial challenges of coping with unforeseen turbulence. According to the authors, turbulence is triggered by events, exogenous or endogenous, that had not been foreseen and is negatively linked to project performance. Given the long lead times and extended development time spans applying to megaprojects, turbulences are likely to happen (Miller and Lessard 2000, 20–23; 25).

The authors differentiate three types of management approaches used for megaprojects, rational planning, adaptiveness, and shaping, the latter being the preferred one. Rational planning or hyperrationality assumes that the future can be forecast. The media which often cites better planning as the key solution to megaproject delivery performance is a supporter of that approach. However, uncertainty is an inherent fact of large-scale infrastructure projects, and therefore "their management can never be tidy" (Miller and Lessard 2000, 14). In contrast, supporters of the adaptiveness approach argue that megaprojects are unmanageable and a successful outcome is a matter of luck. In the eyes of Miller and Lessard, this is also an inadequate approach. They prefer an approach that includes both, deliberate, planned action and responses to events—what they call "shaping" (Miller and Lessard 2000, 93–112).

Miller and Lessard's focus is on the sponsors of the projects that both lead and coordinate. They state that "successful projects are not selected but shaped" and that "[t]he seeds of success or failure are thus planted and nurtured as choices are made" (Miller and Lessard 2000, 93). Successful sponsors create "governability," the capacity of project participants, which on one hand are autonomous players and on the other are linked to each other through interdependencies, to get through turbulences (Miller and Lessard 2000, 131; 135).

Tools proposed to achieve "governability" are numerous, covering relationships with all project stakeholders. For this book, the devices proposed for relationships with contractors are of special interest. They include turnkey contracts, incentives in target price contracts, functional specifications, and contractors being involved in ownership (Miller and Lessard 2000, 137–140). In the authors' words, looking at the track record, "collaboration between owners and contractors-suppliers and design-build contracting have led to substantial cost and time reductions" (Miller and Lessard 2000, 27).

In a re-examination of the results of the research program, Miller and Hobbs highlight "intense scrutiny" as another key theme of performing projects. Again, strong and performing sponsors are important to ensure and manage the scrutiny of projects. To achieve this, a framework needs to be created where stakeholders with different and conflicting interests and perspectives have the ability and the incentive to dissect, comment and ask for, or demand changes. The authors mention evaluations by financiers and also public consultation as examples (Miller and Hobbs 2005, 42–50).

Flyvbjerg et al.

Flyvbjerg sees the causes for the widespread performance issues at megaprojects in two phenomena, optimism bias (delusion) and strategic misrepresentation (deception). He dismisses the often-stated technical explanations, including inadequate data, honest mistakes, and imperfect techniques, as not consistent with his large sample. In particular, that there is no improvement in accuracy over time and that costs are constantly underestimated, whereas benefits are overestimated, are cited as the reasons that technical explanations do not fit the data (Flyvbjerg 2005, 8–10).

A growing body of social science research concludes that many decisions humans make do not follow rationality and good reasoning but are influenced by irrationality and cognitive biases. "Humans predictably err" according to Thaler and Sunstein (2008, 8). Overoptimism can be linked to these cognitive biases. Another term used in the literature is planning fallacy, specifically used to describe the propensity to underestimate completion times and costs of tasks (Flyvbjerg et al. 2009, 7–8). Nonetheless, Flyvbjerg does not see optimism bias as the primary cause of planning mistakes. Learning processes would have decreased the mistakes that result from the biases over time, but this has not happened according to Flyvbjerg's database (Flyvbjerg 2005, 11).

Instead Flyvbjerg comes to the conclusion that planners and backers deliberately lie and strategically misrepresent costs and benefits driven by political pressure to secure political approval and financing for the project. This conclusion is backed by a series of interviews of individuals involved in large infrastructure projects conducted in the UK in 2004. Another study by Wachs of transit planning cases in the USA came to a similar conclusion (Flyvbjerg 2005, 12–15). The essence of the quote of a consultant given 1990 is basically identical to a quote by Meinhard von Gerkan, architect of the BER Terminal, when interviewed about the Airport Project.

> Success in the consulting business requires the forecaster to adjust results to conform with the wishes of the client.
>
> Consultant, US transit planning, 1990 (quoted after Flyvbjerg 2005, 15)

> The full truth does not get you further in this business. The Sydney Opera House would have never been approved, had it been known from the start what it would cost. It only works with a lie at the start.
>
> Meinhard von Gerkan, architect, 2013 (quoted after Der Spiegel 2013)

Flyvbjerg explains the occurrence of strategic deception with the principal–agent theory. Agency theory deals with situations where one party (the principal) assigns a task to another party (the agent) and describes the relationship between the two parties with the tool of a contract. The contracting problems focus in particular on moral hazard and different attitudes toward risk (Eisenhardt 1989a, 58–59). Based on this theory, Flyvbjerg highlights the necessary conditions that encourage deception (Flyvbjerg et al. 2009, 10–16):

- existence of differences in the actors' self-interest;
- presence of asymmetric information;
- actors have different risk preferences;
- actors have different time horizons; and
- diffuse or asymmetric accountability.

Having identified deception as the primary cause of planning mistakes, Flyvbjerg amends his views in subsequent publications and calls delusion and deception "complementary rather than alternative explanations of failure of large infrastructure projects due to cost underestimation and benefit overestimation" (Flyvbjerg et al. 2009, 16). He recognizes that learning from one's own mistakes has only a limited influence, as "[a]lthough large infrastructure projects occur frequently across the globe, any individual project is often a once in a career decision for a public or private executive" (Flyvbjerg et al. 2009, 30).

Flyvbjerg goes on to propose a cure each for the identified causes for planning mistakes. Delusion can best be confronted by a better forecasting technique, reference class forecasting. Reference class forecasting applies actual experiences on comparable projects by aggregating those in statistically meaningful reference classes. The project is then placed in a statistical distribution of results from the relevant class of projects (Flyvbjerg 2005, 17–18). In order to prevent bias when predicting where the project falls along the historical distribution, the methodology includes mechanisms to correct intuitive estimates.[3]

Deception can best be tackled through accountability and transparency, or—in keeping with the principal–agent theory—through an optimal contract between the principal and the agent. Such a contract would be either behavior-oriented (e.g. salaries, hierarchical governance) or outcome-oriented (e.g. transfer of property rights, market governance) (Eisenhardt 1989a, 58–61). The practices recommended by Flyvbjerg aim at improved control structures via "contracted" changes to the incentive structure. The first practice is for proposing and approving authorities to share financial responsibility. This is relevant for projects where local authorities are proposing and where a minimum contribu-

[3] For more detail, refer to Flyvbjerg (2005: 24–28).

tion by these same authorities may decrease the incentive for deception. More convincing and with a broader application is the second practice to include private financiers in the financing of the project, who put their own capital at risk. This proposal unquestionably would improve control structures, including through in-depth project finance lender due diligence. A third proposal aims at implementing independent peer reviews for consultants and advisers. A further proposal recommends placing financial risk with contractors for delays and scope increases (Flyvbjerg et al. 2009, 19–24). In addition, strong governance frameworks with professional and criminal penalties and clear accountability including director liability are cited as mechanisms to deter lying (Flyvbjerg 2005, 22–27).

Flyvbjerg et al. are more structured when they propose to achieve accountability in megaproject decision-making through four specific "basic instruments" (Flyvbjerg et al. 2003, 107–123):

- Transparency, as this is the main mechanism to achieve accountability in the public sector. All documents to be available for public scrutiny. Also active stakeholder engagement is advised.
- Performance specifications; these would "derive from policy objectives and public interest requirements to be met by the project" for a "goal-driven appraisal and decision-making process" (Flyvbjerg et al. 2003, 123–124).
- Explicit formulation of the regulatory regime.

  The involvement of risk capital; importantly, "no total sovereign guarantee should be given to the lenders" (Flyvbjerg et al. 2003, 109). Private risk capital "will ensure a higher degree of involvement by the lenders during the final design, construction and operation of the project, and more efficient monitoring" (Flyvbjerg et al. 2003, 121).

Mott MacDonald

In its study for the UK Treasury, Mott MacDonald made the premise that optimism bias was the reason for the recorded timetable and cost overruns. The study found high levels of optimisms in forecasting costs and delivery times, as well as project benefits (Mott MacDonald 2002, 1–4). The authors saw in turn the main cause for optimism bias in failed risk identification and management. Whereas the authors did not see a correlation between project size and optimism bias, there was a strong correlation between the project size and the number of project specific risks (Mott MacDonald 2002, 19).

In comparing traditionally procured projects with PFI projects, Mott MacDonald came to the conclusion that the latter showed less optimism bias. Two explanations were given for this finding. First, the negotiated risk transfer of PFI projects passed on the risks to the party best placed to manage the risk, and second, PFI projects showed higher levels of due diligence.

Interestingly and in contrast to Flyvbjerg et al., Mott MacDonald have identified a trend of reducing levels of optimism bias, which the authors have contributed to the use of, among others, the following improved project management tools (Mott MacDonald 2002, 3; 21–31):

- improved risk allocation, through focus on output (instead of input) specified requirements, as well as risk allocation through new contracting techniques including PFI;
- greater diligence at the project definition stage, resulting in more robust business cases;
- partnering; in the authors' definition a structured management approach to facilitate team working across contractual boundaries through formalized mutual objectives and agreed problem resolution methods; and
- more controlled cost monitoring.

Institute for Government/2012 London Olympics

Commissioned by the Government Olympic Executive (GOE) and the Department for Culture, Media and Sport (DCMS), the lead government entities coordinating the 2012 London Olympic Games, the Institute for Government undertook a "lessons learned" exercise of the Games (Institute for Government 2013) that have been widely seen as a great success and exceeding expectations. Whereas the study is particularly relevant for the staging of large-scale, high-profile events touching all aspects of government, many of the building blocks discussed and lessons to be learned are very much applicable to stand-alone large-scale infrastructure projects.

Institutional Design and Governance

(a) Necessary powers to implement project to be provided
The Games' governance built on an established model in the UK and Australia, where a statutory body was created to deliver the infrastructure. The Olympic Delivery Authority (ODA) was given clear powers through legislation to see through the delivery of the infrastructure. This included planning powers, avoiding that several local government entities acted as planning bodies (Institute for Government 2013, 34).
(b) Binding all important players into decisions
The governance structure of the Games was complex, with the London Organising Committee of the Olympic and Paralympic Games (LOCOG), ODA, and GOE being the core actors. On top of the governance structure were two cross-program decision-making bodies, the Olympic Board and a Cabinet subcommittee. While these bodies seldom made formal decisions, the Institute highlights these bodies' role in "binding all the important players into decisions" (Institute for Government 2013, 37).

People and Skills

(c) Attract best people with track record of success
The Games followed the strategy of hiring the best-in-class, which meant that established leaders in their respective fields were targeted across the full spectrum of the structure. This resulted in the need to pay relatively high salaries. In exchange, ODA and GOE had access to exceptional talent from the construction, operations, communications, and financial worlds. To run LOCOG as CEO, for example, the then chief operating officer (COO) of Goldman Sachs Europe was hired (Institute for Government 2013, 39–40).

Budget

(d) Include a sizeable contingency into the budget
The Games' public sector funding budget of GBP 9.3 billion as of March 2007 included a contingency of 30 %. This contingency resulted in the broad understanding that the envelope was fixed. Whereas significant unforeseen or unexpected funding requirements surfaced in the next 5 years, the overall budget stayed at GBP 9.3 billion—a fact that contributed significantly to the overall view that the Games were a great success (Institute for Government 2013, 44–48).

Program and Project Management

(e) Set a robust design and engineering scope and discourage change. According to the study, strict change control was identified as crucial to ensure project delivery in time and within budget. This required on one hand time and effort to get the scope right upfront, and on the other to limit subsequent changes to this scope. Making changes was made very difficult by creating a Change Board that needed to be convinced of the merits of any change (Institute for Government 2013, 51–52).
(f) Limit innovation
Tried and tested methods have a clear advantage when dealing with high-profile projects and hard deadlines. For the Olympics this meant working with tried methods and processes and scaling them to the required size or capacity (Institute for Government 2013, 69)

Risk and Scrutiny

(g) Seek for scrutiny by external bodies
The Institute for Government attributed a high value to the Games from the scrutiny of external bodies, in particular the IOC's

Coordination Commission and the Commission for Sustainable London 2012 (Institute for Government 2013, 64)

Eggers and O'Leary (If We Can Put a Man on the Moon)

Eggers and O'Leary sets itself apart from the academic studies and research papers outlined in this chapter. In content and style, it is not targeted as much at academics or practitioners, but rather the discerning reader in the mass market. Nevertheless, its case study–based outline of traps for and problems in the delivery of large policy programs and public projects contains some interesting findings that are relevant for this book.

The book's findings are based on the analysis of 75 large public initiatives of the US Government, ranging from wars in the Middle East to the war on poverty, and from environmental programs to large infrastructure projects (Eggers and O'Leary 2009, Loc 336). The findings are summarized in common and recurring "pitfalls," of which the ones relevant for this study are outlined below:

1. Confirmation Bias
   Only facts that confirm the leadership's view of the issues and the world are sought and acknowledged. Information and evidence that does not fit into that worldview is ignored (Eggers and O'Leary 2009, Loc 806; 880).
2. Overconfidence Trap
   "Those who fall into the Overconfidence Trap dismiss those who advise caution, consider only the best-case scenario, and plan with unrealistic budgets and impossible time lines. The best way to avoid the Overconfidence Trap is to take the possibility of failure seriously – and take precautions to avoid it" (Eggers and O'Leary 2009, 451). A way of embracing the risk of failure is through scenario planning and risk mapping.
3. The Complacency Trap
   There is a tendency to become complacent when things are going well. This can lead to risks of not being recognized or appreciated (Eggers and O'Leary 2009, 3528; 3550).

Analytical Framework for Review of BER Project

Each one of the research projects outlined above is a comprehensive and multifaceted work of analysis revealing some important insights of what makes large-scale infrastructure projects succeed or fail. With the aim of applying the key findings to the research question of this paper, the vast body of findings is distilled into ten criteria to assess the governance of BER, as shown in Table 4.1.

Five of the criteria focus on the fundamental setup of the project. Governance as rules set the framework for the delivery of the infrastructure project. The other five criteria focus on processes, more specifically on decisions when shaping and undertaking processes.

The BER Project

> The full truth does not get you further in this business. The Sydney Opera House would have never been approved, had it been known from the start what it would cost. It only works with a lie at the start.
>
> Meinhard von Gerkan, architect of BER (Der Spiegel 2013)

Background: The Long Road Toward a New Airport in Berlin

With growing air traffic to and from West-Berlin hitting constraints in the walled city by the late 1980s, plans to build a new airport for Berlin emerge immediately with the Fall of the Wall. A few months before German Reunification in October 1990, a working group comprising West and East German Government representatives commences work on finding a location for a new capital city airport. In early 1991, 3 of the 53 reviewed potential locations are shortlisted: Schönefeld-Sued, Genshagener Heide, and Sperenberg (During 2013: section 1). A final decision was not taken until mid-1996, when the Federal Republic of Germany and the States of Berlin and Brandenburg executed the "consensus decision" (Konsensbeschluss) to develop Schönefeld to the "single" airport in Berlin and thereby close Tempelhof and Tegel Airports in the

Table 4.1 Assessment criteria

	National Research Council	Miller and Lessard (IMEC)	Flyvbjerg et al.	Mott MacDonald	Institute for Government	Eggers & O'Leary
Governance as rules—fundamental decisions about project setup						
Comprehensive control and steering structure with: (i) clear responsibilities and lines of authority, as well as (ii) decision-making structures that channel expertise and bind all key stakeholders	×	×	×	×	×	×
Transparency and public control to enforce accountability in the public sector	×		×		×	
Expertise on all levels—hiring of best-in-class people and purchase of outside expertise (consultants and advisers)		×			×	
Involvement of risk capital—effective scrutiny by financiers/lenders that put own capital at risk		×	×	×		
Procurement contracting allocating construction and interface risks to contractors and also using incentives/penalties constructs	×	×	×	×	×	
Governance as processes—key decisions when shaping and undertaking processes						
Diligence at project definition stage and robust design at the outset	×	×	×	×	×	
Taking the possibility of failure seriously—inclusion of significant contingencies in cost and time estimates to account for optimism bias	×		×	×	×	×
Discouraging of change requests after design has been agreed					×	
Confront information that makes you uncomfortable include people with different combinations of knowledge and experience and test ideas with skeptics						×
Undertaking of scrutiny processes, for example, independent reviews or peer reviews by external bodies	×	×	×	×	×	

old west of the city. The decision also included a new runway in addition to the existing system at Schönefeld that had served as East-Germany's central airport. Further, the Governments decided to privatize the airport holding, then called Berlin Brandenburg Flughafenholding GmbH (BBF), and have the new airport developed, built, owned, and operated by the private sector (BBF 1996).

In 1999, a consortium led by HOCHTIEF, a German construction group with a nascent airport operations business, was selected as the preferred tenderer in the bidding process. But underbidder IVG, a German real estate company, objected the process and results, ultimately leading to a cancellation of the privatization attempt due to procedural errors (Handelsblatt 2012). A new attempt to privatize BBF also failed. In 2003, the three involved Governments announced that the discussions with HOCHTIEF and IVG, now working together, were cancelled and the entire privatization process terminated. The airport would be built but under public sponsorship. Berlin's Governing Mayor, Klaus Wowereit, stated that "now we have to tackle it ourselves" (FAZ 2003). Flughafen Berlin Schönefeld GmbH (FBS), since 2012 called FBB, was created by merging BBF with two subsidiaries tasked with the new airport development (During 2013).

In August 2004, the Planning Authority of the State of Brandenburg, on which territory Schönefeld is located, confirmed the plans for the expansion of Schönefeld Airport (Planfeststellungsbeschluss; Ministerium für Stadtentwicklung, Wohnen und Verkehr des Landes Brandenburg 2004). The go-ahead for the project was confirmed in 2006, when the Federal Administrative Court in Leipzig dismissed lawsuits by residents against the planning approvals driven by noise concerns (Berlin gegen Fluglärm 2013).

BER Governance and Project Setup

Against Better Knowledge: Failure to Appoint a General Contractor and Consequences for Risk Allocation

When the three Governments decided to change plans and undertake the development of the new BER as a public project in 2003, the decision-makers were aware of the pitfalls of megaprojects. In order to avoid "sloppiness and cost blow outs" of other large public infrastructure projects, Wowereit said they would hire an experienced project manager from the private sector (FAZ 2003). He did this by poaching Thomas Weyer who led HOCHTIEF's efforts during the privatization processes. Starting on January 1, 2004, Weyer became General Manager Berlin Brandenburg International and Technology and in this capacity the project leader responsible for the technical and financial aspects of the Project (FBB 2003). Weyer reported to the CEO/spokesman of the FBB management board, which comprised both of them plus a general manager for human resources. Weyer set up the initial project organization to have a single general contractor take on the responsibility of detailed design, construction planning, and construction work of the BER passenger terminal (Ernst & Young 2012). As part of that project organization, FBB engaged Planungsgemeinschaft Berlin Brandenburg International (pg bbi) as the general planner in January 2005. pg bbi was a joint venture including architects Gerkan, Marg und Partner, and JSK Architekten. The scope of the general planner was to undertake the design stages required to lodge the necessary building permits and prepare the design and program documents for the general contractor tender (i.e. initial design or design planning). Further part of the project organization was the review and supervision of the general contractor's detailed design and ongoing construction performance by an expert on behalf of FBB. In mid-2007, FBB selected pg bbi also to undertake this role.

Whereas the initial project organization was modeled on FBB being a "traditional" client with a general contractor in charge of the passenger terminal, FBB did not appoint a general contractor. This turned the entire project organization on its head and laid the foundation for future problems. On October 9, 2007, the FBB supervisory board approved the proposal of FBB management to annul the tender for the BER passenger terminal because the four offers obtained were perceived as uneconomical. Instead, the works would (likely) be tendered out in seven lots. According to FBB, the re-tender would not impact the completion date, targeted for October 31, 2011 (FBB 2007b).

A challenge by HOCHTIEF, one of the bidders in the terminal tender, was dismissed by the procurement chamber (Vergabekammer) of Brandenburg. The court concurred with FBB's argument that the offers were uneconomical, as all four bidders exceeded the expected lump sum of €630 million by around €400 million (FBB 2007a). The tricky contention of the day was whether €630 million or €1.0 billion was the right construction price for the passenger terminal. FBB and its advisers, buoyed by rumors and allegations of price collusion by the tenderers voiced by small- and medium-sized contractors (Der Tagesspiegel 2007), rejected the calculations of the tenderers that without doubt included sizeable contingencies and discarded the talk of the increased risk of time delays and cost blow outs. A without question biased and upset comment by an HOCHTIEF representative at the time was that breaking the project up into lots would make it more complex and result in a completion date much later than originally planned (Berliner Zeitung 2007). A statement that time proved correct, as HOCHTIEF's external legal counsel reiterated in May 2012 saying that the "adventurous" assessment of the day that by undertaking the detailed design themselves and breaking the project into smaller components would save €350 million and time had been proven as completely wrong (Leinemann Partner Rechtsanwälte 2012).

An immediate consequence of the refusal to appoint a general contractor was that FBB would now take on responsibility for the detailed design and construction planning. The detailed design of the passenger terminal was therefore tendered, with pg bbi securing the role which was agreed in early 2008. The scope was increased to also cover the piers north and south in addition to the main terminal building. Further, pg bbi was to prepare and to be involved in the tender of the seven lots. The targeted completion date remained the October 31, 2011 (Ernst & Young 2012, 7).

The challenging situation for FBB was not helped by the sudden departure of key man Thomas Weyer, who moved on to become general manager at Munich Airport. He resigned in March 2008, during the tendering phase, and had left FBB by August 2008. Weyer was replaced by Dr. Manfred A, Körtgen (FBB 2008a, b).

To bolster FBB's skill set through external know-how, in 2008 FBB outsourced project management and controlling, that is, the construction manager role, first to Drees & Sommer, and after their departure in early 2009 to WSP/CBP (BZ Berlin 2012). Press reports of the time stated that Drees & Sommer were terminated because they reported in

November 2008 that it would be illusory to believe that the terminal could open at the envisaged date at the estimated costs—either the costs needed to increase or the opening date pushed back (Die Zeit 2012). Years later WSP/CBP said that they never reported directly to the supervisory board with their cost and timing estimates but only via FBB management (Abgeordnetenhaus Berlin 2013b, 52).

The press reports on Drees & Sommer's advice were corroborated when a confidential letter (Drees and Sommer 2008) from the construction manager to FBB's Manfred Körtgen, Weyer's replacement, from November 2008 was published in early 2014. However, whereas Drees & Sommer introduced their analysis by highlighting that the practice of undertaking the different tenders before the detailed design was completed resulted in significant follow-on cost risks, their advice on what to do would ultimately lead to further problems.

Drees & Sommer's analysis was undertaken because the tenders of the seven lots returned significantly higher costings than anticipated. With the exception of the baggage handling system, the costs were 55–175 % higher than estimated. According to the construction managers, the reasons were that the lots of €50 million and more were too large for a strong competition to form and the inherent interface risks within these work packages plus the lack of completed detailed design resulted in high contingencies (Drees and Sommer 2008, 5). Based on the tender results the construction costs of the passenger terminal would increase to approximately €1.1 billion (Drees and Sommer 2008, 8). Drees & Sommer then analyzed three alternatives. The first alternative was to progress with the seven lots and accept the higher costs. Even then the targeted opening date would be "significantly threatened and only achievable through fast-tracking measures" (Drees and Sommer 2008, 10). The second alternative saw the cancellation of most of the tenders and negotiated awards with the chance of some cost reductions (approx. €12 million). A delay of at least 6 months would result. The third alternative had the seven lots broken up into many smaller lots. This would result in a delay of 12–18 months and savings versus the first alternative of €56 million. The risk of achieving the cost targets and the (revised) time targets was seen as lowest for alternative three (Drees and Sommer 2008, 12–20). Also, it was advised to change the contracts from fixed time, fixed price contracts to fixed unit rates contracts without penalties, in order to decrease the contractors' contingencies and achieve the envisaged cost savings.

Intriguingly, FBB took the advice to break up the passenger terminal construction into around 35 lots with as much tenders—a decision that with the benefit of hindsight can be seen very negatively and as key contributor to the experienced delays (Ernst & Young 2012, 12). However, FBB did neither take the advice to amend the completion date by 12–18 months as clearly outlined in Drees & Sommer's analysis nor rectified the inherent problem that tenders were undertaken and construction commenced prior to have the detailed design and planning phase concluded.

Through the change in the award structure, FBB turned from principal and client to ultimately something resembling a general contractor. Subsequently, it became apparent, however, that FBB had bitten off more than it could chew. Ernst & Young concluded years later that FBB did not revise its structure and internal processes accordingly (Ernst & Young 2012, 10). A key example is the double role of pg bbi as mentioned above. When pg bbi's scope as general planner increased to take over the detailed design, after it had already won the separate tender for the role to review and supervise the (general contractor's) detailed design and the ongoing construction performance, pg bbi did in effect supervise itself (Der Tagesspiegel 2012). Interestingly, this apparent conflict of interest was discussed at the FBB supervisory board but not rectified. Key argument was that pg bbi was legally entitled to participate in both tenders and won both based on the bid criteria (Abgeordnetenhaus Berlin 2012a, 33). The revision of the award structure for the passenger terminal building had significant consequences for the risk allocation. The responsibility for the detailed design would remain with FBB—without a chance to allocate it in its entirety to other parties. Instead of only overseeing one general contractor that would also be charged with the detailed design, FBB was now in charge of the detailed design and the interface with around 35 contractors. These many interfaces made it impossible to effectively contract out the risk that the works of the many contractors would function as part of a whole state-of-the-art passenger terminal.

Project Supervision and Control: Deficiencies in Structure and Expertise Levels

The Project was managed by FBB management, supported by its advisers and consultants, which in turn reported to the FBB supervisory board, a board of non-executive directors tasked by the German corporation law (Aktiengesetz) to supervise management.[4] This board is a statutory body applying to all German corporations and its governance takes no special consideration of the requirements of a megaproject. In this particular case, the board was tasked with both, supervising the management of three operating airports (until Tempelhof's closure) and supervising the development and construction of a new airport.

The supervisory board of FBB met four to five times a year (Abgeordnetenhaus Berlin 2012b) and comprised representatives of the three shareholders, who made up two thirds of the members, and representatives of the company's employees, who made up the remaining one third (rbb 2013a).[5] As of December 2013, eight of the ten supervisory board members sent by the shareholders were politicians on premier/cabinet minister or state secretary level. The remaining two were a hotel and gastronomy consultant and the manager of the chamber of industry and commerce of Cottbus, a small city in Brandenburg with around 100,000 inhabitants (rbb 2013a). When the symptoms of ineffective project governance started to pile up, members and ex-members of the board started to voice criticism about the lack in relevant expertise. Harald Wolf, Minister of Economics in Berlin's previous Government and during his tenure member of the FBB supervisory board, stated to the investigative committee that the airport company had too little know-how of construction issues to manage such a complex project and that he only realized that fact in hindsight. Purchasing the missing skills externally was counterproductive as it further increased complexity and contributed to the disaster (rbb 2013b). Engelbert Lütke Daldrup, a former state secretary in the Federal

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[4] Refer to Aktiengesetz, §111 Aufgaben und Rechte des Aufsichtsrats.

[5] In the period from 2003 to 2011, only in 2007, there were more than five meetings p.a. (there were eight).

Ministry of Transport, Construction, and Urban Affairs and supervisory board member from 2006 to 2009, concurred with the expertise point. Interviewed by the investigative committee of the State Parliament Berlin, he said that experts were missing on the board. He would have wished for more expert knowledge on construction issues (rbb 2013c). Instead of focusing on the important matters, the board spent its time on minor issues and details. Daldrup also stated that his proposal to nominate an FBB finance director was implemented only 5 years later (Piraten Fraktion Berlin 2013a). Asked by the Berlin State Parliament on the issue of expertise, Klaus Wowereit, chairman of the supervisory board, was quite clear when he said that there is no proven expert with construction competences, no one that had been chosen with those requirements in mind, on the board (Abgeordetenhaus Berlin 2012a, 7).

Another point of ex post criticism is that the board may have been seen as unapproachable, given its political whiff and the fact that it was chaired by two top politicians, the Governing Mayor of Berlin and the Premier of Brandenburg. pg bbi reportedly indicated later, after they got dismissed, that they were repeatedly told by FBB management, "we solve the problems here among professionals. They are politics. We keep them out of it" (Abgeordnetenhaus Berlin 2013b, 47). Harald Wolf's statement to the investigative committee that "there were substantial deficiencies in the flow of information" backs that argument (rbb 2013b). But it also points into the direction of inaccuracy of information. Whether the supervisory board was lied at is a contentious issue—it is one's word against another's. Serious allegations have been made by disgruntled architect Meinhard von Gerkan against FBB management. With management falsifying internal conclusions, minutes, and timetables, "[t]he reporting to the supervisory board, […], corresponded therefore not always to the truth, to say the least" (von Gerkan 2013). Supported are these allegations by the statement to the investigative committee of Michael Zehden, the hotelier on the supervisory board, that he believed controlling reports provided to the supervisory board had been altered (Piraten Fraktion Berlin 2013b).

In any case, the need for a tight control of the airport company should not have been news to the responsible politicians. Mismanagement and sloppy business practices were an issue before, when the company spent

400 million Deutsche Mark including 19 million in fees to its own advisers for 118 hectare of overpriced agricultural land assumed to be required for the airport expansion but then written off because the plans changed (Der Spiegel 1995). The supervisory board of the time did not undertake its control function effectively as clearly stated by the Bundesrechnungshof, which wrote in its report that "the federal Government should strongly advise its representatives on the supervisory board to comply with their control obligations and ensure that the BBF-Holding keeps house properly" (Deutscher Bundestag 1995, 2774).

Financing and the Role of Banks

FBB's shareholders provided a 100 % guarantee in regard to the entire debt amount of €2.4 billion (Landesrechnungshof Brandenburg 2011, 226). The guarantee, including waiving rights to contest, offset, or pursue any other remedies (Landesrechnungshof Brandenburg 2011, 226), was provided to the airport company on June 24, 2009 (Bundesrechnungshof 2011, 10). Given the nature of the guarantors, the loans are virtually risk-free for the lenders, a fact that is underlined by the exemption to provide equity capital under the banking regulations (Landesrechnungshof Brandenburg 2011, 226). As a result, the feasibility of the project, the design of a robust project delivery governance including customary checks, and the typical contractual requirements of lenders that aim to avoid cost and time overruns were of no economic interest to the lenders (Landesrechnungshof Brandenburg 2011, 226). Taking the "corrective" lenders out of the equation, however, can lead to a significant deficit of expert knowledge in the overall design of the project, ranging from the contractual relationships of parties, over input of lenders' independent experts, to oversight.

In order to offset the loss of banks as actors, the guarantors set up a guarantors controlling by engaging PriceWaterhouseCoopers, an accounting firm, to undertake certain services (Bundesrechnungshof 2011, 9). The extent of the guarantors controlling was the topic of two court of auditors reports, one on federal level, the Bundesrechnungshof (Bundesrechnungshof 2011, 10), and one on state level, the Landesrechnungshof Brandenburg

(Landesrechnungshof Brandenburg 2011), both of which critiqued that the controlling did not follow the processes and methodologies applied by banks for arms-length commercial loans.

The Landesrechnungshof Brandenburg provided the following concise summary:

> According to the Ministry of Finance its guarantors controlling is, in its core, composed of the auditing firm receiving information from the airport operating company, the auditing firm evaluating this information and then providing this information plus analysis to the ministry. In the view of the Landesrechnungshof is such a guarantor controlling not adequate to properly compensate for the loss of the bank monitoring of the guaranteed loan commitment. (Landesrechnungshof Brandenburg 2011, 235)

The Design Process and Change Requests

Despite revising the award structure in late 2007, FBB was focused on keeping the targeted completion date of October 31, 2011, unchanged, as outlined above. In order to keep with that timetable, the different tenders were undertaken before the detailed design was completed. In several cases, the tenders were undertaken with designs that were subsequently changed significantly. That meant that detailed design and construction were often undertaken in parallel, resulting in both, additional claims by the contractors and interruptions in the construction (stop-and-go; Ernst & Young 2012, 8; 11). Whereas construction on the BER passenger terminal started on July 11, 2008 (FBB 2010b, 7), the changes to the design were so substantial that new building permits were sought on March 30, 2009 (Ernst & Young 2012, 12). According to pg bbi, additional new building permits were sought during their time of involvement, including in February 2012, 3 months before the planned opening date (rbb 2014a).

The parallel designing and constructing resulted in a considerable complexity that made the project overly vulnerable to mistakes in design documentation (by pg bbi) as well as change requests (by FBB). Following the fourth postponement of the opening date Horst Amman, then COO of FBB, summarized as follows:

> We had to endure a whole range of changes in planning and use, […] and therefore had to undergo constant changes in the design of these facilities. Unfortunately, we also have in many places a lack of planning quality, a very late delivery of design documents, and therefore time delays and the need to increase the pressure of time massively, all of which has ultimately resulted in the problems. (Abgeordnetenhaus Berlin 2013b, 5)

Ongoing design changes were at the heart of the complex problems with the fire safety services that have not been solved to date. The fire safety services including the smoke extraction services were originally designed in a much smaller scale and were upsized as the building envelope grew over the design and construction period (Abgeordnetenhaus Berlin 2012a, 51–52). According to a representative of one of the many contractors responsible for components of the smoke extraction services, Robert Bosch GmbH, the many change requests by FBB resulted in requirements to redesign and retest the service installations. During the project, there were very many change requests, for Bosch, more than 300 (Abgeordnetenhaus Berlin 2013b, 15).

Some design changes might have been inevitable because of changing demands of the important airlines. But one design change stands out as a said example of misguided ambition and ignorance of its later repercussions of FBB management: the redesign of the terminal building to prepare it to handle the newly developed A-380 Airbus plane with a capacity of up to 800 passengers. An airplane which can economically only be employed by airlines in hubs where several passenger streams can fill up the huge volume of this plane. Thus, a decision which only made sense if BER could develop into a third hub in Germany after Munich and Frankfurt or the fifth hub in Europe considering Amsterdam and Copenhagen. This was already an illusion at the time of the FBB management decision to redesign. By now, it turns out that the A-380 will not use the BER airport in any regular schedule in the future, but the change in the terminal building including new bridges and a breakup of previously separated floors have necessitated major changes in the smoke extraction system further undermining its functionality. (Information to the author by a well-informed insider.)

The aggregate number of change requests alters by time frame and definition. Wowereit confirmed that FBB requested around 150 changes in the time from January 2008 and December 2012. In any case, he put emphasis on the point that each one of such requests was examined by pg bbi before implementation as of cost and time implications (Abgeordnetenhaus Berlin 2013c). According to Meinhard von Gerkan pg bbi did include 286 change requests and 201 orders, that is, a total of 487 changes requested by FBB, into its design of the passenger terminal, until it got dismissed in early 2012 (von Gerkan 2013).

On January 29, 2010, FBB management ordered a stop to any more change requests, however, without success (von Gerkan 2013). Only weeks before the second delay and pg bbi's dismissal as general planner, Ernst & Young, on behalf of pg bbi, detailed a number of change requests, including six major disruptions that in their opinion resulted in significant interferences and ultimately mistakes and delays. One of those was the redesign of the passenger boarding bridges (see case study below; Ernst & Young 2012, 15–16).

Case Study: Redesign of Passenger Boarding Bridges

In pg bbi's initial design of 2007, agreed by FBB and used as basis for the contractors' tenders, international passengers had to use stairs or elevators before accessing the passenger boarding bridges. During the use by international passengers, the stairways were not available for domestic/Schengen passengers. As a result, there were only 25 gates available for international passengers. Change request no. 68 provided for a fundamental redesign of the boarding process by including double-story boarding bridges that resulted in a more comfortable boarding experience for international passengers and increased the number of gates available for international flights to 39. After taking into account pg bbi's review of impact on time and costs, FBB directed on July 10, 2008, that change request no. 68 be implemented.

By the time change no. 68 needed to be implemented, the detailed design, based on the original 2007 initial design, was already progressed. But not only initial design and detailed design needed to be redone to take into account the new structural realities but also a new building approval application lodged, which was finalized on March 30, 2009. The partial restart of the detailed design of the passenger terminal structure and the resulting procedure of designing and constructing in parallel ultimately led to several construction stops and an increase in proneness to error (Ernst & Young 2012, 15–16).

Anatomy of a Missed Timetable

According to Greiman (2013, 138), the symptoms of ineffective project governance are manifold, including cost overruns, timetable delays, and quality control issues. The following chronicle of the four delays and their explanations is full of those symptoms. Based on that logic, it is important to see the explanations given by FBB and others not as root causes but more as a signal that the governance was not right.

First Postponement—From October 31, 2011, to June 3, 2012

On June 25, 2010, the FBB supervisory board agreed to delay the opening date from October 31, 2011, to June 3, 2012, a delay of approximately 7 months. The reason cited by FBB in its media release was the need to expand the airport security screening area following EU directive 297/2010. It also referred to the insolvency of one of the joint venture partners in pg bbi, IGK-IGR Ingenieurgesellschaft Kruck mbH, which was responsible for the design of the technical building services/installations/equipment (FBB 2010a).

This delay followed an internal tussle of at least a few months. According to the parliamentary committee investigating this first delay, the FBB supervisory board discussed, at its meeting on March 26, 2010, the two issues in-depth and, following a report by construction manager WSP/CBP, came to the conclusion that the completion date October 31, 2011, was not in jeopardy (Abgeordnetenhaus Berlin 2010, 3). According to FBB, the remaining pg bbi partners confirmed verbally and in writing to be able to keep to the envisaged timetable (FBB 2010b, 4–5). Interestingly, a letter by pg bbi to FBB CEO Rainer Schwarz dated February 26, 2010, clearly documents doubt that the completion date can be realized. The general planner refers to the time lost because of the change in contracting strategy in 2007 and design mistakes resulting from the time pressure that meant designing and constructing in parallel (Planungsgemeinschaft Flughafen Berlin Brandenburg International 2010). On May 19, 2010, WSP/CBP changed its estimates and issued a letter to FBB advising that the construction end date was in danger due to insolvency-related delays. Then, on May 25, the German Federal Police, the agency in charge of screening passengers, advised FBB that it was of the view that a doubling of the space allocated for screening was required due to the new EU directive on liquids, aerosols, and gels (FBB 2010b, 5). In the end, the FBB supervisory board agreed to the (first) delay, of which Matthias Platzeck, Prime Minister of the State of Brandenburg, said: “The decision we took today is a decision driven by reason” (FBB 2010a). It is interesting, though, that WSP/CBP’s letter, which reasoning for the delay fit into the “official story,” was made public by FBB at the time, not so pg bbi’s that addressed more fundamental problems.

The repercussions of EU directive 297/2010 show how rushed, thoughtless, and unmonitored the detailed design process must have been, for FBB and its consultants being startled by a meeting with the federal police. Rainer Schwarz, CEO of FBB at the time, summarized the path the EU took in its directives regarding liquids, aerosols, and gels (Abgeordnetenhaus Berlin 2010, 10–11). EU directive 300/2008 from March 11, 2008, provided for specific security standards to be agreed in the future. Directive 272/2009 from April 2, 2009, then advised a deadline of April 29, 2010, for announcing technology and process standards in regard to liquids, aerosols, and gels. This then occurred with directive 297/2010 that went into force on April 29, 2010, and prescribed new screening technology from April 2013 (FBB 2010b, 13–14). That this directive was developed with at least some influence by the aviation industry can be construed by two letters by the Airports Council International Europe, the second one in conjunction with the Association of European Airlines, from June 17 (Airports Council International Europe 2009) and September 14, 2009 (Airports Council International Europe and Association of European Airlines 2009), where the lobbyists set out their concerns to the European Commission about the state of the available technology and the required investment by more than 400 airports.

In the end, even by 2014, the ban on carrying liquids, aerosols, and gels had not been lifted after a concerted effort by aviation industry and EU member states arguing the lack of adequate equipment (Airportfocusinternational.com 2012, 11–12). According to the European Commission, the ban will not be lifted before 2016, at the earliest, giving technology providers plenty of time to develop "skinnier" machines (EC 2014). That the aviation industry is involved in the process and does not need to be "surprised" is further documented in the Airport Council International Europe's position paper on the EU's Aviation Security Technology Roadmap from April 2013 (Airport Council International Europe 2013):

> The European Commission has established a Technology Roadmap Group, involving different Commission services, industry stakeholders and EU Member States and observers. The aim of the group will be: to develop a consensus vision of what technology will be needed and be available for aviation security at different points in the future; to develop a strategy and concrete actions regarding research funding and pre-commercial procurement; and to monitor and support the European Commission Security Equipment Industrial Policy.

Second Postponement—From June 3, 2012, to March 17, 2013

> The construction work has progressed on schedule. Passenger terminal, aerobridges, connections to the road network as well as plant buildings are to a large extent ready. "The opening date of 3. June 2012 is firm. Until then the works on BER will run at full speed," so Dr. Manfred A. Körtgen.
>
> FBB media release, dated 14.12. 2011 (FBB 2011)

On May 8, 2012, 27 days before the planned opening of the BER passenger terminal, FBB hit the brakes. Completion, acceptance testing, and approvals of the fire safety services, in particular the smoke extraction services, could not be achieved for the planned completion date (FBB 2012g).

As at April 20, 2012, the day of the supervisory board meeting, FBB management and its consultants were still of the view that the opening date could be achieved. However, this view was based on the feasibility of a fall back mechanism in regard to the smoke extraction services. Instead of operating a fully automated smoke extraction including computer-guided fire doors, FBB was planning since December 2011 to implement a "human–machine interface" with up to 200 people per shift operating fire doors. After building code officials outlined their doubts about that interim solution, it was finally shelved. Subsequently, on May 7, the chairman of the FBB supervisory board, Klaus Wowereit, was advised of the need for a postponement (Abgeordnetenhaus Berlin 2012a, 3–5; 23).

The chair of the supervisory board as well as FBB management confirmed at the parliamentary committee session discussing this second delay that problems to get the different components of the fire safety services/smoke extraction services, provided by five different firms, to interoperate on time were the sole reason for the postponement. Large problems on site were the complex collision and interface checks between the deliverables of the different providers (Abgeordnetenhaus Berlin 2012a, 21–22; 37; 45).

Following the FBB supervisory meeting on May 17, 2012, FBB announced a new completion date, the March 17, 2013. As reaction to the second postponement, FBB fired pg bbi, the general planner and construction supervisor. It also dismissed Manfred A. Körtgen, General Manager Berlin Brandenburg International and Technology responsible for the technical aspects of the project (FBB 2012f). Körtgen was replaced by Horst Amann from Fraport, who commenced as COO at FBB on August 1, 2012 (FBB 2012e).

Interestingly, the target date of May 17, 2013, was based on a timetable developed by pg bbi in the week before their dismissal as general planner and construction supervisor (FBB 2013d).

Third Postponement—From March 17, 2013, to October 27, 2013

Following his appointment and start at FBB, Amann undertook a detailed review of the construction timing for the BER Terminal (FBB 2012d). The conclusions of the review, made public on September 7, 2012, were drastic: The opening date was postponed to October 27, 2013, and an additional capital requirement of €1.2 billion was identified (FBB 2012c). In a media release, Amann highlighted crucial issues concerning the fire safety installations as reasons for the delay. He stated, "We are still lacking plans for a coherent, integrated planning process. Further work is needed in this area to ensure that the construction companies have a reliable basis to work from for the remainder of the project" (FBB 2012c).

In a report to the FBB supervisory board months later, Amann admitted that an act that aimed at solving the maladministration totally backfired and resulted in months of construction stop commencing in May 2012 (FBB 2013d, 1–2):

> In particular, the core of the project was destroyed through the dismissal of pg bbi as general planner and construction supervisor and not properly replaced. Even the approach to recruit previous subcontractors and have them managed by FBB has failed. The result was a construction stop of several months.

The additional capital requirement of €1.2 billion was broken down as follows (FBB 2012c):

- Additional construction cost so far: €276 million
- Additional construction cost due to delayed opening: €67 million;
- Additional operational cost due to delayed opening: €230 million;
- Risk provision for other cost and loss of revenue: €322 million; and
- Additional cost due to noise abatement measures: €305 million.

Subsequently, an additional €250 million were reallocated to construction costs, without altering the total sum (FBB 2012a).

Fourth Postponement—From October 27, 2013, to No Firm Date yet

First official indication that the opening may not be realized in October 2013 was given by FBB in November 2012. Amann was quoted in a media release as follows (FBB 2012b):

> In their letter, [fire safety experts] hhp admit to deviations between the fire safety concept, planning permission and actual construction of the airport. An analysis of hhp's statement in the last few days has shown that acceptable solutions have not been found for all unresolved issues. We are currently working intensively with planners and experts on finding solutions to any outstanding problems. Further consultations over the next few days will bring clarity.

Clarity of some sort was provided on January 7, 2013, when FBB announced, "that the proposed opening date of 27 October 2013 is no longer viable." "This further delay is the result of problems with the fire protection system, in particular the fresh air supply in the case of a fire and the complexity of the system as a whole." A new opening date was not provided (FBB 2013f).

In an internal report to the supervisory board Amann is more sanguine of what happened. In setting the opening date to October 27, 2013, FBB had deliberately taken the risk of getting necessary construction sign-offs despite actual construction differing from the building approvals received. In the end, though, comprehensive replanning and reprogramming of services were required given feedback from the building authorities. Even more disturbing, a number of extreme building defects were unearthed (FBB 2013d, 1–2).

As a result of the further delay, the FBB supervisory board dismissed Rainer Schwarz, FBB CEO and Commercial Director since 2006, with immediate effect (FBB 2013e). On March 8, 2013, the chairman of the supervisory board presented veteran troubleshooter Hartmut Mehdorn as new FBB CEO (FBB 2013c). Following a public power struggle between Mehdorn and Amann, the latter was relieved from his role as COO (FBB 2013b).

Also in the aftermath of the fourth delay, Klaus Wowereit, Governing Mayor of Berlin, was taken out of the firing line by swapping the role of chairman of the FBB supervisory board with Matthias Platzeck, Prime Minister of the State of Brandenburg, until then deputy chair (FBB 2013e). Wowereit, who was chairman from 2001, was reinstated as chairman on December 13, 2013 (FBB 2013a).

In February 2014, Mehdorn hinted that the airport may not open before 2016, 5 years after the first target opening date (Berliner Morgenpost 2014b).

The Long Road to Final Completion

It turned out that in the month preceding the intended opening date in June 2012, a chaotic rush to completion had taken place. For most of 2012 and 2013, the FBB primarily concentrated on analyzing the multiple deficiencies of the terminal building. Hundreds of issues for repair were lined up, but the most serious deficiencies had to do with the building services technology, in particular the legally required higher standards of fire protection, that is, the design and engineering of the smoke extraction system and several of its software as well as hardware components.

The whole concept including its automation and control was deficient, and a new one had to be designed. In addition, miles of cable channels had been overcrowded with a disorganized assembly of high- and low-voltage cables. This long period of analyzing the deficiencies was negatively impacted by the fact that the architects and the general planner as well as key staff from FBB had been dismissed in the aftermath of the failed opening. Altogether, this resulted in a long period of standstill with no visible progress. As it turned out later, the repair of the damage caused by the rush to completion will ultimately take at least another 4 years (Der Tagesspiegel 2014c).

After Mehdorn had taken over as CEO in mid-2013, he had tried several ways to speed up the completion. But Mehdorn was not successful with the person charged with redesigning the fire protection facilities. This person had to be dismissed because of legal procedures against him regarding presumed conflicts of interest and corruption.

Another approach of Mehdorn was his “SPRINT” program and the attempt to prepare a partial opening of the North Pier for air traffic in order to offset the total standstill. But both did not result in the intended progress. It was not before Mehdorn had been successful to recruit Jörg Marks as the new technical director of FBB that things finally started to move forward in a technically and professionally successful way. Marks had been manager for Siemens for years and in this role also deeply knowledgeable in the intricacies and deficiencies of the fire protection and smoke extraction devices installed in the terminal building.[6]

Since Marks has taken over a re-designed system for fire protection and smoke extraction was decided upon. It is based on splitting the previous

[6] Siemens had been awarded only a limited part of this larger system, only responsible for the automation and control system. Therefore, Siemens was not able to solve the deficiencies alone.

system into three parts. Its official approval by Brandenburg's building authority will be required for opening to occur. Moreover, Marks started a time-consuming room-by-room restoration of the overcrowded cable channels. Since 3.600 kilometers of cable is involved, this will altogether last until mid-2016. Then the official acceptance of the construction work, especially of the smoke extraction system, will follow. Afterward, a larger period of test runs for the terminal building and the facilities at large will follow.

In December 2014, Mehdorn declared that he would step down once a successor would take over. Shortly afterward, the supervisory board decided that the official opening of BER should take place in the last quarter of 2017. A successor from private industry took over in March 2015.

The number of negative surprises, however, did not end in 2014 which by now makes the official opening in the last quarter of 2017 again less likely. In Spring 2015, another standstill of two weeks concerning the crucial completion of the building service technology, especially the fire protection and smoke extraction, occurred. A key contractor went into receivership. It took tough negotiations with the receiver to have that contractor continue their work at BER.

Later, in summer of 2014, it became apparent that in the rush to completion in 2012 it was overlooked that the roof extending over the whole terminal building might have been overloaded by large air-turbines for smoke extraction, which had twice the weight as previously planned. So, the building authority shut down works on the site until a new static analysis cleared the issue.

Finally, more than 600 parts of the internal walls have to be replaced because they contain material not allowed under fire protection regulation. The newly installed CEO of FBB in September 2015, when forced to comment publicly, admitted that management assumes that additional surprises might surface.

Budget Blowout at BER

Throughout the project, the cost situation at BER has lacked transparency. Once the delays started, only high-level figures about new equity injections, one in 2012 and the other in 2014, have been made public. For over 12 months after Mehdorn had taken the reigns, neither the supervisory board with its representatives of the three shareholding Governments nor the parliaments have been provided with a financing plan for the completion of the Airport Project, as confirmed by the State of Brandenburg's finance minister and member of the supervisory board (Märkische Allgemeine Zeitung 2014). An updated plan was finally discussed and agreed at the BER supervisory board meeting on June 30, 2014 (Der Tagesspiegel 2014a). All along, all the requests of the opposition parties in the Berlin State Parliament (Grüne, Linke, and Piraten) for a full disclosure of the costs for BER had been defeated by the governing "grand coalition" (Abgeordnetenhaus Berlin 2013a).[7]

It has become clear, though, that FBB management follows a strategy to "discuss away" that the inevitable further cost increases are the result of planning errors and construction faults. On television (rbb 2014), in print media (Der Tagesspiegel 2014b), and through public rebukes of supervisory board members via media release (FBB 2014), FBB's CEO Harmut Mehdorn took refuge in three key messages. First, that "more airport costs more money" (FBB 2014) referring to the increase in planned capacity of the passenger terminal since construction commenced from 17 million to 27 million. Second, that new noise abatement regulation increased "the cost of noise insulation of resident homes" (FBB 2014). And third, that a final cost of "a bit over 5" billion € (Frankfurter Rundschau 2014) would still be "good value" (Der Tagesspiegel 2014b).

Mehdorn's core statement that the terminal's space "nearly doubled" can be refuted by referring to the airports own media release archive. In 2006, the media release introducing the new airport said: "Once the airport opens at the start of the 2011/2012 winter timetable with a capacity to handle 22–25 million passengers per annum" (FBB 2006), and not 17 million as publicly claimed by Mehdorn. But even if the capacity increased through change requests and other decisions, this would have only been the case until the first completion date in 2011 and before an additional €1.2 billion of capital was called by FBB in 2012. After that, the building shell

[7] For a detailed description of the activities of the Piraten Fraktion, refer to Delius and Ugarte (2014).

was finalized and, therefore, large-scale capacity increases could not have been possible.

The lack of information is exacerbated by legislation that does not allow the parliamentary investigative committees to inquire about the costs to complete the airport while the airport is still under construction. The parliamentarians have only the right to ask about actions or events that happened in the past; "preventive control" through investigative committees is not allowed (Berliner Morgenpost 2014a).

Nevertheless, the pillars of the financing are known, as well as some large-scale increases to the aggregate costs. The capital requirements quoted refer to the construction of the passenger terminal building, the expansion of the existing runway and the construction of a second runway, the construction of access road, and other related investments (Europäische Kommission 2009, 4–5).

On initial sources of funds the following is known:

– In 1996, when the Federal Republic of Germany and the States of Berlin and Brandenburg agreed to develop Schönefeld to the "single" airport in Berlin, the three shareholders contributed together a shareholder loan of €224.5 million to the airport company to partially prefund the development (Europäische Kommission 2009, 2).
– In 2005, the shareholders agreed to swap the shareholder loan into equity and inject a further €430 million of equity. In 2007, the State of Brandenburg agreed to finance the access road to the airport with €74 million.
– The total debt amount of €2.4 billion was arranged in 2009, with the European Investment Bank's share of €1.0 billion already agreed in 2007 and available since late 2008 ((Europäische Kommission 2009, 5). As outlined in more detail above, the three shareholders agreed to a 100 % guarantee of the loan, turning the lenders from stakeholders to by-standers.

These total initial sources of funds add to €3.1 billion, compared to the widely quoted initial estimated construction costs of €2.4 billion (FBB 2014).

As discussed above, after the third postponement in 2012, the shareholders agreed to contribute an additional €1.2 billion. This sum included €305 million to fund increased noise protection costs that arose due to a court decision in June 2012 to significantly improve the noise protection for residents (EC 2012b). This increased the total sources to €4.3 billion.

A week before the BER supervisory board meeting on June 30, 2014, media reported of an additional capital requirement of €1.049 billion needed to complete the construction of BER. This sum was made up of €340 million for the passenger terminal, €168 million for other construction and planning services, €286 million for additional noise insulation for local residents, and €255 million as contingency (Der Tagesspiegel 2014b). The limited information released post the meeting confirmed the aggregate of €1.1 billion but did not provide a breakdown (Der Tagesspiegel 2014a, 1).

Including the €1.049 billion, the total sources of funds contributed by the shareholders and the lenders would have increased to €5.4 billion.

Comparing this figure to the originally quoted construction estimate of €2.4 billion and the original sources of funds results in increases of 125 % and 74 %, respectively, including the increased requirements for noise abatement.

The additional repair issues coming up in 2015 might well increase this sum again. In addition, FBB also contributed own resources of up to €400 million stemming from their profits of 10 years of operation of the two existing airports in operation in Berlin. So, the final sum after opening of the airport BER might well run over to €6 billion.

Key Issues Identified at BER

Looking back with the benefit of hindsight, it is surprising that such a large and high-profile project was not embedded in a comprehensive project governance framework designed to ensure expertise on all levels and a degree of assurance commensurate with the public moneys spent. Instead, the project of developing and building BER was squeezed into corporate governance framework of a going concern, furthermore one specialized in operating and maintaining airports, not undertaking billion Currency Greenfield projects.

Consequently, there was no project board or project steering group empowered to hire, fire, and monitor the management team responsible for the project (Greiman 2013, 124). These are tested mechanisms that ensure that the sponsors, through their dedicated representatives or experienced nominees with relevant industry skills, have an ongoing and close engagement through regular meetings (Garland 2009, 35).

In addition to the lack of dedicated decision-making structures, there was an absence of independent assurance and transparency. The supervisory board was toothless, and no other function outside the project challenged the management on progress, cost development, and other key risks. There was no transparency, with parliaments and the public kept uninformed for most of the project.

The architects, some of the contractors, and even some project managers may have been best in class, but without expert steering and expert supervision, they could not reach their potential. Therefore, the lack of expertise on sponsor level weighs heavily. Missing the expertise of lenders in regard to the key risk issues also weighs heavily, given that a full government guarantee was provided. The continuous change requests, both a symptom of governance breakdown and a root cause for the failure of the project, could not have occurred to such an extent in a structure where banks put their own capital at risk and/or sponsors understood the subject matter.

All in all, ignorance and unfounded optimism of sponsors and FBB management trumped thoughtfulness and appreciation of risk. The possibility of failure was not taken seriously and the extent of the problems that eventually surfaced were neither anticipated nor even taken into account. Adequate time and cost contingencies were not included, resulting in cost-driven decision-making that put the entire project on a slippery slope. Also, unwelcome information that was provided by consultants like Drees & Sommer, for example, was neither confronted nor passed on.

The FBB management had to cope early with the political decision to do without a general contractor. This largely overburdened management and the planners they had engaged in finishing planning in time and later managing the interface between numerous contractors. In this situation, it allowed for numerous changes of initial plans, which contributed even more to piling up of coordination problems between different plans. In the chaotic rush to completion, however, they allowed blunders to happen of a magnitude rarely found in the final stages of project delivery. The subsequent figure shows the fatal dynamics of this vicious spiral out of control.

In addition, Table 4.2 summarizes the key issues identified at BER by applying the analytical framework developed above.

Apart from this analytical view, it is worthwhile to look at the fatal dynamics of the different deficiencies in the governance and management of the BER project. Figure 4.1 shows how the initial inadequate governance set a vicious spiral in motion which finally got totally out of control.

Recommendations/Lessons Learned

The lessons seek to reinterpret the specific case study findings and insights into new developments into five succinct conclusions serving decision-makers of large-scale infrastructure projects for the public by the public.

Lesson 1

Governance structures need to be filled with expertise on all levels to be effective; experienced and skilled people on all project levels need to be supported by effective governance to reach their potential

Elaborate governance structures and processes are mandatory to support the experienced and skilled people leading and/or executing the project and its elements. Gerkan, Marg, and Partners are celebrated architects with high-profile projects all over the globe, but these skilled experts failed in an environment without robust processes regarding change requests, without a skilled up client, and without a comprehensive control and steering structure.

At the same time, tested and established bodies like the statutory supervisory board are inadequate if they do not have or do not seek sufficient levels of expertise and skill to understand issues thoroughly and make informed decisions. They are also inadequate if they do not properly assess that the level of supervision and guidance they can provide is not enough for the

Table 4.2 Assessment criteria applied to BER

	Very poor/ nonexistent	Poor	Satisfactory	Good	Very good
Governance as rules—fundamental decisions about project setup					
Comprehensive control and steering structure with: (i) clear responsibilities and lines of authority, as well as (ii) decision-making structures that channel expertise and bind all key stakeholders		×			
Transparency and public control to enforce accountability in the public sector	×				
Expertise on all levels—hiring of best-in-class people and purchase of outside expertise (consultants and advisers)		×			
Involvement of risk capital—effective scrutiny by financiers/lenders that put own capital at risk	×				
Procurement contracting allocating construction and interface risks to contractors and also using incentives/penalties constructs		×			
Governance as processes—key decisions when shaping and undertaking processes					
Diligence at project definition stage and robust design at the outset		×			
Taking the possibility of failure seriously—inclusion of significant contingencies in cost and time estimates to account for optimism bias	×				
Discouraging of change requests after design has been agreed	×				
Confront information that makes you uncomfortable include people with different combinations of knowledge and experience and test ideas with skeptics		×			
Undertaking of scrutiny processes, for example, independent reviews or peer reviews by external bodies	×				

Fig. 4.1 A vicious spiral of governance problems

complexities of a large-scale process, and a project-specific governance structure with a dedicated project board or steering committee is required instead.

Lesson 2

Engaging a general contractor—usually advisable but necessitates a public side which is professionally well equipped

If the governance setup is insufficient as in the BER case, then it is highly risky and almost fatal to execute the project without a general contractor who would take over the technical and financial risks of the execution process and of handling the subcontractors in an adequate way. In the BER case, all risks remained with FBB and its stakeholders, that is, the public budgets.

The execution of the terminal building and its sophisticated building technology for fire protection primarily broke down because FBB management could not handle the interface and coordination of altogether 50 contractors which all had separate pieces of the project to work at. Insolvency or dismissal of the contractors to do this job only aggravated these deficiencies.

The BER case is a sad example of the disastrous consequences in terms of the large amount of time and money spent to repair the consequences of the subsequent rush to completion.

Engaging a general contractor still puts high demands on the public sponsor. Only if detailed preplanning and the quality of contract are well done, floods of costly change requests can be avoided. The Elbphilharmonie case is a good example for this.

Lesson 3

Sufficient time for planning in detail before contracts as well as during execution

In the case of BER, it proved disastrous that when it was decided to go for altogether 50 tendering processes and awarded contracts sufficient time necessary was not allocated. This should have been accompanied by postponing the completion and opening date of the airport. If sufficient time is not allocated either by detailed preplanning or by postponing the intended completion date, the process results in parallel planning and execution—a source of many coordination flaws.

Lesson 4

Assurance, Assurance, Assurance

FBB management lost control over what was happening on site early on. The sponsoring governments, through their supervisory board members, got filtered and possibly altered information by FBB management. The parliaments had no access to accurate and up-to-date information while the problems accumulated and only were allowed to investigate ex post. In short, there was no functioning assurance, no visibility of project performance that could have supported the decision-makers. And nothing was done about it.

The UK examples show that assurance needs to be undertaken on various levels, to be effective: (i) on the level of line managers, (ii) as a centralized cross-project function, (iii) on the sponsor level, and (iv) as an independent function for the political sphere and the public.

An independent assurance with a mandate to review the project is indispensable, especially if the governance of a project does not provide for sufficient overseeing and management bodies with adequate expertise. It is not understandable why the Federal level holding a 27 % share of FBB—represented by the Ministry for Building and Transport—did not mobilize a quality of expertise, which the two state governments were not able to contribute. This could at least have prevented some of the initial flaws of the governance setup, especially the switch from a general contractor model to splitting up contracts in such a vast way.

In the long run, a national body with competencies and expertise as established in the UK with the major project authority MDA would be advisable also in the federally decentralized Germany (UK Government 2014). Such an independent institution would be helpful for advising the governance setup and monitoring the progress of projects. In Germany, an institution like this could only be established by an agreement between federal and federal state governments—which normally would be hard and time consuming to arrive at.

Lesson 5

The responsible public entity to be given all resources, internal and external, to be a "smart client." The public entity responsible for the delivery of the project needs to be skilled up to select, negotiate with, and control the private sector companies ultimately undertaking the design and construction work. The demands this brings with it are very often underestimated

This applies to the entire range of large-scale projects, the ones where the public entity is a "traditional" client relying on a turnkey contract as well as projects where the public entity takes on more risk—by, for example, engaging several private companies to provide specific parts of the project and retaining the interface risk. Both adversarial and non-adversarial contracts require a smart client. The first in order to counterbalance the information asymmetry that contractors may want to exploit, the latter as the collaborative management of risks is at the forefront.

FBB chose a contractual arrangement that gave them a "dumb" project manager. Simple compliance with the demands and expectations of FBB had priority (in particular after the first project manager got fired), not a partnership at eye level. Further, FBB's "architects" were not in a position to successfully push back on change requests endangering overall project deliveries. It is an open question to what extent this was also due to the fact that the architects were not sufficiently incentivized to do so since large change requests would increase their billings.

London 2012 Olympics' ODA has set an example of how to be a smart client. ODA attracted best in class board members and managers and selected a delivery partner that provided it with manpower and know-how. Importantly, the delivery partner was incentivized to meet cost and time targets (Kintrea and Millett 2013).

Appendix 4.1. BER Timeline

Date	Event/Decision/Announcement
June 1996	Consensus decision (Konsensbeschluss) to develop Schönefeld Airport to the "single" airport in Berlin.
March 1999	First privatization attempt; opening targeted for 2007.
August 2002	Second privatization attempt; opening targeted for H2 2007.
May 2003	Entire privatization process terminated; decision to build airport under public sponsorship.
October 2003	Berlin Brandenburg Flughafen Holding (BBF) is merged with two subsidiaries tasked with the new airport development resulting in a new head entity, Flughafen Berlin Schönefeld GmbH (FBS).
January 2004	Thomas Weyer becomes project leader as General Manager Berlin Brandenburg International and Technology; opening targeted for October 2010.
August 2004	Responsible planning authority confirms the plans for the expansion of Schönefeld Airport (Planfeststellungsbeschluss), including passenger terminal with underground train station, new runway, and the extension of an existing runway.
January 2005	pg bbi engaged as general planner.
December 2005	Dr. Rainer Schwarz announced as new CEO replacing Dieter Johannsen-Roth. Starts on June 1, 2006.

(*continued*)

Date	Event/Decision/Announcement
March 2006	Federal Administrative Court in Leipzig dismisses lawsuits by residents against the planning approvals driven by noise concerns, but imposition of night curfew and other limitations due to aircraft noise. Opening date targeted for October 30, 2011.
June 2006	Bridge financing of €350 million in place, provided by banking consortium incl. Commerzbank, Helaba, KfW IPEX.
September 5, 2006	Ground-breaking ceremony.
November 2006	First tender for terminal building fails as only one bidder qualifies (HOCHTIEF).
Mid 2007	pg bbi selected to review and supervise the general contractor's detailed design and ongoing construction performance.
October 9, 2007	Second tender for terminal building fails. All four bidders provide bids that are within a very narrow range and around €400 million in excess of the estimated €620 million. Decision not to have a general contractor for the terminal building. Opening targeted for October 30, 2011, "ambitious but achievable."
December 2007	A challenge by HOCHTIEF against the termination of the tender for the terminal building was dismissed by the procurement chamber (Vergabekammer) of Brandenburg.
Early 2008	Following refusal to appoint a general contractor, detailed design of the passenger terminal to be undertaken by pg bbi. Scope also included piers North and South in addition to the main terminal building.
March 20, 2008	Thomas Weyer announces that he will leave FBS.
March 2008	Drees & Sommer selected as construction manager for BBI.
June 2008	Award of construction contracts for structural works of BBI terminal.
July 11, 2008	Construction of the passenger terminal commences.
September 1, 2008	Manfred Körtgen succeeds Thomas Weyer.
October 30, 2008	City-Airport Tempelhof closes.
November 2008	Drees & Sommer analysis of cost and schedule situation after the tenders of the seven lots were received; Drees & Sommer terminated as Construction Manager.
Early 2009	Passenger terminal construction broken up into around 35 lots.
March 2009	New building permit sought.
May 13, 2009	European Commission agrees to 100 % guarantee for debt package.
June 24, 2009	100 % guarantee in regard to the entire debt package by FBS's shareholders.
June 30, 2009	Financing package agreed with a banking group.

(*continued*)

Date	Event/Decision/Announcement
December 2009	FBS supervisory board decides to use the abbreviation "BER"; "BBI" is discontinued. Airport named after 'Willy Brandt."
January 29, 2010	FBS management ordered stop to any more change requests—unsuccessfully.
February 8, 2010	IGK-IGR Ingenieurgesellschaft Kruck insolvent.
February 26, 2010	Letter from pg bbi to FBS stating doubts about meeting target opening date.
May 7, 2010	"Topping out ceremony" (Richtfest) of the new passenger terminal.
May 19, 2010	Letter from WSP CBP to FBS stating that opening date is in jeopardy.
May 25, 2010	German Federal Police advised of its view that a doubling of the screening space was required due to a new EU directive on liquids, aerosols, and gels.
June 25, 2010	*First Postponement*: Supervisory board agrees to delay of opening date from October 30, 2011, to June 3, 2012.
June 8, 2011	BER branding introduced.
January 2012	Flughafen Berlin Schönefeld GmbH changes its name to Flughafen Berlin Brandenburg GmbH (FBB).
February 2012	Start of 4-month long live testing of terminal.
May 8, 2012	*Second Postponement*: Announcement that opening date of June 3, 2012, cannot be achieved.
May 17, 2012	New opening date of March 17, 2013, announced; pg bbi and Manfred Körtgen dismissed.
From May 2012	Construction stops for several months post dismissal of pg bbi.
June 2012	Horst Amann announced as new FBB COO and head of the Airport Project, commences on August 1, 2012.
September 7, 2012	*Third Postponement*: New opening date October 27, 2013, announced; additional capital requirement of €1.2 billion identified.
October 30, 2012	Fire safety experts hhp highlight deviations between the fire safety concept, planning permission, and actual construction.
December 2012	EU Commission agrees to capital injection of €1.2 billion by BER's owners.
January 7, 2013	*Fourth Postponement*: Announcement that target opening date cannot be achieved.
January 16, 2013	No new date. Schwarz dismissed as CEO; Klaus Wowereit relinquishes role as FBB chairman and becomes deputy chair.
March 2013	Hartmut Mehdorn announced as new CEO.
October 2013	Amann relieved from his role as COO.
December 2013	Klaus Wowereit reinstated as FBB chairman.

(*continued*)

Date	Event/Decision/Announcement
June 2014	Mehdorn provides “planning assumption” of opening in late 2015 or early 2016 reiterating that this was not a firm date.
June 30, 2014	FBB management presents supervisory board an updated financing plan; additional capital requirement of €1.1 billion. Approval of shareholders in April 2015.
August 2014	Sreweus Manager Jörg Mark becomes new Chief Operating Officer of FBB.
December 2014	Klaus Wowereit resigns as FBB chairman, his sucessor is new governing Mayor of Berlin Michael Müller (from July 2015).
March 2015	Karsten Mühlenfeld succeeds Hartmut Mehdorn as CEO of FBB.
December 2015	Mühlenfeld confirms that FBB on track to open the airport in the second half of 2017.

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5

Offshore Wind Power Expansion in Germany: Scale Patterns, and Causes of Time Delays and Cost Overruns

Genia Kostka and Niklas Anzinger

Introduction

Germany wants offshore wind energy to become a key driver of its *Energiewende* (energy transition), a transformational "megaproject" intended to reengineer Germany's energy infrastructure. The German government envisioned offshore wind delivering approximately 15 % of electricity consumption by 2030, making it a crucial element for the *Energiewende* to succeed (Bundesregierung 2010).

Megaprojects are generally difficult to manage. Bent Flyvbjerg (2014, 6) defines megaprojects as "large-scale, complex ventures that typically cost $1 billion or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people." Such projects often take longer and cost more than initially planned. Offshore wind power expansion, as a national policy, is such a megaproject. An individual offshore wind park (OWP) is a megaproject as well, as a 300- to 400-MW park typically costs €1.5 billion. Analyzing offshore wind power expansion in Germany contributes to drawing lessons for the energy governance as well as planning and forecasting of large electricity infrastructure projects.

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The aim of this study is to analyze the scale, patterns, and causes of cost overruns in OWPs. Their construction and installation currently faces a 22 % average cost overrun—low compared to other large-scale energy projects. However, the regulated connection of the OWPs to the grid led to additional costs. This is the result of the separation of responsibility for construction of the OWP between the wind park developer and the transmission system operator (TSO), a governance problem. Time delays in grid connection, 13 months on average per park, led to a compensation of forgone revenue to the wind park developers, paid by an additional surcharge (Offshore-Haftungsumlage) to consumers. These additional surcharges cost more than €1 billion for the eight existing OWPs finished by the end of 2014 (Netztransparenz 2013, 2014a). Consequently, offshore wind expansion in Germany was and will remain a challenging project on many levels.

Research Objective and Motivation

The key driver of offshore wind energy development is the political will to develop a "greener" energy infrastructure, currently at a higher cost than other sources of supply. As a carbon-free renewable source, OWPs are promising contributors to greenhouse gas (GHG) emission reductions. But offshore wind power is currently not market-competitive: in 2014, its cost per unit of power generation in the European market was more than double the cost of onshore wind, which is market-competitive (Energy Intelligence 2014). To boost offshore wind development, Germany implemented feed-in tariffs (FIT) and set the target of 10 GW of installed capacity in 2020 and 25 GW in 2030. However, capacity development went slower than expected. Newspapers reported cost overruns and time delays, criticizing the expansion plan. In 2012, only 280 MW were installed and the government revised its targets to 6.5 GW in 2020 and 15 GW in 2030. This study analyzes this process in-depth.

The aim of this study is to identify problems in planning and forecasting of large projects, in order to develop solutions for better project delivery in the future. To study the impact of the offshore expansion plan, this chapter investigates developments in the wind offshore industry.

An analysis on the scale, patterns, and causes for the time delays and cost overruns of German OWPs is necessary to draw lessons for German energy and climate policy, and, more generally, development of offshore wind power, management of national energy infrastructure, and industrial policy. Further, this study adds value to the existing literature by examining complex interaction processes between public and private stakeholders in energy infrastructure projects.

Literature Review

There is an increasing body of literature on megaproject planning and delivery. Early systematic accounts of opportunities and risks of megaprojects were done by Sawyer (1952) and Hirschman (1967). Merrow et al. (1979) and Merrow (1988) have systematically used large dataset and statistics to analyze energy process plants. Hall (1980) has done influential case study research. Flyvbjerg et al. (2003) have developed a systematic approach to megaprojects combining large datasets, statistical analysis, and supplemental case studies. Cost underestimation and benefit shortfalls, according to Flyvbjerg et al. (2003), are a systematic part of large transportation infrastructure projects, with nine out of ten experiencing either one or the other, or both (Flyvbjerg et al. 2003; Flyvbjerg 2007).

A key question is whether learning takes place in planning and forecasting of large projects. Hirschman (1967) sees underestimation of project complexity not only as the cause of problems but also for entrepreneurial learning. Flyvbjerg (2014) criticized this technological argument as deceptive, because it would encourage projects planned without due diligence. Flyvbjerg et al. (2003) reject this argument because they find no improvement in forecasting accuracy for infrastructure projects over 70 years. Much research has focused further research on human instead of technological factors such as delusion, appraisal bias or optimism bias, and strategic deception (Flyvbjerg et al. 2003; Flyvbjerg 2007, 2008, 2009). Learning effects in planning have not been tested by other scholars. The theory of learning effects usually looks at per unit costs. Competing firms are assumed to be able to reduce the overall cost per unit of production with experience over time (Krugman et al. 2012).

Weaker firms, with higher per unit costs, drop out of the market, and stronger firms, with lower per unit costs, stay in the market. Various studies have shown empirical evidence for learning curve effects in terms of per unit costs in power generation from offshore wind (see, e.g. Prognos/Fichter 2013; Reimers and Kaltschmitt 2014).

The electricity infrastructure sector seems to have different patterns than the transportation infrastructure sector. Cost overruns strongly vary across project types. Ansar et al. (2014) looked at 245 hydropower projects and found an average cost overrun of 96 %. Sovacool et al. (2014a) found a 117 % average cost overrun for nuclear power plants and much lower cost overruns for thermal plants (13 %), wind farms (8 %), transmission lines (8 %), and solar facilities (1 %). Studies for electricity infrastructure projects with the highest sample size are listed in Table 5.1. These results suggest that the technology factor plays an important role in explaining differences in cost overruns between project types.

Sovacool et al. (2014b) have found learning effects in electricity infrastructure. They tested if technological improvements drive costs down and improve learning. Because the first-of-their-kind projects use new technology, the cost overruns are predicted to be higher than with projects that replicate this technology over time. The evidence for learning effects is mixed for transmission lines, thermal power plants, and hydropower. Onshore and offshore wind parks are relatively stable, that is, have no obvious learning effects. Solar facilities have positive learning effects over time. Nuclear power plants have negative learning effects over time, that is, cost overruns become higher. Learning is hence a crucial dimension. Sovacool et al. (2014a) have found only 8 % average cost

Table 5.1 Reference classes for electricity infrastructure projects

Project type	Sample size	Average cost overruns (%)	Average time overruns (%)
Hydropower	245	96	44
Nuclear reactor	180	117	64
Thermal plant	36	13	10
Wind farm	35	8	10
Solar facility	39	1	0
Transmission	50	8	8

Sources: Ansar et al. (2014), Sovacool et al. (2014a).

overrun for wind farms (onshore and offshore). Their explanation is that quicker construction lead times (average 12.6 months for a wind farm compared to 90 months for a nuclear power plant) and more standardized technology makes wind parks more accurately predictable assets. But since they do not distinguish between onshore and offshore wind farms and do not examine policy-related interfaces, this hypothesis will be subject to a closer examination.

Additionally, there is no reference study for Germany. Some studies and reports from the private sector such as KPMG (2010), PWC/WAB (2012), and Prognos (2013) have analyzed OWP performance for commercial purposes such as regulatory factors and pathways for reduction of per unit costs. But there is no study to date which has systematically looked at the planning dimension and governance issues such as the interface between the regulated grid connection and development of the private industry. The key contributions of this chapter are the unique focus on governance problems in the planning of OWPs, the first systematic analysis of time delays and cost overruns in OWPs, and analyzing whether learning takes place in planning and forecasting.

Methods and Data Selection

This study's case is offshore wind expansion in Germany, which is an interplay between public policy and industrial development. The units of analysis are OWPs in Germany. Currently, 8 OWPs are operational (see Table 5.2), 5 under construction and 29 are planned or proposed. The study selected the eight OWPs currently operational as a sample.[1] For those, all construction-relevant decisions have been made (e.g. grid connection, turbine type) and observable issues have already occurred or not occurred. Furthermore, these OWPs are the result of current policies, while future OWPs are potentially subject to different ones.

To learn more about specific causes, this study further looked at four OWPs (Alpha Ventus, BARD 1, Nordsee Ost, and Riffgat) in-depth.

[1] An OWP is operational as soon as the offshore wind turbines (OWTs) are installed, are connected to the grid and produce electricity.

Table 5.2 Key data on finished OWPs in Germany

Offshore wind park name	Capacity (MW)	Start of construction	Planned end of construction	Time delay (months)	Planned cost (million €)	Final cost (million €)	Cost overrun (%)
Alpha Ventus	60	August 2007	2009	12	190	250	32
Baltic 1	48	July 2009	2010	6	200	200	0
BARD 1	400	June 2009	2013	24	1500	2900	93
Nordsee Ost	295	July 2012	2013	18	1000	1300	30
Borkum-Riffgat	108	September 2012	2013	6	480	480	0
Global Tech I	400	August 2011	2014	12	1600	1800	13
Meerwind	288	September 2012	2013	18	1200	1300	8
DanTysk	288	December 2012	2014	6	1000	1000	0
					Ø 13		Ø 22

Source: OWP database; adapted from Anzinger and Kostka (2016).

The reason for choosing case studies is that the sample is too small ($n = 8$) to develop a statistically significant model. Nevertheless, it is possible to learn about causes by looking deeper into selected, representative cases (George et al. 2005). The case selection represents a diversity of differences in size, location, and potential governance issues. The four cases consist first of two deviant cases to find out how they are different from the average. Those are Alpha Ventus, a pioneer case, and BARD I, an extreme case, both with significantly higher cost overruns than average. Second, it looks at Nordsee Ost because it had almost the same cost overrun as Alpha Ventus but was not a pioneer. Third, it looks as Borkum-Riffgat, exemplifying OWPs with no reported cost overruns that nevertheless had problems not captured by conventional analyses of cost overruns for construction.

The governance setup of energy infrastructure project planning in Germany is a dynamic interaction process between various private (investors, TSOs, suppliers) and public actors. The study refers to the governance setup as "semi-private," because wind park construction and power generation is private, supported by FITs, while the grid construction is regulated.[2] The outcome variables are delays and cost overruns. A cost overrun is the difference between the initially planned costs at start of construction and the cost at the end of construction (Cantarelli et al. 2012). This study refers to the "building block" research design (George et al. 2005). Such a study looks at a particular subtype, which is the OWP, of a type-category, which is the "megaproject" as defined by Flyvbjerg et al. (2003).

Data Sources

This study uses a database of 42 OWPs, classified according to their name, location, wind park developer, TSO, operational status, distance to shore, water depth range, capacity, number of turbines, turbine type,

[2] This study uses the term "semi-private" and not "semi-public" because the feed-in-tariffs are an incentive-based policy for private developers. No private developer is obligated to construct an OWP, nor are OWPs in public ownership (however, the national grid is owned by state-regulated companies).

converter platform, start of construction, planned end of construction, time delays in months, forgone revenue estimate, planned cost at start of construction, and actual cost at the end of construction. The data is from the Windenergie-Agentur (WAB) and the 4C Offshore Ltd. (4CO). Supplementary sources are company publications, newspaper articles, and interviews. Data on German offshore wind energy capacity development is from Deutsche WindGuard (DWG) and European capacity development from the European Wind Energy Association (EWEA). Further, the study uses academic articles, and reports by private consultancies, official institutions or think tanks, as well as eight interviews in person, over the telephone or email with representatives of the government and the industry, including wind park developers, TSOs, supplier companies, and consultants.[3]

Policy Context

European Energy Policy

The European Union (EU) has ambitious renewable energy expansion targets and wants offshore to become a key pillar of its future energy system. The European Commission's (EC) "2020 climate and energy package" emphasizes the "20-20-20 target," 20 % reduction in GHG emissions, a rising share of energy consumption from renewable sources by 20 %, and a 20 % improvement in energy efficiency compared to 1990 levels (EC 2014). In its "Communications" document in 2008, the EC announced that "offshore wind can and must make a substantial contribution to meeting the EU's energy policy objectives through a very significant increase—in the order of 30–40 times by 2020 and 100 times by 2030—in installed capacity compared to today" (EC 2008). This would equal 40 GW installed by 2020, 4 % of the projected EU electricity demand, and 150 GW by 2030, 14 % of the demand. The "Communications" document of 2008 identified project finance and grid planning as the key challenges facing the offshore wind industry

[3] The interviewers asked to remain anonymous.

and recommended various regulations and initiatives to boost industrial development (EC 2008). According to the "Communications" document of 2012, the European Investment Bank (EIB) had lent €3.3 billion between 2005 and 2011 for offshore wind projects and will sustain the effort to meet the targets (EC 2012).

Europe is the world market leader in offshore wind capacity with a current 92 % share (EWEA 2015; GWEC 2015). In 1991, DONG Energy (then DONG) built and installed the world's first OWP, Vindeby, off the shore of Denmark, with a capacity of 5 MW. The UK, the current market leader in Europe, installed its first OWP in 2000 and pursued active policies to enable sector growth (EESI 2010). By the end of 2014, 11 European nations had installed and connected a total of 74 OWPs to their grids, equivalent to 2488 OWTs and about 8 GW capacity (EWEA 2015). Germany ranks third in Europe with a currently installed capacity of about 1 GW, 13 % of total offshore wind capacity, after Denmark (1.3 GW, 16 %) and the UK (4.5 GW, 56 %). China had ambitious targets to build 5 GW by 2015 and 30 GW by 2020 but had installed only 429 MW by the end of 2013 and revised its target to 2 GW (Bloomberg 2014).

The key issue that affected development of offshore wind energy in Germany was the "unbundling" decision. Because the EU saw power supply as driven by quasi-monopolistic vertically integrated energy companies, it enacted regulations to separate them. With the "Third Energy Package" in 2009, the EU defined the requirements to separate power systems into supply, generation, distribution, and transmission (CEER 2013). This significantly impacted the German electricity market, which was dominated by the "big four" utility firms (E.ON, EnBW, Vattenfall, and RWE). The "unbundling" decision was the origin of the twofold system in Germany between private wind park developers and regulated TSOs.

German Energy Policy

Germany has even more ambitious targets than the EC and intends to substantially reengineer its national energy infrastructure. Germany's plans to shut down all nuclear power plants by 2022, reduce GHG emissions by 80 % by 2050, increase the renewables' share of power generation to 35 % in 2020 and 80 % in 2050, and increase the renewables' share of total energy consumption to 18 % in 2020 and 60 % in 2050 (BMUB 2014). In total, Germany plans that 15 % of power generation will be made up of offshore wind in 2030.

Legal Support Scheme

Germany has support schemes, the "Erneuerbare Energien Gesetz" (EEG) and the "Energiewirtschaftsgesetz" (EnWG), which are intended to support the development of the renewable energy industry by incentivizing producers with FITs. Because offshore wind is not market-competitive with other sources of power generation, and the original FITs were initially too small, the government discussed amendments to increase them in the early 2000s (see Table 5.3). A government representative recalls: "[…] one of the main issues of the strategy were the subsidies, which were not enough for offshore to be economically viable. Second was the grid connection, which the government later decided to guarantee as additional support." (Interview 013115) The government enacted five amendments to the EEG in 2000, 2004, 2009, 2012, and 2014 (see Table 5.4), which increased the FITs and introduced new models, intended to make OWPs profitable and incentivize learning.

Table 5.3 Timeline for offshore wind development, infancy period (1997–2009)

2000	EEG amendment Explicit offshore feed-in tariff of 9.1 c/kWh for 9 years in the EEG
2001	BSH issues the first construction permit for an OWP
2002	Government adopts offshore strategy with nonbinding target of 2–3 GW until 2010 and 25 GW by 2030
2004	EEG amendment Differentiated offshore feed-in tariff of 9.1 c/kWh for 12 years Extension depending on distance to shore and water depth
2006	Infrastructure Planning Acceleration Act (Infrastrukturplanungsbeschleunigungsgesetz)
2007	DOTI consortium starts construction of pilot-OWP Alpha Ventus
2009	Area designation act determines the EEZs of the Baltic and North Sea

Sources: Falk and Wagner (2012), Offshore-windenergie.net (2015).

Table 5.4 Timeline for offshore wind development, from Gold Rush to Gridlock (2009–2011)

2009	EEG amendment
	Increase of the feed-in tariff to 13 c/kWh for at least 12 years
	Speed-bonus (2 c/kWh) for projects operational by the end of 2015
	Incentive to self-market (reduction to 3.5 c/kWh after 12 years)
	Extension of grid connection obligation for TSO for OWPs with start of construction before the end of 2015
	BNetzA publishes position paper
2009–2011	Financial crisis 2008 complicates finance of large projects
	EU "unbundling" regulations in 2009 to separate vertically integrated energy companies
	German government introduces the KfW-Offshore-Program total of €5 billion liquidity for financing OWPs up to 50 % of necessary borrowing
2011/2012	Grid connection debate
	November 2011: Tennet suspended transmission expansion because of financial, material, and personnel shortages (Brandbrief)
	January 2012: Philipp Rösler, Minister for Economics, initiates the "AG Beschleunigung," (Acceleration Commission) a convent of experts from the industry and government, moderated by the Offshore Wind Energy Foundation

Sources: Falk and Wagner (2012), Offshore-windenergie.net (2015).

Ambitious Expansion Targets

"Our targets were too ambitious in the beginning," a government representative said. "The key mistake was the flawed assumption that 'wind energy is wind energy.' Many people thought offshore wind would be the same as onshore at sea […]. But offshore was a completely different industry […]" (Interview 013115). In 2002, a government strategy paper set a nonbinding target of 0.5 GW by 2006, 2–3 GW by 2010, and 25 GW by 2030 (KPMG 2010). But only about 100 MW were installed in 2010. In the wake of the 2009-EEG amendment, the government took more concrete strategic steps and set the target of 10 GW by 2020 and 25 GW by 2030 (EEG 2009). But by the end of 2011, the grid connection problem proved more severe than expected. In the 2014-EEG amendment, the government revised its targets from 10 to 6.5 GW in 2020 and from 25 to 15 GW in 2030 (EEG 2014). According to a government representative, the key issues were cost control and transparency. "Our intention was to pass two critical stages, collect experience and manage expectations" (Interview 013115).

During this infancy period, companies started small offshore wind projects, and the government began defining the regulatory framework. A few small German companies intended to replicate their experience in onshore wind but at sea. First experiences with offshore wind power existed in Denmark and the UK, where the first commercial OWPs fed electricity into the grid (Interview 011415). As the German government supported the development of renewable energy sources, it made decisions on the regulatory questions of the maritime zone, the EEG FITs, and the grid connection. Under the 2006 IPAA, German TSOs were obliged to connect OWPs under construction to the grid before 2015 (see Table 5.3). The regulation was unclear because the TSOs wanted to make grid connection commitments contingent on secured financing (KPMG 2010).

However, banks or big utility firms, who could finance capital-intensive projects, needed a secured grid connection before lending large sums of money—a chicken–egg problem. Furthermore, due to environmental lobbying, state regulators decided the wind park developers had to bundle their grid connections, obliging Alpha Ventus, the pioneer project, to lay them at the junction of the island Norderney (Interview 011415). But, as a former engineer of a wind park developer recalls, the companies involved in the consortium for Alpha Ventus could not agree on a financing arrangement for the grid connection cluster (Interview 011415).

In reaction, the government decided Tennet TSO GmbH should build the clusters and connect the transmitters to the onshore grid. To clarify the regulation, the Federal Network Agency (BNetzA) published a position paper (see KPMG 2010). Expecting guaranteed grid connection, wind park developers staked maritime claims and started construction. A consultant and former project engineer said: "If a company decided to build a wind park, there was little central planning involved [...]. Other than in Denmark, where offshore wind farms were planned centrally and tendered by the Danish Energy Agency, what followed in Germany was a gold rush" (Interview 011415).

Because spatial planning was not fully centralized and key questions were still unresolved, offshore wind energy development stagnated at the end of 2011. Other than in Germany, wind park developers in the UK had to build the grid connection on their own. A German government official recalls: "Our wind parks would be further offshore (than in the UK) […] Since the North Sea is environmentally protected and there were a lot of shipping routes, we believed the grid connection had to be centrally planned" (Interview 013115).

But there were two key problems with the position paper by the BNetzA: the criterion of secured finance, which led to an investment bottleneck, and the optimistic calculation of 30 months for the TSO to provide the grid connection, which led to unrealistic time schedules for the wind park developers. In a report, KPMG (2010) foresaw that the investment bottleneck would lead to a supply bottleneck because of the high number of connections that would be simultaneously required in 2012 and 2013. "This may result in delays to grid connections even though all deadlines and criteria are met. […]. Both developers and lenders face significant investment risk in this context" (KPMG 2010).

Faced with high numbers of granted applications for grid connection, Tennet could not deliver on time because they underestimated the technological challenges. As delays occurred, Tennet and the wind park developers were concerned about liabilities for forgone revenue and cost overruns. In Tennet's letter of urgency (Brandbrief) in November 2011, they announced suspension of transmission expansion because of financial, material, and personnel shortages, until the liability issue could be resolved. A government representative recalls: "[…] the fact that it was unclear who would be responsible for time delays and cost overruns led to a gridlock" (Interview 013115).

In response to the gridlock, the government undertook a reform program that substantially transformed the regulatory and policy framework. On January 12, 2012, Federal Minister of the Economy Philipp Rösler initiated the "AG Beschleunigung," a convention of experts from the industry (developers, suppliers, and lobby organizations) and the government (BNetzA, BSH), moderated by the Offshore Wind Energy Foundation (see Table 5.5). The initiative led to amendments of the EEG in 2012 and 2014 (EEG 2012, 2014) and the EnWG in 2013 (EnWG

Table 5.5 Timeline for offshore wind development, transformation period (2012–2014)

2012	EEG amendment
	Optional "bottom out" model by end of 2017 (19 c/kWh for 8 years)
	Alternative: feed-in tariff of 15 c/kWh for at least 12 years
	7 % degression from January 1, 2019, onward
	Unlimited obligation for grid connection for TSO
2012–2013	Change of the regulatory system (Systemwechsel)
	EnWG warrants onshore and offshore grid development plan (NEP, ONP)
	Spatial planning law and marine facility regulation
	BNetzA authority over grid connection regulation
	BSH authority over maritime spatial planning and approval for OWPs
2013	EnWG amendment about liability ("Offshore-Haftungsumlage," §17 F EnWG)
	TSO has to compensate 90 % of forgone revenue, due to time delays, to the wind park developer, between €17.5 and €110 million per OWP annually
	TSO can charge electricity consumer up to an additional 0.25 c/kWh
2014	EEG amendment revises target expansion from 10 to 6.5 GW in 2020 and from 25 to 15 GW in 2030
2015	Expansion of offshore wind capacity to 1 GW by the end of 2014
2020	Target capacity of 6.5 GW
2030	Target capacity of 15 GW

Sources: Falk and Wagner (2012), Offshore-windenergie.net (2015).

2014). The 2013-EnWG amendments clarified the liability issue: in case of time delays, the TSO is responsible for 90 % compensation to the wind park developer for forgone revenue, including an additional electricity surcharge of up to 0.25 c/kWh.[4] The 2014-EEG amendments revised the expansion targets from 10 GW in 2020 to 6.5 GW and from 25 GW to 15 GW in 2030. Further, the government assigned authority for spatial planning to the BNetzA and the BSH: the four German TSOs (Tennet, Amprion, 50 hertz, TransnetBW) are required to report an annual offshore grid development plan (Offshore-Netzentwicklungsplan)

[4] According to a government representative: "We could not grant the wind park developers full compensation, because they would have no incentive for alternative or intermittent grid connectors; but of course, they had to be adequately compensated."

to the BNetzA. Developers are required to apply to the BSH for OWPs to be approved by 2020, followed by an auction system. A government representative recalled: "we need[ed] to balance between [...] wind energy development and the grid expansion, as well as environmental protection" (Interview 013115).

Actual Capacity Development

Before the transformation period, expansion in offshore wind capacity was sluggish. By the end of 2012, the wind park developers had only installed a capacity of 280 MW (see Fig. 5.1), significantly below expectations. According to a former engineer, "politicians expected more

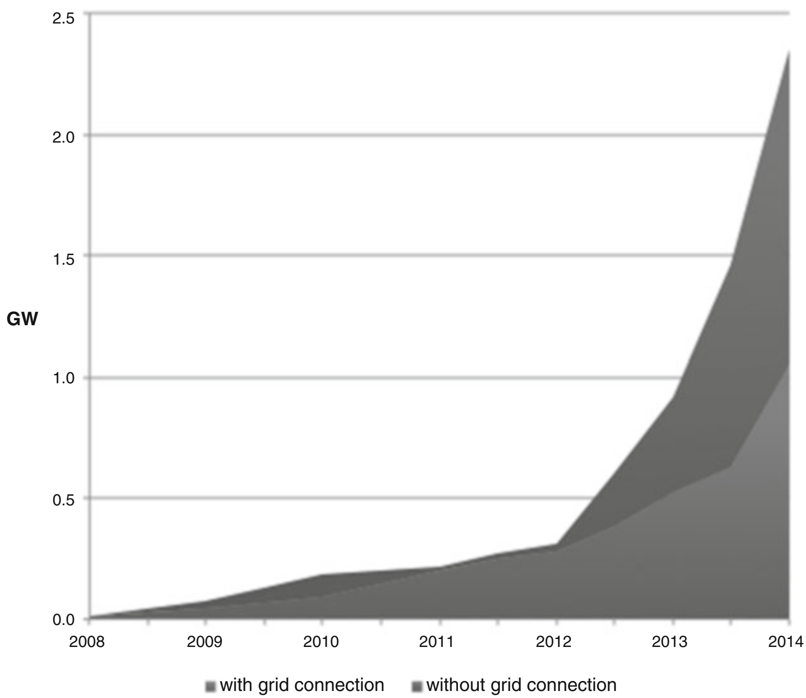

Fig. 5.1 Actual offshore wind capacity development in Germany (*Source*: Authors based on data from DWG (2015))

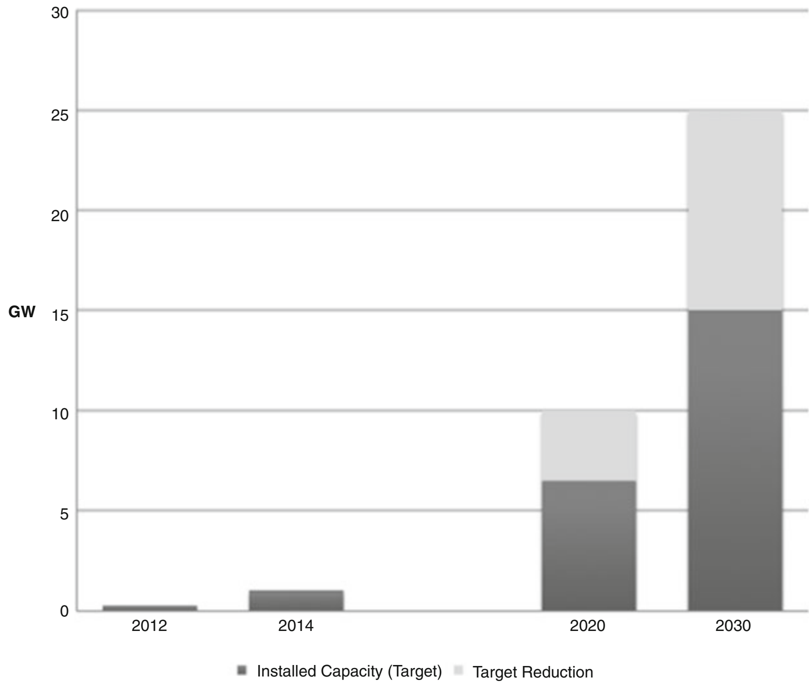

Fig. 5.2 Offshore wind capacity with grid connection in Germany: 2020 and 2030 targets (*Source*: Authors based on data from DWG (2015))

than the technology could deliver, too much and too early" (Interview 011415). In the subsequent 2 years, however, installed capacity increased by almost four times to 1.1 GW, with an additional capacity of those awaiting grid connection of 1.3 GW and 920 MW for those under construction (DWG 2015). Figure 5.2 shows the expansion from 2011 to 2015 including the 2020 target of 6.5 GW. In a press release, the Offshore Wind Foundation (OWF 2015) noted that they expected an additional 2 GW in installed capacity in 2015. If continued, the expansion of offshore wind power capacity is likely to meet the 2020 target. According to Hermann Albers, president of the German Wind Energy Association BWE, "despite all the past challenges, we have achieved a stable growth of offshore wind capacity. The offshore technology […] is on the edge of a decisive breakthrough" (OWF 2015).

Industrial Development

The previous section looked at the German policy context in the wake of the EU unbundling decision and the *Energiewende*. The government decided to regulate the grid connection, which led to interface issues between wind park developer and TSO. The following section examines how this affected the development of the offshore wind industry in Germany, more specifically the wind park developers, the TSOs, and the supplier industry.

Wind Park Developers

The wind park developers are responsible for the execution of the project and face several risk factors: supply chain, policy uncertainty, governance model, and project finance. Because offshore wind projects have long time horizons, they require long-term planning, policy coherence, and market certainty (Interview 011315.2). A project entails project development, preparation and construction, operating phase (plus possible extension), and decommissioning.[5]

Supply Chain Logistics

Questions of supply chain logistics are part of all phases of value creation, from project development, laying foundations, installing and connecting wind turbines to the grid, logistics, and operation and maintenance (O&M).[6] In 2008, installation vessels were scarce and maritime infrastructure insufficient (Interview 011415). OWPs turned out to be a more risky construction environment than previously assumed, because they involved working at sea, at great height, and heavy lifting (Skiba and Reimers 2012). According to industry sources, supply chain logistics led to bottlenecks between 2008 and

[5] Subject of this study is only the cost overrun for the period of construction.

[6] What is part of the supply chain of an OWP is the national grid. But in Germany, as well as in most countries, the grid is publicly regulated national infrastructure. Because the connection of the OWP to the national grid was legally guaranteed, it was not considered part of the wind park developers' responsibility.

2012 and slowed industry development, but companies quickly adjusted and found solutions (Interview 011315.2; Interview 011415).

Governance Model

The internal governance model, for the value chain of the OWP, is defined in project contracts and a key factor for legal risk allocation.[7] The industry uses two models: a turnkey contract and a multicontract model. In a multicontract model, there are interface risks, which can lead to delays and cost overruns, for example, the cable installation contractor cannot lay the intra-array cables if the foundations are not installed (Interview 011215). If there is a time delay or higher costs, it has to be borne by the responsible party. In the turnkey model, an EPC (engineering, procurement, construction) contractor is responsible for delivering the OWP to the developer. The contractor is in charge of subcontracts, usually between 5 and 20, for example, for turbine manufacturing or installation (Interview 011215). Here, the wind park developer does not risk increased costs due to interface problems but pays the contractor a risk premium. This model was used in the first phase of offshore wind energy development in the UK. Because it could not avoid time delays and cost overruns, the developers shifted toward multicontracting. In this model, the owner is responsible for the interface risks. Without a premium, the total cost is lower, but the owner is not insured against cost overruns (Interview 011215).

Project Finance

Questions of project finance and financial risk allocation are important for this capital-intensive industry. A standard 300- to 400-MW wind park costs, on average, €1.5 billion (Sobotta 2012), usually financed by big utility firms or banks. The project finance usually entails a "contingency budget" for cost overruns (Böttcher 2012) between 10 % and

[7] In contrast to the "external" governance model between wind park developers, TSOs, and public stakeholders.

15 % of the initially panned costs.[8] The contingency budget allows the consortium to adjust cost control and risk allocation. When cost overruns became higher than expected, the planners usually increase the contingency budgets for subsequent projects. An industry source commented: "Nobody knew what would work and now we know that the answer depends on the type of investor, the configuration of the wind farm, and the experience of contractors" (Interview 011215).

Policy Uncertainty

The policy framework is the defining factor for the development of the German offshore wind industry. First, it impacts investment decisions: without a guided market development, ensured by FITs, a strategy, and targets, the industry could not profitably develop. Second, regulatory standards, such as safety and spatial planning, were crucial. German maritime safety standards are stricter than international norms. As a result, a consultant estimated that the material costs in Germany are about 10 % higher than those in Belgium, for example (Interview 011415). In addition, environmental protection standards in Germany are strict, and the German "Wattenmeer" is a UNESCO-protected natural habitat; therefore, the turbines had to be built further offshore than in other countries, increasing risk and cost. Third, Germany's infrastructure policy was a key element of the offshore wind energy framework. Tennet TSO GmbH's obligation to provide a guaranteed grid connection became a risk for wind park developers, as it led to an investment bottleneck and "forgone revenue" of power generation.

Transmission System Operators

Tennet, a Dutch state-owned TSO, faced technological challenges in providing the grid connection, including supply chain and project finance problems, resulting in time delays for OWP connections between 6 and 32 months. After the EU decision to "unbundle" power generation and

[8] This "contingency budget" is different from the cost overruns examined in this study, because those cost overruns are not unplanned. The cost overrun begins as soon as the contingency budget is exhausted.

transmission, Tennet bought the North German grid network from E.ON in 2010, when 23 OWPs were already approved. With the 2006 Infrastructure Planning Acceleration Act (IPAA) and regulatory clarifications, Tennet was obliged to provide the grid connection for the OWPs in the North Sea. The BNetzA-position paper in 2009 determined the expected time period to provide the grid connection to be 30 months as a reference for wind park developers to enable planning. After time delays occurred, Tennet suspended construction in November 2011 because of financial, material, and personnel shortages, until regulatory issues could be resolved. A period of legal disputes followed in which liability in the case of time delays and potentially increasing electricity surcharges for consumers were debated (Wirtschaftswoche 2012). Currently, the industry plans 50 months for grid connection per park (Interview 011315).

Public voices criticized Tennet for increasing the cost of the *Energiewende* for consumers. Robert Busch, CEO of the Verband Neuer Energieanbieter (Federation of New Energy Suppliers), said: "The planned regulation is a non-transparent contract between offshore wind park operators and transmission system operators to the burden of the consumers" (Die Welt 2012). Tennet was certainly in a difficult situation as they faced a technology and investment bottleneck. Table 5.6 depicts the grid connection clusters and the individual projects that Tennet was responsible for.

Technological Challenges

Laying underwater transmitter cables far from shore, construction of the converter platforms offshore, as well as accurate risk assessments were the key technological challenges faced by the TSOs, Tennet, and 50 hertz. The installation more than 100 km distance from shore, in more than 40 m water depth, an unknown supplier market, and the previously untested direct current (DC) transmission technology were crucial factors. "The technology was first used in the North Sea and is still in development," a Tennet representative said. "This was new territory for all actors involved, not only us. There was no previous experience we could use" (Interview 012815). As a result, Tennet faced the risk of using infant technology in development, construction, and maintenance, which can increase costs.

Table 5.6 Grid connection clusters in the North Sea, key data

Project name	Planned installation	Wind park connections	Capacity (MW)
Alpha Ventus	2010	Alpha Ventus	60
BorWin 1	2010	BARD Offshore 1	400
BorWin 2	2015	Global Tech I Veja Mate	800
BorWin 3	2019	OWP Albatros	900
BorWin 4	2019	Deutsche Bucht	900
DolWin 1	2014	Trianel Windpark Borkum MEG Offshore I	800
DolWin 2	2015	Nordsee One Gode Wind I Gode Wind II	900
DolWin 3	2017	Borkum Riffgrund I Borkum Riffgrund II	900
HelWin 1	2014	Nordsee Ost Meerwind Süd/Ost	576
HelWin 2	2015	Amrumbank West	690
Nordergründe	2016	Nordergründe	111
Borkum-Riffgat	2014	Riffgat	108
SylWin 1	2014	Dan Tysk Butendiek Sandbank	864
Total			**8009**

Source: Offshorewindenergie.net (2015).

In 2012, Tennet faced problems laying the underwater cables for the alternating current (AC) connected OWP Borkum-Riffgat. Tennet found potentially dangerous wartime material waste at the seabed. CEO Lex Hartmann said they had to pay €57 million for the removal of 30 tons of material within 18 months and €43 million in compensation to Riffgat for forgone revenue (Tennet 2013). The incident was likely due to an inaccurate risk assessment and a lack of information sharing between Riffgat and Tennet. In August 2013, Tennet connected BARD I, a 400 MW-OWP, with BorWin1, in the agreed time period of 30 months. But for reasons that are unclear, BARD I stopped feeding electricity into the grid in November 2013. Certainly, the technology development for grid connection has not reached a mature stage, and further challenges can be expected.

Supply Chain Bottlenecks

Supply chain problems entailed delays in components of cables and problems with the construction of converter platforms. Production bottlenecks of transmitter cables are due to low levels of previous demand. Because potential suppliers, for example, the French company Nexans, Italian Pyrsmian, and Swiss-Swedish ABB produced above demand, they were in a period of downsizing before the European offshore wind expansion took off. Wirtschaftswoche (2012) quoted an E.ON manager saying, "The cable market is narrow and monopoly-like." Due to the sudden increase in demand, the cable producers have started expanding their production. For example, ABB invested €325 million in new facilities to double production capacity by 2015. Due to the demand shock, Tennet faced a supply chain bottleneck that led to time delays. Tennet CEO, Lex Hartmann, said delivery times for cables are at 50 months (Wirtschaftswoche 2012).

Converter stations built by Siemens were the most significant reason for the supply chain bottleneck. Because they underestimated technological challenges, delays in manufacturing and preparing the converters had cost Siemens roughly €900 million in 2 years (WSJ 2014). Hans Bünting, CEO of RWE Innogy, said: "I can understand them because they are also in the grip of the supply chain, but we haven't got a firm date. And I think it is because their supplier also doesn't have a firm date, so it's a bottleneck" (Toptarifnews 2013).

Project Finance

Tennet faced a huge financial challenge. Falk and Wagner (2012) questioned the economic potency of one TSO to meet the requirements of the necessary extension of transmission capacity in Germany. In 2011, Tennet had annual revenue of €1.5 billion and a net profit of €200 million, while the estimated necessary investment in the Netherlands and Germany was around €20 billion for the next 10 years. According to a government representative, "We expected the TSOs to anticipate the challenge. But external finance was a problem for them and the technology was completely new" (Interview 013115).

The TSOs needed secure investment in wind park development. But there is a mismatch between grid connection capacity and financed wind park capacity in the North Sea, a Tennet representative said: they had an obligation to construct 7.1-GW connection capacity, but only 3.8-GW wind park capacity had sufficient finance (Tennet 2014). "With the EEG amendments, the government took key steps to reduce investment uncertainty. The next year will show if this is sufficient to close the gap between grid connection capacity and electricity generation capacity" (Interview 012815).

Supplier Companies

Supplier companies face technological and economic challenges related to the wind park developers and the TSOs. To make offshore wind a competitive source of power generation, wind park developers depend on learning curve effects in the supplier industry to drive down per unit costs, for example, in turbine manufacturing. TSOs contract some parts of the construction of the grid connection out to suppliers, for example, the construction of the converter platforms to Siemens.

Turbine manufacturing is a capital-intensive process that requires long-term market security (Interview 011215). OWTs have the highest share of total investment, 35 % for offshore compared to 70 % for onshore wind (Skiba and Reimers 2012).[9] To reduce costs, the turbine manufacturers need to achieve a higher scale and build larger turbines. Contrary to the market for cables and transmission, the turbine manufacturing market is more competitive among potential suppliers such as Siemens, Areva, Senvion (former REpower), and Vestas. To have market security, the manufacturers need a long-term commitment by the national governments to support the industry. An industry source said: "The suppliers need to scale up and invest. But they need to know if there will be a sufficient market in the future. With lower targets, they invest less, which tames cost reductions" (Interview 011215).

One of the biggest technological and economic challenges is the construction of offshore converter platforms. Converter platforms are wired to the OWTs and transform the generated electricity into DC, transport it via subsea transmission cables to a station onshore where

[9] Costs of operation, maintenance, logistics, and installation are much higher for offshore than for onshore, which drives the relative share of OWT costs down.

it is retransformed into AC and fed into the national grid. OWPs in the UK, closer to shore, the industry mostly used AC. But DC is more efficient over longer distances, such as in the German North Sea. The technology was new, however. Siemens-constructed platforms led to significant problems for the time schedule of the grid connection. Tennet contracted Siemens to deliver four out of eight offshore converter stations in the North Sea. But anchoring foundations for converter stations more than 40 m beneath the surface, shipping, installation, and starting up grid components became more expensive than expected (WSJ 2014). Platforms have a unique design, and there was no previous experience in technology, regulation, and standards (Die Zeit 2012). In 2014, Siemens said delays in manufacturing and preparing the converters have cost them roughly €900 million since 2012 (WSJ 2014). Without a converter station, the TSO could not connect the OWTs to the grid. RWE Innogy CEO Hans Bünting said that Siemens was the "weak link" in supplying the connection of their OWP Nordsee Ost. "They (Tennet) have informed us that they are late, and they always blame it on their converter station supplier, Siemens" (Rechargenews 2012).

Case Studies

The above analysis shows that there was an interface problem between wind park developer and TSO, which significantly impacted the value chain of OWPs in Germany (see Fig. 5.3). The context was the German policy framework for offshore wind in reaction to the EU's "unbundling" decision. The interface problem resulted in regulatory uncertainty for an infant industry, which already faced huge technological challenges, supply chain bottlenecks, and insufficient finance. Results were time delays caused by grid connection problems and cost overruns in the construction of OWPs. In the next section, four case studies illuminate the impact of these factors on the development of OWPs in more detail. The analysis shows that explanatory factors (technology, supply chain, management, regulatory) for time and cost overruns varied among the cases (Tables 5.7 and 5.8).

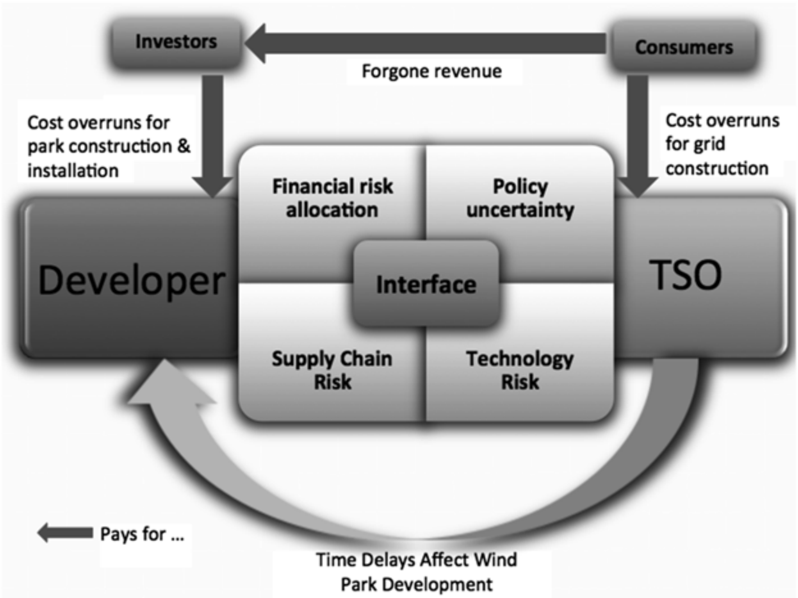

Fig. 5.3 Illustration of the governance setup (*Source*: Authors)

The Pioneer: Alpha Ventus

As the first German OWP, Alpha Ventus was a pioneer project with a mixed outcome. After several delays of the project before construction start, engineers started first cable installations in August 2007. In September 2008, Alpha Ventus (2008) announced that bad weather conditions would delay construction until spring 2009. Construction ended in November 2009, and the park officially opened in April 2010. Costs increased from planned €190 million to €250 million, 32 % above planned cost (MMO 2010). But it produced 15 % more electricity than expected (Alpha Ventus 2012).

Alpha Ventus launched the start of the offshore wind industry in Germany. In 1999, a small company from Leer planned to build a pilot-OWP 45 km north of the island of Borkum. In November 2001, the BSH permitted the park with the condition that construction had to

Table 5.7 Key factors in four selected case studies

	Alpha Ventus	BARD I	Nordsee Ost	Borkum-Riffgat
Developer	E.ON, EWE, Vattenfall (DOTI)	BARD Engineering GmbH	RWE Innogy	EWE Erneuerbare Energien GmbH, ENOVA
TSO/grid cluster	Tennet/none	Tennet/BorWin1	Tennet/HelWin1	Tennet/none
Capacity	60	400	295	108
Number of turbines (turbine type)	12 (6 × REpower 5 M, 6 × AREVA M5000–116)	80 (Bard 5.0)	48 (REpower Systems 6.0)	30 (Siemens SWT-3.6–120)
Distance to shore	56 km	112 km	51 km	42 km
Water depth range	33–45 m	40 m	22–25 m	18–23 m
Start of construction	August 2007	June 2009	July 2012	September 2012
Planned start of operation	2009	2011	2013	2013
Actual start of operation	April 2010	Currently not operational	December 2014	April 2014
Time delay (months)	12	>36	18	6
Planned cost (million €)	190	1500	1000	480
Actual cost (million €)	250	2900	1300	480
Cost overrun (%)	32	93	30	0

Table 5.8 Key factors affecting planning and construction in four case studies

		Alpha Ventus	Nordsee Ost	Borkum-Riffgat	BARD I
Technology	Construction technology	Unknown factors such as wind strength, capacity, and transmission	Difficulties in construction of converter platform and transmission		In-house operation of turbine manufacturing and unsolved transmission problems
	Supply chain and logistics	Installation logistics or maintenance in an extreme environment	Insufficient maritime infrastructure	Removal of underwater wartime material	Extreme conditions of work at sea led to deadly accidents
Human	Management	Consortium of three firms faced coordination problems and unclear responsibilities		Communication problems between project developer and TSO	Planners underestimate challenges; firm declared insolvency
	Regulatory/ political	Political intervention by the federal government	Uncertainty regarding the liability for grid connection delays	Diplomatic dispute between the Netherlands and Germany	

start before April 2004. It did not happen. In September 2005, the OWF was newly found due to an initiative by the BMU. OWF intended to build Alpha Ventus as planned and connect it to the grid by 2007 (OWF 2010). DOTI, a consortium of E.ON, Vattenfall, and EWE, founded in June 2006, intended to lay the cable connection between the 12 OWTs and the onshore grid. Supported by a €30 million grant from the BMU, Alpha Ventus was intended to cost €190 million at construction start in 2008 and finish early 2009, accompanied by the research organization, RAVE, to study weather conditions, technology, and determinants of electricity generation. An industry source said: "A process of learning and ramping up is not only very normal but also very important to improve processes and organization" (Interview 011215).

DOTI turned out to be "the most complicated structure one could imagine for the construction of the first offshore wind park in Germany" (OWF 2010). With different company cultures, frequent changes in project management, organizational structure, and internal responsibility, the companies were hesitant to invest (Interview 011415). The BMU, including then Minister of the Environment Sigmar Gabriel, had to repeatedly intervene to save the project (OWF 2010). Alpha Ventus reported time delays due to "extreme challenges to installation logistics, construction, project management and the maintenance far off coast" (Alpha Ventus 2012). Additionally, environmental factors of salty air, strong wind, and waves were "massively increasing investment and maintenance costs compared with close-to-coast offshore locations or onshore wind parks" (Alpha Ventus 2012). In April 2010, Alpha Ventus was finished at a total cost of €250 million and fed electricity into the grid.

Nevertheless, industry and government reacted positively to the finalization of Alpha Ventus. While the developers originally expected 3.900 full load hours per year, Alpha Ventus had 4.450 full load hours, generating 267 GW/h in 2011–15 % more than expected. An engineer who was involved said: "It was pioneering work and the project was uniquely challenging. A lot of problems occurred and it became more expensive than intended. But technologically, Alpha Ventus was very successful [...] which created a lot of optimism" (Interview 011415).

Large and Complex: BARD I

BARD I is an extreme case compared to the others. In June 2009, the BARD Engineering GmbH started construction of one of the largest OWPs in Europe with 400 MW capacity. In March 2010, the first turbines fed electricity into the grid and the park was expected to become fully operational by mid-2011. It was repeatedly delayed and finished in August 2013. Only 3 months later, BARD I had to be plugged off because of technological problems. It is not fully operational to date. It was originally intended to cost €1.5 billion and was estimated to cost €2.9 billion in January 2012 (UniCredit 2012).

In 2003, the Russian–German engineer and entrepreneur, Arngold Bekker, had begun planning an offshore wind venture in Germany. A former Gazprom-official and multimillionaire, Bekker formed the BARD Engineering GmbH (the initials are Bekker–Arngold–Russland–Deutschland) and planned to finance the construction of BARD I with €100 million of his private fortune (Die Zeit 2009). The company held its own subsidiaries for nearly all parts of the supply chain, including turbine manufacturing, logistics, steel, and installation. UniCredit was the main financier, with a 70 % share in 2009, and the EU subsidized the project with €53 million (Energie Chronik 2012). Developing their own turbine, the Bard 5.0, the engineers started construction in June 2009, 112 km off Borkum in the North Sea, planning to finish by mid-2011. A consultant said: "It was a mistake to manufacture the turbines by themselves. I could say back in 2006 that this would not work. BARD believed they could take it on all by themselves" (Interview 011415).

The construction period was a disaster. It seemed BARD could not ensure workplace safety. A diver who worked on a trafo platform drowned in June 2010 (Die Welt 2010). Another worker died in January 2012, when a docking platform he climbed accidentally slid (BARD 2012). Tennet provided the grid connection BorWin1 without time delays (Energie Chronik 2012). BARD did not comment on reasons for installation time delays that occurred continuously. But likely, the combination of technological challenges and the ambitious undertaking of manufacturing turbines in-house, resulted in investors gradually losing confidence as setbacks and incidents mounted.

In August 2013, BARD finished construction but had to declare insolvency. Ocean Breeze, a subsidiary of UniCredit, took over. In November 2014, unexpected electricity transmission disturbances occurred. Ocean Breeze assigned a task force with Tennet and ABB to investigate (IWR 2014). To this day, the task force did not find a cause. BARD I had damaging repercussions for the offshore wind industry in Germany and worldwide. Critics in Germany problematized the cost of the *Energiewende* (Die Welt 2014). The Economist (2013) called the project an "expensive disaster."

Facing Typical Problems: Nordsee Ost

Nordsee Ost, substantially larger than Alpha Ventus, faced problems often observed in the development of offshore wind energy in Germany: time delays caused by the grid connection, regulatory uncertainty, supply chain bottlenecks, and technological challenges. Originally intended to finish in late 2013 and cost €1 billion, engineers started construction of Nordsee Ost in July 2012. It finished in December 2014 and had a 30 % cost overrun (€300 million additional cost).

RWE, a utility firm, faced public criticism for not investing in renewable energy in Germany. In February 2008, RWE founded a subsidiary, RWE Innogy, to bundle and expand their renewable energy portfolio, which included biomass, solar, and onshore wind (RWE 2014). RWE had offshore wind industry experience in the UK but closer to shore and with smaller turbines. RWE decided to invest in Germany and take over the Dutch company Essent, including their project pipeline: Nordsee Ost, already in the preconstruction phase, and Nordsee One, Two, and Three, with a planned total capacity of 1.3 GW (Interview 011415). Between 2008 and 2012, Nordsee Ost faced construction delays because maritime infrastructure was insufficient, with too few installation vessels to sustain difficult work at sea. In 2012, RWE bought two installation vessels and founded a subsidiary for installation logistics to support their projects (Interview 011315.2; Interview 011415).

After the logistics bottleneck was solved, the grid connection debate began in Germany. RWE Innogy CEO Hans Bünting criticized regulatory uncertainty caused by the government. He said: "There is a lack of standardization and centralized planning, and this leads to lack of certainty in the supply chain—and that all leads to the mess we see today" (Rechargenews 2012). Because Tennet was late in finishing the converter station HelWin1, Nordsee Ost faced a time delay of 18 months. RWE Innogy threatened legal action against Tennet, claiming that delays cost them up to €12 million per month (Toptarifnews 2013). An industry source commented: "The transmitter cables, converter platforms and other components were not available on a tech supermarket, but uniquely challenging as the technology was young and huge investments were necessary" (Interview 011315).

After the liability issue was solved with the 2013-EnWG amendments, the debate ebbed. In December 2014, all OWTs of Nordsee Ost were installed and the company expects commercial operation in spring 2015 (RWE 2014). RWE managers said they have learned from their experience with Nordsee Ost and will improve if political certainty remains (Die Welt 2014).

Staying on Budget: Borkum-Riffgat

Riffgat has no reported construction cost overruns but faced time delays caused by the grid connection. After repeated delays of construction start due to technological and political problems, engineers started construction of the 30 OWTs in September 2012 for a planned €480 million investment. Because Tennet had to remove wartime material from the seabed to lay underwater transmitter cables, the grid connection cost €57 million more than planned. Riffgat avoided sources of cost overruns that other projects did not, such as the turnkey contract for the subsea station, but the increased cost of €100 million in total was controversial in the media because consumers had to pay (FAZ 2014). Riffgat was technologically easier than other cases studied, because it was the closest to shore and in the shallowest water, potentially an enabling factor for more successful planning.

EWE and ENOVA, two regional companies, planned Riffgat in 2000 and founded the consortium Offshore Riffgat GmbH & Co KG. In 2010, the project developers obtained permission and approval for grid connection for Riffgat, planning to start construction in 2011 and finish by the end of 2012 (Riffgat 2015). Riffgat is 42 km off the island Borkum in the North Sea and within the 12-mile nautical zone of Lower Saxony, which launched an "Action Program Offshore Wind Energy" at the time. Other than for Nordsee One, Tennet was not legally responsible for the converter platform. Instead, it was built by Strukton-Hollandia under a turnkey contract (Strukton 2015). Riffgat is in a sea area, whose demarcation line between the Netherlands and Germany had not been finally concluded. Speculatively, this dispute led to delays in construction start (FAZ 2014). In 2012, investigations by Tennet for laying the subsea transmitter cables found more wartime material under water than previously known. Their CEO, Lex Hartmann, said they paid €57 million for the removal of 30 tons of material within 18 months, as well as €43 million compensation to Riffgat for forgone revenue (Tennet 2014).

Tennet was accused of insufficient risk assessment and preliminary investigation. A risk consultant said: "Going about it that way is dangerous, and highly expensive" (WPO 2014). But possibly, Riffgat did not communicate their knowledge with Tennet effectively (EEM 2014). In August 2013, Riffgat was operational but had to wait for grid connection until February 2014. Reportedly, electricity production was higher than expected (IWR 2014).

Discussion

Two Types of Cost Overruns

Because of the interface problem between wind park developers and TSOs, this study distinguishes between two types of cost overruns. First, the wind park developer has a cost and time schedule regarding the EPC tasks of the project. For any problems in the value chain that cause cost and time overruns, there is a responsible party as defined by the contracts. Second, the TSO has a cost and time schedule for providing the grid connection. For time delays, the TSO has to compensate 90 % of the forgone revenue of electricity production to the wind park developer, in turn compensated for by higher electricity prices for consumers. Table 5.9 depicts the scale of cost overruns resulting from this distinction.

Table 5.9 Scale of cost overruns until the end of 2014

	Compensation for loss	Total additional costs (million €)	Average cost overrun per OWP (%)
EPC	Private (investors)	2060	22
Grid (forgone revenue)	Public (consumers)	1047	15
Grid (construction)	Public (consumers)	*Unknown*	*Unknown*

Construction of the Offshore Wind Park

The average cost overrun for OWP construction and installation is 22 % for finished projects. From previous analysis, a number of explanatory factors could be deducted. According to this model, the key factors for project delivery are supply chain logistics, governance, and project finance. It depends on the individuals firm's performance whether it can learn from previous failures to avoid cost overruns and reduce cost. Firms can mitigate cost overruns by selecting proper risk allocation models (contracts, insurance, contingency budgets, etc.). An example of good performance, according to industry sources (Interview 011315; Interview 011415), is DONG Energy, because they have achieved the scale to build integrated supply chains which helped them solve logistical and financial problems that other wind park developers faced (however, their German OWPs are not in the sample, because they are still under construction).

Surcharge Addition due to Time Delays

The total surcharge addition was more than €1 billion until the end of 2014, which equals a 15 % average uptake per OWP.[10] The electricity surcharge addition is the sum compensated by the TSO to the wind park developer, paid by an electricity surcharge according to the §17 F EnWG (Offshore Haftungsumlage). An information platform of the German TSOs reported the cost to be €295 million in 2013, €762 million in 2014, and €491 million in 2015 (Netztransparenz 2013, 2014a, b). A

[10] This number does not take into account cost overruns due to construction costs of converter platforms and grid connections (e.g. Borkum-Riffgat cost €57 million more) and the potential for wind park developers to use an intermediate grid connection to mitigate against losses.

TSO representative said the total of €1.5 billion will not significantly increase over the next few years, because five grid connections are already operational, and the subsequent projects will not be delayed as much. Surcharge additions can be seen as the specific additional cost of public planning of the development of offshore wind energy in Germany.

Learning Effects

There have been learning effects in the planning of OWP construction and installation (see Fig. 5.4). Four parks (Alpha Ventus, BARD 1, Baltic 1, and Global Tech 1), which started construction before the end of 2011, had an average cost overrun of 34 %. Four parks, which started construction after the beginning of 2012 (Meerwind Süd/Ost, Nordsee Ost, DanTysk, Riffgat), had an average cost overrun of 10 %. A consultant said that pioneer challenges such as maritime logistics, supply chain, and finance have gradually become less problematic as the industry learned (Interview 011415).

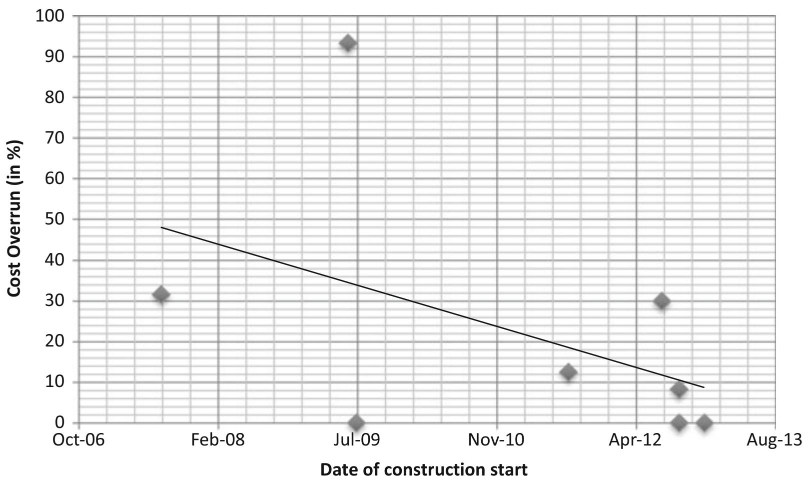

Fig. 5.4 Learning effects in offshore construction over time (*Source*: OWP database)

Conclusion

This study looked at the scale, patterns, and causes of time delays and cost overruns in offshore wind power expansion in Germany. Germany has ambitious targets to make offshore wind a market-competitive source of power generation and an essential pillar of its *Energiewende*. But this development faced governance problems due to interface complexity between wind park developers and TSOs. The industry faced technological, financial, supply chain-related, and political challenges in construction of the wind park at sea, resulting in an average cost overrun of 22 % per OWP. But time delays in the grid connection were an additional factor that led to additional costs of forgone revenue compensation to the wind park developers of more than €1 billion by the end of 2014.

These results show that learning takes place in the planning of construction and installation of OWPs, contrary to other sectors such as transportation (Flyvbjerg et al. 2003). Therefore, the technology factor of high standardization plays a key role. Human factors generally play a large role as well, but technology is the defining factor for the scale of cost overruns across sectors. Further, these results show that a "semi-private" megaproject such as offshore wind expansion has specific governance problems with the risk of time delays and cost overruns, for both private and public shareholders and stakeholders. This opens various avenues for further research in infrastructure planning and management, the public–private nexus, as well as energy and climate governance.

Recommendations

Cost overruns and time delays for construction and installation of OWPs are a manageable issue, as the industry is maturing and learning from experience. But the impact of cost overruns and time delays in grid connection and expansion is underexplored. Based on the results of this study, the authors recommend:

Strengthening coordination between TSOs, wind park developer, and supplier industries

Coordinating with governments of North Sea countries to enable long-term planning, share best practices, and develop transnational scenarios for offshore wind and grid expansion and interconnection (e.g. North Seas Countries Offshore Grid Initiative)

Developing a policy framework for the expansion of offshore wind after 2020 that enables investment security, competitiveness, and regulatory coherence

To identify potential problems and find better solutions, the Federal Ministry for Energy and Economy should order a study on the impact of time delays and cost overruns in grid construction on total costs of offshore wind expansion

To avoid further ad hoc measures, an independent auditor should assess potential sources of time delays and cost overruns and develop accurate estimates for financial contingency budgets as well as risk insurance models

Offshore wind power is likely to assume an important role in Germany's energy mix. It will remain a key challenge for the industry, government, and the public to find the right solutions to make the *Energiewende* succeed.

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6

Conclusion

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Infrastructure is an important investment asset worldwide. Currently, about 8 % of the global GDP is spent on very large infrastructure projects, and more and more of such investments are locked in bigger and bigger projects (Flyvbjerg 2014). As projects get bigger, so does the problem of time delays and cost overruns. Many infrastructure projects are under construction in developing countries, which often lack resilience and capacity to shoulder such complex endeavors, and are hence more vulnerable to these risks (Ansar et al. 2014). Many Western states, too, face an investment bottleneck in maintenance and refurbishment as roads, rails, tunnels, and bridges are aging. Allocating resources properly becomes especially important, as insufficient investment budgets necessitate more efficient spending. But this study has shown that there is significant need for improvement also in Germany to avoid waste of resources urgently needed for maintaining existing infrastructure.

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Patterns of Infrastructure

What are the scale and patterns for time delays and cost overruns for large German infrastructure projects, and what lessons can we draw? Our analysis has shown that for a selection of 165 megaprojects worth a total of more than €193 billion, average cost overruns are at a staggering 52 %, equaling a total of €47 billion in total cost. But the findings show that cost overruns vary significantly between sectors. With 131 %, information and communications technology (ICT) projects have the highest average cost overrun in the sample, followed by 91 % for energy projects (nuclear and offshore wind). Nuclear power plants are the most risky projects with an average cost overrun of 187 %. Defense acquisition projects also have high cost overruns of 85 % and weigh especially heavily on the public budget because they are the largest projects in the database of this study—€8.1 billion on average. The building sector (51 %) and transportation projects (32 %) are below the average cost overrun but also significant because those are the most cases in the database—78 and 50, respectively. The database also contains 51 unfinished projects with a lower cost overrun average of 39 % compared to 52 % for finished projects, but more cost overruns can be expected.

The study found only slight differences in cost overrun performance comparing Germany with other countries (see Table 6.1). With 51 projects in the database, the transportation sector is well documented and

Table 6.1 Comparison of findings with relevant transnational studies

	Germany		The Netherlands		Northwest Europe		World	
	Average cost overrun (%)	Sample size (*n*)	%	*n*	%	*n*	%	*n*
Road	**28**	**19**	19	37	21	315	20	537
Rail	**33**	**6**	11	26	22	90	34	195
Tunnel/bridges	**23**	**4**	22	15	32	54	33	74
Total	**29**	**29**	17	78	22	459	24	806

Source: Infrastructure Project Database, Cantarelli et al. (2012).

allows best for comparison with research done for infrastructure projects internationally. We have found that within the sector, roads have a low average cost overrun of 28 %, but a large cost overrun range from 23 % below to 125 % above budget. Rails experience slightly higher average overruns of 33 % but in a smaller range from 10 % below to 59 % above budget.

Causes of Infrastructure Problems

With our in-depth study of the Hamburg Elbphilharmonie, the Berlin Brandenburg Airport (BER), and offshore wind parks in Germany, we can confirm many of the previous explanations for time delays and cost overruns. We found that technological, political-economic, and psychological factors played a role. Among various technological factors, interface challenges, unanticipated changes in project technology, and unknown technological risks at project start were common pitfalls. For example, the challenging construction of the Elbphilharmonie's façade, the necessary change in fire protection technology in the BER due to a change in EU-wide requirements, and grid connection problems in offshore wind projects were of such nature. Common economic reasons include hidden action and perverse incentives for project planners and promoters. For the Elbphilharmonie and the BER, extensive claim management was at play and for offshore wind parks, ad hoc consumer surcharges as part of the *Energiewende* cushioned cost increases for private developers. Political factors observed include inexperienced planners and project managers, for example, in the project management entities in the Elbphilharmonie Hamburg and Berlin Airport cases. Both chose risky project governance setups in which top politicians instead of experts were sitting in the driver seat, thus weakening oversight cost control and enabling strategic deception. Finally, "optimism bias" was a factor in all case studies, as risks had been systematically underestimated while benefits overestimated.

Moreover, the study found additional factors in the case of specifically large German infrastructure projects. First, German project performance in some cases suffers from "pioneering risks" of implementing projects with high technological challenges. Germany often chooses previously untested technology for its projects, which then carry additional high-risk, high-impact pitfalls. Examples here include nationwide IT systems, like a federal taxation, toll, or health-card system, and the expansion of renewable sources of power generation on an unprecedented scale. With limited previous experience, such transformative projects are naturally more risky. For example, offshore wind parks were no new technology but had to be built in a significantly more complex project environment both physically, far from shore, and regulatory, with unclear legal responsibilities in case of time delays. However, offshore wind parks faced a decrease in project cost overruns over time, illustrating that learning takes place in planning and reduce the initial pioneering risk.

Second, Governance problems play a huge role for project performance as well. The case studies on the Elbphilharmonie Hamburg and on the BER show that the chosen governance setups are often unfit for the project. Early in the run-up phase of projects, politicians—inexperienced in large project governance—entrusted managers of public corporations, which also lacked adequate experience with key roles in project management. Thus, often transparency and control of the project were lost resulting in a sequence of change requests, strategies to hide bad performance resulting finally in budget and time overruns. In the BER case, the failure to appoint a general contractor early in the project put the public airport corporation into the role of coordinating numerous contractors, which overwhelmed it completely. The failed rush to completion to meet a fixed opening date resulted in a chaos that is taking at least 5 years to analyze and repair. In the Elbphilharmonie case, the managing firm made governance decisions, underestimating their interdependencies, which led to an unmanageable amount of necessary coordination effort. In both cases, supervisory and control bodies lacked the knowledge to detect bad performance and scrutinize project developments.

Finally, the findings further show that the nature of the German political, decentralized system with planning responsibility and funding often divided between the federal state, the Länder, and the local government level may play a large role as well, though this study could not explore this issue deeper.

Lessons for Better Delivery

Important lessons can be drawn from this study, which are relevant beyond Germany. The performance of infrastructure projects can be considerably improved across sectors. Based on the German case and drawing on the results of previous research on improving project management, we recommend the following measures.

Key Recommendation: Sector-Based Benchmarking

To improve the governance of large-scale infrastructure projects in Germany, the German government should systematically gather and analyze data on the performance of current projects to first allow for a comparison of different projects, and thereby to create a "reference cost database." Sector-based benchmarking is a set of recommendations primarily targeted at the technical side of the planning process and consists of three individual measures. First, as part of sector-based benchmarking, Germany needs to establish a comprehensive, detailed, and publically available database on large-scale infrastructure as a basis for further analysis, to give the interested audience a mean to participate in the formation of projects and to allow for a democratic process of public scrutiny. This would also restore credibility with regard to the recent mismanagement of large public projects. In the UK, the newly founded "Major Projects Authority" has recently established such a database, which could serve as an example for the German case.

Germany should use "reference class forecasting" (RCF), a planning method first suggested by Kahneman and Tversky (1979a). RCF allows for planners to give an estimate of the degree of risk of a project and to calculate budget contingencies, to safeguard against cost overruns. For any proposed project, planners look at a subset of similar, already realized projects. Then, planners place the proposed project is in a statistical distribution with these past projects and chose a level of security (e.g. a factor of risk-aversion). From that, a contingency sum can be calculated.

Finally, Germany needs to change the current incentive theme for public projects. Under the current system, governments and project managers are insufficiently accountable for above-budget projects. Therefore, schemes for micro-level risk allocation, such as penalty-and-reward systems for missed and met targets, should be introduced. With legal responsibility and public accountability, project managers are better incentivized to perform well.

While sector-based benchmarking is a key instrument in improving performance, and a first vital step in systematically enabling better monitoring of the performance of large public infrastructure projects, our database analysis and the deep-dive case studies have shown that the governance of large infrastructure projects has major shortcoming, which policymakers need to address.

Inclusion of Expert and Private Sector Knowledge

In many cases, supervisory bodies staffed primarily with politicians (e.g. Elbphilharmonie, BER) often lack experts with firsthand experience in designing the governance and management of large projects and are instead staffed with politicians and top public officials without adequate capacity for competent oversight. Without expertise, it is not possible to assess the fit of the governance setup and the credibility of plans and cost estimates, nor to efficiently and effectively run and control projects. Supervisory bodies need to be staffed with experts in the project matter. Especially for choosing an adequate project governance, the respective politicians in government should consult early on with various experts in the field. Aside from civil servants with infrastructure experience, this mainly means the inclusion of private sector knowledge at this highest level of project management through consulting contracts. For the governance setup of large infrastructure projects, the engagement of private sector knowledge is highly advisable as was done in the planning and project delivery of the London Olympics. It would be most beneficial to include those experts who not only qualify through private sector practice but also understand the mechanics and constraints of public service and can freely roam both in the process-oriented world of civil service and the solution-oriented private sector.

Independent Monitoring

For many managers, real large public projects are once-in-a-lifetime projects. Processes of learning of course take place for managers over the lifetime of a project, but often, they rarely get the chance to apply lessons learned to a new project. Knowledge management for public managers is absent. Therefore, we recommend introducing an independent competence center for large public projects, shared by the federal, state, and communal levels. With a pool of knowledgeable, experienced members, such a center could early on get involved in planned projects and advise managers and planners on key issues like the planning of tender schedules, best practices and methods in processes and organization, trustworthiness of cost estimates, risk management, and necessary steps to get projects back on track if necessary. Under the federalized German political system, it is unrealistic to expect the installation of an agency similar to the "Major Project Authority" in the UK that has a clear review and auditing function over British major projects totaling whole lifecycle costs of GBP 488 million (UK Government 2014). A "cell" or small coordinating body in Germany, however, would allow already for much improvement in the delivery of large-scale projects. This would not be easy to achieve, but it is not unfeasible as shown in the field of E-Government coordination by a newly created Federal coordinating body. In addition, for matters of project performance and cost control, the German Länder and the federal government have sufficient expertise with their respective auditing offices (Bundesrechnungshof and Landesrechnungshöfe). These agencies need to be included in monitoring, advising, and reviewing processes and plans early on, in the project planning phase, to improve project performance.

Planning, Planning, Planning

The best guard against cost overruns is comprehensive front-end planning. While a longer, more-detailed planning process is costly itself and does contain the possibility that a project may be canceled before start, it can mitigate risks before they occur and avoid costly ad hoc change requests. Since for project promoters, longer planning processes are undesirable because usually cost estimates increase with longer planning processes, this recommendation needs to be implemented in regulatory standards for future projects.

Standardized, Professional Project Governance

Large projects in Germany often get into trouble because basic requirements of a fitting governance setup were ignored. Instead of choosing standardized, tested models for governance and management that save time and money, they are often deficient regarding expertise involved in the oversight, adequate planning, and risk provisions or change requests after design has been approved. In these cases, the public side is overburdened with work and management effort and with additional risk that could have been better allocated to the private side with improved risk management capabilities. While deviation from standardized project governance may sometimes be necessary to pay respect to the specific context of each individual project, a completely individual, different-than-other project governance setup increases the risks of missing interdependencies and the resulting cost increases and delays. Only experienced public institutions, with a longer record of planning and managing larger projects, should do without a general contractor in large and complex projects. The mechanisms and tools to set up a project organization are existent and need not be invented but only need to be applied regularly.

Inclusion of Private Capital

In several instances in Germany, neither ministries nor public agencies are responsible for larger infrastructure projects but public corporations. If their funding is not paid out of public budgets, they take bank loans in between. In this case, the advantage to bring in private sector expertise can be used. But this does not take place if the bank loans are covered by 100 % guarantees of the public entity as was the case with BER. So banks were not incentivized to deliver what they could have contributed in terms of risk management expertise.

Communications

Our analysis has shown that, often, project managers and politicians fail to manage the public and other stakeholders' expectations regarding running projects. Under the pressure of getting projects funded and started, the need to make them look good on paper is even bigger, and promoters promise both the skeptical opposition and the public highest-quality delivery at the lowest price. If project then run into problems like delays or budget problems, the public is even more disappointed. Often, the political opposition can use these accusations of false promises and scandalous atmosphere to profit in the next election. But in the political arena, this can easily backfire on the project itself and allow private companies to benefit even more from the political conflict through improved claim management (as, e.g. seen in the Elbphilharmonie case). A well-run communications department can help in managing public and political expectations early on. Participatory processes can be implemented to get the public and all political parties to buy into the project and limit the opportunity costs originating from dissent. If a project then runs into problems, a unified public side is strengthened in the negotiations vis-à-vis private firms. A hopefully less-politicized project with less room for benefit through a system of "divide et impera" helps problem stay on a stable course.

Outlook

In Germany, it was known that large infrastructure projects can go awry but not on what scale and by what specific mechanisms. But since the management of large public project first appeared on the public agenda in 2011/2012 with the Elbphilharmonie and BER developments, numerous other infrastructure projects with huge time and cost overruns surfaced around the country (a hospital, a port development, or an opera house in Berlin, just to name a few). This indicated that performance improvements were badly needed. German taxpayers' money continues to be wasted on inefficient public management. The German government in April 2013, therefore, installed an expert commission on large public infrastructure project management in the Federal Ministry for Traffic and Digital Infrastructure (Bundesministerium für Verkehr und digitale Infrastruktur), which is also responsible for federal building projects. The commission, staffed with 36 experienced project managers, architects, lawyers, consultants, scholars, civil servants, and other practitioners, was tasked with investigating the sources of time delays and cost overruns in Germany and with presenting recommendations for improving the current status. Over the course of 2013 and 2014, the commission met several times and established working committees in which members analyzed different aspects of large public project management in Germany. In June 2015, the commission published its final report (BMVI 2015), giving several recommendations on how to improve project delivery—taking into account our research results, which had been made available to them. Most of them echo or are at least similar to our own recommendations. These include the finalization of planning before project start, clear and professional project governance and risk management, and, finally, cooperative, transparent, and participatory planning procedures including the private side and the public. Aside from these recommendations, the commission focused on the technical aspects of project planning. One core recommendation of the commission that was promoted early on was the increased, professionalized use of Building Information Modeling (BIM) software tools to plan projects. What is more, the commission suggested paying considerably more attention to risk technical and financial risk assessment during project's design and development phases, as often, it is high impact risks which drive cost escalations. Finally, the commission analyzed how to handle legal issues between the public and private side, which often are a component of public project management. The commission advises to focus on mechanisms to solve issues outside of court, where a clear winner is unlikely and both sides sometimes wait decades before a verdict is received. It remains to be seen whether the German government will in fact implement at least some of the recommendations.

The planning and execution of large-scale infrastructure projects in Germany needs significant improvement. Our analysis has given both a comprehensive overview over the scale and patterns of time delays and cost overruns of large-scale projects in Germany and explored specific causes. Many industrialized countries suffer from cost and time overruns in megaprojects. Especially in Europe and North America, the political, social, and economic systems are similar to the German system, meaning that the scales, patterns, and sources of cost and time overruns can also be found in other countries the planned Fehmarn Belt Bridge connecting Germany and Denmark, international train links, European airports, the new Gotthardt Tunnel in Switzerland, the San Francisco Oakland Bay Bridge, and the new Now York Subway Line currently under construction are all examples of megaprojects under similar political and social mechanisms. The lessons we have drawn from the German case are similarly applicable for these projects. This is necessary to improve the performance of global infrastructure projects, to allocate resources properly and reduce the waste of taxpayer's money.

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