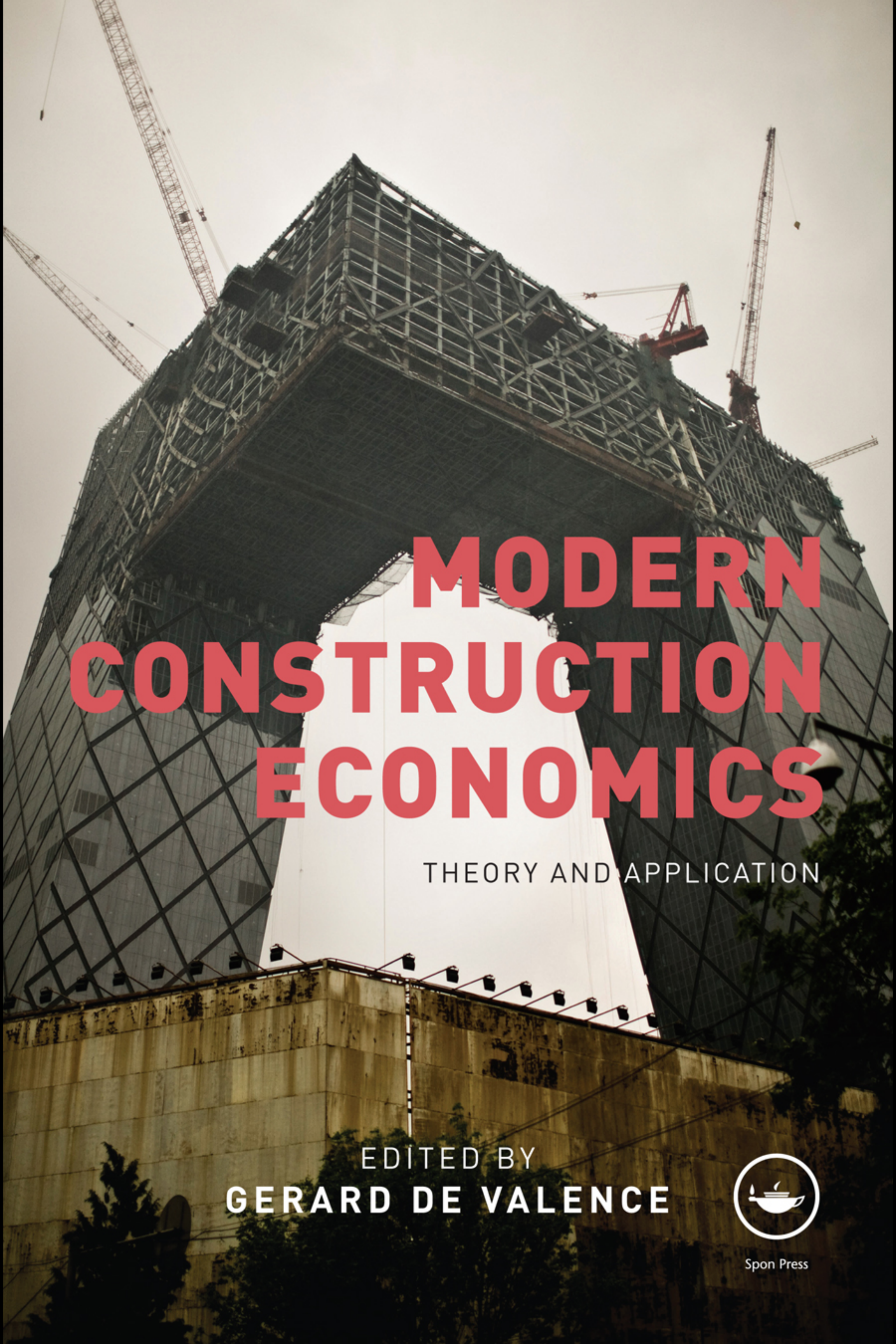

MODERN CONSTRUCTION ECONOMICS

THEORY AND APPLICATION

EDITED BY
GERARD DE VALENCE

Spon Press

Modern Construction Economics

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Preface

This is a somewhat unusual book, in the context of the books found in contemporary construction management and construction economics. It is neither a textbook nor a guide to any of the many and varied functions and tasks of construction managers and construction economists. Instead it is a collection of chapters all of which are concerned in different ways with the question of how we analyse and understand the industry.

The building and construction industry has many aspects. It is often given an important role in the macroeconomy, both in its own right as a sector and also as one with extensive linkages to other industries. In line with its contribution to output goes a large share of employment, with residential building typically being one of the most labour-intensive activities. The industry has significant recruitment, training, skills and safety issues. Building and construction accounts for a major proportion of business investment and thus is an input to virtually all economic activity, and purchase of a home is often the largest purchase many households make. Much of the sustainability agenda involves the built environment. The list can be added to endlessly.

Despite these industry characteristics, most of the published research on building and construction has focused on various aspects of projects and project management. This will always be the case for construction management research, but building economics research has also largely been concerned with a range of activities involved with delivering projects, the tools necessary in the sequences of steps involved in getting a building from conception to delivery, such as feasibility studies, cost estimating and planning, life cycle costing, market analysis, and so on.

While construction will always be an industry of projects, analysing projects will not develop an understanding of the industry. What is needed for that purpose could be described as construction industry economics, where the approach taken would focus on issues and topics that are important at the industry level. Examples are strategic behaviour of firms and the forms of competition between them, market structures and the entry and exit of firms, R&D, innovation and technology, and public policy and regulation. These are not, of course, new topics. Previous research has been published on all these, and the other topics that can be included. However, the time seems right to bring this research into an identifiable field that has its own specific set of tools and techniques and typically applies them to the industry rather than projects.

The intent of the book you are holding is to contribute towards the establishment of such a field of research. The range of topics is broad, but neither exhaustive nor definitive. What each of the authors has contributed is a stimulating, original approach to a topic that furthers our understanding of the industry. Some chapters are unabashedly theoretical, others are more practical, thus the title of the book. In many cases the arguments made here have the potential not just to stimulate further research but may lead to revisiting and perhaps revising some core assumptions about the building and construction industry.

Gerard de Valence

1 Theory and construction economics

Gerard de Valence

INTRODUCTION

There has been an ongoing discussion about the future development of construction economics (CE) and the role theory should take in that development. One aspect of that discussion is the lack of agreement on a definition for CE. Broadly, there are three views of CE. The first follows Hillebrandt and her definition of CE as the application of 'economics to the study of the construction firm, the construction process and the construction industry' (2000: 3). Raftery (1991) and Cooke (1996) also cite this as their approach. A second view is based on the classic definition of economics as 'the study of the allocation of scarce resources' by Robbins (1927: 2). Ofori (1990), Gruneberg (1997) and Myers (2004) use this as their starting point.

The third approach is somewhat more eclectic, but could be described as economics with a focus on building and construction. Runeson (2000) does not define building economics (the title of his book) but explains at length the characteristics of economics as a science and the methodological implications of that, a theme investigated further in his chapter in this book. The books by Gruneberg and Ive (2000, and Ive and Gruneberg 2000) also do not neatly fall into one of the two categories above, and offer an alternative approach. Many of the other books on the economics of construction (e.g. Briscoe 1988; Ball 1988, 2006; Finkel 1997) or the economics of the built environment (Warren 1993) do not define CE at all. Although this is a small sample of the field it is representative, and shows why Ofori (1994) could confidently claim then that no definition had been accepted for CE, a situation that still exists today.

Perhaps there is no definitive answer to the 'What is CE?' question, or perhaps the answer depends on the reason for asking the question in the first place. Reflecting the different views of CE there are two approaches to the debate over the future development of CE. The origins of this debate can be traced back to Bon (1989), and has been taken up by Ofori (1994), Myers (2003) and de Valence (2006). Comments by Bon (2001) and Bröchner (2002) put forward the view (in different ways) that CE has not established itself as a distinct discipline. A recent contribution by Ive and

Chang (2007) also considers this issue. In the discussion here these six papers are divided, with the contributions of Bon, Ofori and Myers seen as largely concerned with the domain of CE, while those from Bröchner, de Valence, and Ive and Chang more concerned with the relationship between economics and CE.

An aspect of this debate is the gap between the practice of CE, by quantity surveyors, cost consultants and consulting economists who do life-cycle costing, investment appraisal and cost–benefit analyses, and CE research done mainly by academics. It would be fair to say that the debate over future development of CE and its theoretical foundations is not a major concern for practitioners. But is it really a concern for CE academics? If it is, what is being done about it, and if not why not?

THE DOMAIN OF CONSTRUCTION ECONOMICS

The proposition that building economics is not established as an academic discipline was first made in Bon's *Building as an Economic Process: An introduction to building economics*. In the Preface of that book he stated: 'my main purpose is to provide the foundations of a theoretical framework that will inform further development of building economics', and this will be 'a first step toward a consistent framework for an explanation of economising behaviour in the building arena' (xiii). The five chapters in the book covered building economics, capital theory, the building process, business and building cycles and suggestions on future research. Further, the 'objective of this book is to assemble in one place those concepts that may contribute to the development of building economics as a distinct discipline' (Bon 1989: 25).

In Bon's note on 'The future of building economics' the argument from the 1989 book was restated, the future being 'in fields like corporate real estate and facilities management' (Bon 2001: 256). While the future has turned out to be rather more complex than that statement implies, the significance of topics connected to facilities management such as building use and reuse decisions has increased greatly over the last decade, and this has been accompanied by a growth in importance of building life cycles. As Bon put it 'buildings will be designed and constructed with the entire building process, that is, the whole building life, in mind' (2001: 256), again reprising his ideas from 1989. This view was echoed by Myers (2003) in his conclusion that the sustainability agenda was central to the future of building economics.

Next Ofori (1994) agued that construction economics has not yet developed to the point where it could be recognised as a distinct part of general economics. The main reason for this was the lack of consensus on the 'main concerns and contents' and a lack of a coherent theory (1994: 304). Ofori also argued for the term 'construction economics' as preferable to 'building economics' because of its wider scope (1994: 296), a distinction dismissed by Runeson in this book.

The contribution to the debate from Myers (2003) came in a paper that followed on from Ofori (1994) and Bon (2001). In his analysis of the syllabus content of quantity surveying, construction management and civil engineering courses at 10 UK universities he followed Ofori's division of the discipline into two types of construction economics: construction industry economics, concerned with the application of economic theory; and construction project economics, concerned with cost planing and control, life-cycle costing and investment analysis. Myers found this distinction reflected in the courses offered, with the emphasis typically on one or the other of these, and thus 'construction economics continues to lack any coherent conceptual structure' (2003: 103). Myers went on to argue the future of CE will be based on sustainability, and this will provide both a common purpose and conceptual approach, thus solving the two major problems identified by Bon and Ofori in their papers.

ECONOMICS AND CONSTRUCTION ECONOMICS

The other three contributions to the debate are less concerned with the topics that CE could or should include in its domain than with the nature of the relationship between economics and CE, and the direction of the flow of ideas.

Bröchner's (2002) paper was a Keynote at a CIB W55 Symposium and a progenitor of his chapter in this book. He asked where building economics should be heading, and answered 'certain types of economic theory are useful for not only providing ideas for restructuring commercial relationships in the sector, but also for predicting the relative sustainability of new patterns' (2002: 1). The issue Bröchner addresses is whether building economics has a role to play in reforming the industry and suggests that proposals to change the way the industry works have come from sociology and psychology. Further, 'building economists appear to have been timid' in their application of economic theory:

> is the application of economic theory a small niche with diminishing relevance to a larger community of researchers and industry practitioners? On the other hand, how far can construction management research proceed if it is based exclusively on case studies, interviews and e-mail questionnaires, with few strong attempts at theory building, somewhat lax in assumptions that are clearly spelled out and where the reasoning is weak on testable predictions?
>
> (Bröchner 2002: 2)

Bröchner concludes that a closer engagement with economic theories of industrial organization (also called industry economics) will provide public and private policymakers with a better understanding of incentives for the efficient use of scarce resources in the construction and management of facilities (2002: 7). The chapter in this book on barriers to entry is an example of an idea from industrial organisation applied to the construction industry, as is Brockmann's chapter on collusion.

De Valence (2006) suggested the arguments and propositions found in the debate over CE provided four distinct paths to the future. Two paths were the based on the distinction between construction industry economics and construction project economics, with the former drawing on economics for its ideas and the latter including building economics topics like cost management and planning, investment appraisal and cost–benefit analyses. These cover what has typically been the set of topics most commonly found in the field. The third path linked building economics to facilities management as Bon advocated, and this would include life-cycle analysis and the sustainability agenda proposed by Myers. This could be seen as a transfer of topics like life-cycle costing in construction project economics into a new category of 'facility sustainability' focused on the application of environmental economics to the built environment. The fourth path is 'closer engagement with economic theories of industrial organization' that Bröchner argued for in 2002, an argument developed further in his chapter here. In an analysis of topics found in fifteen CE texts de Valence (2006: 662) allocated a significant number to the industry economics/industrial organisation area. This lends support to Bröchner's argument about the potential and importance of topics that come from industry economics as a theoretical base for CE. De Valence went on to suggest:

> One of the other interesting things about the range of topics covered in these books is the way that many of them are not found in the CE and CM journals. Examples of this are Hillebrandt's stages of procurement and market power typology, market definition as in Gruneberg and Ive, the industry as perfectly competitive (Runeson, Cooke) or not (Ive and Gruneberg), and whether the output of the industry is a product (Ofori) or a service (Runeson, Hillebrandt). These would seem to be debates worth pursuing, because the discussion would contribute to our understanding of the nature of the industry, the activities undertaken, relationships between players and theoretical foundations for CE.
>
> (de Valence 2006: 663)

De Valence then suggested 'an alternative fifth' path based on emerging economic theories and approaches that have changed or challenged widely held views on macroeconomic issues such as capital theory, the business cycle and interest rates, and provide alternatives to the neoclassical synthesis that worked so well in macroeconomics for several decades. Examples of new macroeconomic theories include endogenous growth theory, with its emphasis on capital investment and innovation, real business-cycle theory and the effect of supply side shocks, evolutionary economics with its focus on capital, productivity and the dynamics of growth, and new Keynesian economics which emphasises the roles of time and capital. All these theoretical approaches offered fresh insights into many (mainly macroeconomic) issues, and pointed to potential new research and policy directions. The ideas found in these economic theories could be applied to the building and construction industry, and this offers potential for development of theoretical foundations and new research directions for modern CE. Like Bröchner, this sees a flow of ideas from economics to CE rather than the reverse.

The last contribution to the debate discussed here is from Ive and Chang (2007) in a paper that also addressed the relationship between CE, economics and management. Their concern was the extent of progress towards recognition of CE as a sub-discipline of economics, measured by citations and authorship across the journals of the main discipline and the 'putative subdiscipline'. Papers published in *Construction Management and Economics* between 2000 and 2006 were examined and classed as 'economics of construction', 'construction management' or 'building economics'. In their view, without a theoretical breakthrough that is recognised by mainstream economics the best that construction economics can aspire to is the application of propositions from economics to the understanding of behaviour and explanation of institutions within construction:

> we can conclude that the economics of construction is still closer to 'management of construction' than will be most economics papers to any body of management literature and that ideas coming out of economics do not predominate in it relative to those coming out of management science. We also found a substantial body of papers that we categorized as 'building economics', because of their lack of reference to recognized economics.

And:

> The economics of construction should 'ideally' face two ways: back towards the sources of its ideas (which should include the economics profession), to whom it can report on applications of theory, and forward towards the users of its normative work, to whom it can make recommendations. Meanwhile it also needs to look 'sideways' at itself, developing positive analysis whose value lies in adding to our understanding of why construction is organized as it is – something of critical importance for the development of CE, but which is not perhaps a main concern either to mainstream economists or to construction 'users' (Ive and Chang 2007: 14).

Also, Ive and Chang point out that in economics after 1980 topics emerged and gained recognition that 'potentially bear closely upon the practical concerns of construction economics'. These include transactional relationships, contracts and reputation, networks, contracting-out, joint ventures and auctions. The chapter by Drew on auctions in this book is clearly in this path.

Ive and Chang share a similar view to Bröchner and de Valence, with a largely one-way traffic in ideas from economics to CE, but by highlighting the requirements are rather more pessimistic about the prospects of CE finding an area where a breakthrough to sub-discipline status could be possible. This point is important and is revisited below. Before then, however, questions about the relationship between the economics of construction and construction management (CM) the Ive and Chang paper raises should be given more consideration.

PRODUCTION THEORY

The economic theory of production developed after the mid-eighteenth century was one of the main topics of classical political economy and focused on the generation of net revenue, first from agriculture and later from industry and manufacturing. As marginal analysis replaced classical economics in the second half of the nineteenth century, 'production theory was squeezed into the general framework of the optimal allocation of scarce resources: a framework originally developed to deal with the problem of pure exchange' (Gilbert 1987: 990). In the neoclassical theory of production the starting point is a set of physical technological possibilities represented by a production function, based on the cost minimisation and profit maximisation objectives of the firm. The objective of neoclassical production modelling has been to construct general equilibrium models with demand and supply functions for a wide range of products and factors of production, based on the range of substitution possibilities among outputs and inputs at different points in time. The main issue has been the technical constraint that describes the range of production processes available to a firm and determines the cost base (Jorgenson 1987: 1003).

The economic theory of production described above is clearly based on the manufacturing industry and the production decisions that these firms have to make in regard to technology, processes and routines used to create output. This gives technology a key role in determining efficiency. However, there is more to the story, because management of the production process determines, to a large extent, the efficiency with which inputs are utilized. Denison (1993: 24) concluded his review of growth accounting and productivity research with comments on the role of management in productivity. He argued that some, probably significant, portion of the productivity slowdown in the 1970s was due to a decline in management effectiveness in American industry. Alternatively, there may have been a slackening in competitive pressures and less innovation in management methods, leading to a slower rate of productivity growth in the 1970s and 1980s compared to the 1960s. This sentiment has been echoed by Hamel and Breen (2007) who argue that there have been no new ideas in management thinking for many years. Either way, the key role of management in generating production efficiency is clear, and the importance of managing technology is central to that role (Mowery and Rosenberg 1998).

Outside the lean construction movement there has been limited interest in a, or indeed any, theory of production as applied to the construction industry. What is found instead are various practice-based approaches, typically based on one of a range of management theories. Influential management theories, such as Porter's five forces (1980) and international competitiveness (1990), Hammer and Champy's process reengineering (1995), also Davenport (1993) on reengineering with information technology, and learning organisations (Argyris 1999) are all regularly found in papers in the building and construction literature addressing issues such as competitiveness, global markets and organisational capability.

The construction literature has many examples of management theories being used, usually during a period when they had gained a high profile in other industries. The short time in the spotlight for many management theories was the basis of Shapiro's (1995) book, and described by Abrahamson (1996). Some candidates for management fads in construction might be total quality management (e.g. Love *et al.* 2000), supply chain management (e.g. Love *et al.* 2002), knowledge management (Anumba *et al.* 2005) and relationship management through partnering (e.g. Cheng and Li 2002) or strategic alliances (e.g. Pietroforte 1997). Project-based management (see Turner and Keegan 2000) may have already come and gone.

In the evolution of lean construction and Koskela's ideas since the 1992 publication of *Application of the New Production Philosophy to Construction,* his production theory has developed into what is now the Transformation-Flow-Value (TFV) theory (see Koskela's chapter in this book for more on this, and an alternative approach to the argument here). For the construction industry, the ideas and methods of lean construction offer an alternative to the management theories mentioned above, and any of the many other management theories around. Apart from the usefulness of conceptualising production processes in a discipline traditionally preoccupied with practical matters, lean construction is the only theory of production to have been developed specifically for the construction industry. Therefore it provides insights into the range of processes that are involved, based on theory, that lead to propositions that can be tested by application to building and construction projects.

When discussing how the theory of production can be related to CE and CM it would seem a natural step to suggest that the economic theory of production aligns with CE; after all, these are both about economics. However, is this true? The economic theory of production is concerned with output and technology, typically defined (modelled) as production under a technical constraint. Much of CE is concerned with a range of activities that seem to be more involved with delivering products necessary to the sequences of steps involved in getting a building from conception to delivery: feasibility studies, cost planning, life costs, market analysis and so on. These are much more on the management side, akin to common tasks such as capital budgeting, activity-based costing and marketing, which also deliver tangible outputs (budgets, plans, etc.).

An interesting aspect of managerial theories is the extent of productive knowledge that is implicit in them. Most of the strategic, reengineering, marketing and so forth theories use extensive knowledge about a firm, its competitors, products and markets as their base. Likewise, many of the tasks undertaken within CE have a significant amount of prior productive knowledge, such as a method of measurement, a design evaluation or an industry analysis. A distinctive characteristic of productive knowledge is that it is typically distributed in work groups or across organisations (Nelson 2000). Some knowledge is shared (held by several individuals) and some is complementary and used in a coordinated manner. This seems to reflect the diverse range of skills and tasks that CE encompasses, from project-based to industry-wide analyses. Based on the two aspects of products delivered and the productive knowledge required to produce them, a link between CE and management theories of production can be drawn.

On the other hand, CM seems to be about resource allocation and delivery of a product (i.e. project), apparently a very economic-orientated set of activities. Although a wide range of management tools and methods are used in the course of a project over the conception-to-handover cycle, the emphasis is actually on the way that the production process is managed. Thus the central role is given to schedules and risk management. Further, the generic nature of project management supports this view. There is some specific knowledge in CM required for delivering construction projects, but the broader set of project management skills are not industry specific and are very much about getting the various processes needed for a particular project right.

Also, many of the important decisions in CM are often about the technology to be used: what type and how many hoists and cranes, and on-site versus off-site fabrication for example. The substitutability of capital (how much equipment) and labour (how many workers on-site) is apparent on every construction site. The treatment of production technology in construction seems rather *ad hoc*, and a theoretical framework backed up by modelling of processes could significantly improve productivity and efficiency. Economic theory gives technology the key role in determining efficiency, with management of the production process determining the level of efficiency. Thus a link between CM and the economic theory of production is found. These are both process-based and concerned with production technology choices.

To confound this neat, if unanticipated, linking of CE to management theory and CM to economic theory is the position of lean construction. Lean is all about management, as Womack *et al.* (1990) keep reminding us, and is the manufacturing philosophy of the age (see Fujimoto 2000 and

Florida and Kenney 2000 for the extent of this). While the underlying vision of lean construction is an industrialised process of delivering construction projects, the focus is on managing processes. This is particularly true of the Last Planner and the activity definition model but also applies to the overall Lean Project Delivery System in general (Koskela *et al.* 2002). Following the argument above, a process-based approach is closer to the economic theory of production (a view that the key points made in Koskela's chapter here rather support). In fact, with the roots of lean construction in CM this result fits nicely with the preceding argument.

This is not the obvious form of linkage between the theories of production discussed above and CE and CM. What it strongly indicates is the gap between theory, research and practice in CE. The activities referred to above all fall into the parts of CE that relate to building economics and the construction industry economics of sustainability. Where are the topics and issues that underpin theory and research?

CONCLUSION

The proposition that building economics is a still-emerging field does not appear to be controversial. From the debate over the future of CE five distinct paths were identified:

1 Building economics, or construction project economics
2 Construction economics, or construction industry economics
3 Facility sustainability, or environmental economics applied to buildings
4 Theories of industrial organization applied to building and construction
5 New macroeconomic theories applied to the building and construction.

Clearly CE has not, to date, developed a theoretical base that would allow a claim for it as a discipline or body of knowledge in its own right, and Ive and Chang were not optimistic about the ability of CE to generate the sort of theoretical development that would give it the status as a recognisable sub-discipline within economics. However, CE is not a theory-free zone. Many of the papers published in the field are explicitly or implicitly based on a theoretical proposition of some sort, usually imported from another discipline such as economics, finance, management or organisational theory. Often the theory is not elaborated at length or in detail. Generally, theory is not the focus of the research, and the paper for publication is typically about the application, because construction journals tend to emphasise research results rather than theory.

Production theory is one area that could be relevant to CE and CM because the delivery of a new building or construction project is clearly about producing something. However, production theory is complex. The economic theory of production developed out of the classical concern with marginal productivities into a production function focused on substitutability of factors under a technological constraint. CM could be reinterpreted in these terms because of the emphasis on construction technology, but it would need to explicitly consider the labour–capital trade-offs available in the choice of production methods. A relationship between CM and the economic theory of production was suggested because both are process-based and concerned with technology choices.

For CE the evidence does not support a strong link to economic production theory. On the other hand, the link to management theories appears to offer opportunities for extension and development of the skill and knowledge base. The management and application of productive knowledge could be taken as a core capability of CE because of the strong technical base and analytical nature of many of the tasks covered by CE. Further, putting this productive knowledge into the context of distributed knowledge also makes sense for CE, because of the diverse range of tasks and skills that CE incorporates.

It was argued that many CE tasks deliver products associated with different stages of a project, many of course associated with budgets and cost planning. There is not the apparent emphasis on managing processes that was found in CM. Combined with the productive knowledge required for CE products, a relationship between CE and management theories of production was suggested.

Perhaps surprisingly, it turns out that production theory may be useful in conceptualising CE and CM, at least as academic disciplines. While this may be regarded as irrelevant scholasticism by today's industry practitioners, much of what they do is based on the work of research and theory developed decades ago by our predecessors. Likewise, we should aspire to influence what will be taken for granted as industry practice in the decades to come.

Therefore there is a need for these theoretical bases to be more fully developed and elaborated for CE to become recognised as a discipline. Indeed, a debate over what theoretical bases are available, where they could be used, and the appropriate methodology would be useful in its own right. Perhaps more important, though, would be an ongoing debate about the characteristics of the industry, projects and participants from a theoretical perspective rather than an ongoing 'accumulation of facts' from case studies and surveys. In this respect the approach taken to industry studies by researchers in the economic field of industrial organization is relevant, because the field uses empirical research into firms, products and markets to inform and develop their theories.

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2 Developing construction economics as industry economics

Jan Bröchner

INTRODUCTION

Work by many construction economists has been directed towards cost and time prediction in construction projects, along with macroeconomic applications. While part of this orientation can be explained by linkages to the teaching of estimating and scheduling, the question is posed whether construction economics can be instrumental in reforming construction. The development of information and telecommunications technologies as well as deregulation in many countries are identified as two forces of change that jointly explain recent vertical disintegration and horizontal integration in construction-related industries. In addition, theories of industry economics have changed and developed new approaches to information, institutions and incentives.

Three topics for construction economics are outlined against this background. These are integration and innovation, signalling in real-estate markets and finally, developing public procurement. Concluding remarks broaden the discussion of knowledge and incentives to include global aspects of the future development of construction economics, in particular the links between the economics of construction and of constructed facilities.

THE SCOPE OF CONSTRUCTION ECONOMICS

For many years, progress made by construction economists has meant an increasing sophistication in analysing and predicting cost and time of projects or otherwise in the analysis of macro data for the construction sector in various economies. Let us begin this chapter by looking at what researchers in the field – not all of whom would brand themselves as construction economists – actually do, before we turn to background forces that are changing both industry in general and economic theory itself. Next, the question will be where construction economics should be heading. The argument is then that certain types of economic theory are useful for not only providing ideas for restructuring commercial relationships and government regulation in the sector, but also for predicting the relative sustainability of new patterns. The need for a better understanding of incentives for innovation in construction, both for firms and for individuals, is emphasized in that context.

Just mention construction economics, and most readers will think of forecasts of cash flow in construction projects, studies of tendering for projects, both how these should be priced, and given the tenders, how these can be used for predicting total project cost to the owner. Sometimes the focus is on predicting duration rather than cost, and then we are not far from studies that analyse and assess construction site productivity. Costs of maintaining and running buildings and their components are also studied with similar methods. The time dimension enters when investment analysis is applied to find the optimal extent and timing of investments in construction projects or concessions that cover longer periods of time. Another group of studies involve cost minimization for construction site logistics or equipment, using simulation or other methods for finding optimal solutions. Access to more efficient software has been important here, just as for the application of more advanced statistical methods to analysis and prediction.

Construction economists also engage in macroeconomic issues. How the construction sector is related to the rest of the economy in terms of growth, construction output in relation to GDP, the effect of money supply on construction output, as well as other applications of sectoral input/output analysis are subject to increasingly sophisticated econometric analyses. Today we see raised ambitions to investigate the dynamic properties of these relations. As to the use of results, regardless of how actively or passively a government pursues industrial policies, there remains a need for regional and national forecasts of construction activity. Other dynamic theories account for stages of the property cycle and its consequences for new construction. Optimistic investors in the nineteenth century could still be excused for a lack of scientific insight into the cyclical nature, but present-day investors should know better. The continued appearance of property booms and busts is an intriguing example of individual incentives being misaligned with solid theoretical and empirical knowledge.

Although construction economists, followed by construction industry representatives, habitually refer to the importance of the construction sector for economic growth and proudly stress the considerable portion of a nation's wealth that is embedded in its stock of built facilities, these sentiments are not always shared by others. A respected, widely read international periodical such as *The Economist* seems to dislike or more often ignore the construction sector. Housing starts and construction booms (Sept. 17, 2005) will appear in its pages as an indicator of business activity, also trends in office rent levels and property crises (June 26, 2010), but a perceived lack of transparency in construction firms (June 3, 2006), as well as their involvement in government infrastructure projects with what reflects dubious political priorities (Dec. 11, 2004), is no help. The old arguments for linking the construction sector to growth are no longer respected.

Over the years, there have been broad studies, mostly published in the United Kingdom and pioneered by Bowley (1966), where economic theories – at least used discursively – have provided the basis for recommendations for changes in government policy or in the way that firms in the industry operate and relate to each other.

One explanation for the present more narrow emphasis which also relies heavily on statistical analysis, easily seen in any of the journals where construction economists publish their research, is that estimating and scheduling are important topics on both the construction management and the quantity-surveying curricula. Many academics believe that good teaching should be based on hands-on experience of analytical research. A second reason is that the pattern for publishing research has changed and that the framework of the single article discourages broadness and obviously precludes a book-length style of treatment. The unfortunate consequence of the publication pattern is that, at present, many construction economists appear to tinker with small refinements constrained within a mindset that belongs to a traditional system of commercial relationships in the industry.

The exercise of construction economics – and obviously if we choose to speak of construction econometrics – is closely associated with access to data. There are many methods in the arsenal that can be exploited in a research context but are of little use in practice because firms lack the data to feed them with. Risk management based on the theory of real options is just one application where data supply is vital. It is possible that the rise of very big firms will provide much better internal access to data, allowing researchers to dust off old reports accumulated on their shelves or disks and finally putting them to good use.

Considering the data used by construction economists for macroeconomic modelling, we suffer from a situation where publicly available macroeconomic data are based on obsolescent classifications of activities, which reduce our ability to understand relations between construction, facilities services and the rest of the economy. The recent (2006) revision of the European NACE classification is a step in the right direction, since both construction project development and facilities management services are identified and brought together with more traditional construction activities.

Analysis of prices is otherwise in the domain of real-estate economists; many construction economists would probably enjoy analysing prices in relation to costs, and it is anything but a new idea that analysis of property prices should be able to provide guidance for the choice of building designs. Unfortunately, linear additivity and other simplifications necessary for regression analysis have so far stopped us from linking hedonic price analyses, which estimate implicit prices for a number of characteristics of a piece of property, to a range of costs for various designs for a new building.

It is recognized that the success of a facilities management contract is not to be measured by traditional indicators of internal productivity for the provider of services, but rather through its contribution to the productivity of a core business. One missing link that would allow us to gauge the true, derived productivity of a particular way of delivering facilities management services is the effect on the productivity of employees that use the facilities in question. But it is seldom thought of that the success of construction, understood as a support phenomenon, should ideally be estimated through its contribution to a client core business.

Finally, the development of information technology with networked personal computers in firms is at least partly responsible for an increased appetite for non-monetary measures, neither cost nor revenue. The meteoric rise of the balanced scorecard has almost thrown us back to the context of premonetary societies such as that of the ancient Mesopotamians who only counted workers, bushels of wheat, and similar quantities (Nissen *et al.* 1993). As we leave the world of old-fashioned accounting, we need more standardization of systems for defining, collecting and weighting 'soft' aspects so that these can be matched with financial data.

TO IMPROVE PROJECTS OR TO REFORM AN INDUSTRY

The question should now be asked whether construction economics could be instrumental in reforming construction by providing a solid base of knowledge, or whether it should be confined to less ambitious tasks on the construction project level, although those tasks are performed with increasingly advanced methods, such as we have seen in recent years.

Meanwhile, the arena for scientifically based proposals to change the way the construction sector operates has been populated by researchers who rely on concepts more likely to emanate ultimately from sociology and psychology than from economics. The successive spread of economic analysis to broader fields of application through the inclusion of concepts taken from sociology and psychology (Lazear 2000) has attracted less interest. The economic approach implies that we recognize individuals and firms to be maximizers of utilities and profits; thus light is thrown on the institutional context that makes it rational for construction contractors and other sector participants to engage in behaviour that appears to be in need of change. Although as we shall see there are recent contributions that change the picture, construction researchers have been slow to rise to the challenge. Perhaps this is because the application of economic theory is felt to be more rigorous than alternative theoretical foundations. Perhaps it is because of lack of suitable data.

So is the application of economic theory a small niche with diminishing relevance to a larger community of researchers and industry practitioners? On the other hand, how far can construction management research proceed if it is based exclusively on case studies, interviews and e-mail questionnaires with low response rates, displaying few strong attempts at theory building, being somewhat lax in theoretical assumptions that are clearly spelled out, and where the reasoning is weak on testable predictions? It can be argued that we need more economic analysis if we wish to create a better industry in the sense of finding commercial patterns that brings the activities of firms closer to customer preferences, managing scarce resources in consonance with sustainable growth.

FORCES OF CHANGE

Just like other industries in both rich and poor countries, construction is subject to two main forces that have had a strong impact on integration and disintegration of firms over the last fifteen or twenty years. The first force is the development of information and telecommunications technologies, whereas the second is widespread deregulation, in particular the liberalization of financial markets in many regions of the world. Which has been the impact on firms? The oddity is that what was claimed as distinguishing features of 'New Economy' firms in the millennium hype wave sounded familiar. Firms were now supposed to be virtual, agile, project-based and engage their customers in co-production, but this was something that has been known as typical of construction contractors during history. Indeed, it can be thought mysterious that anything at all happened to construction, while firms in other industries looked as if they strived for remodelling themselves on construction, such as in the case of tyre manufacturing (Brusoni and Sgalari 2006), usually blind to the fact or reluctant to admit the model.

The effect of the two main forces can be accelerated or retarded by other background factors. Thus, tax considerations in a given national context may affect both divestment and integration. While the two forces imply a much freer flow of information across country boundaries and globalized financial markets, the same cannot be said for the movement of individuals. Legal restrictions on immigration and how these restrictions are applied in practice affect the development of the construction workforce and thus also the industry image and way of functioning in many countries.

Around 1990, vertical disintegration, or outsourcing as it rapidly was labelled, at IBM and other large firms was a reality, accompanied by a new way of thinking about the core competencies of a firm. While this had a long history in manufacturing, outsourcing of services was a relative novelty (Bröchner 2006). The deregulation of financial markets appears to have reduced the comparative advantage of an efficient internal mechanism for assessing and financing new ventures within conglomerates. Instead, core competencies and core business gained prominence. This implied greater reliance on external suppliers, often created by outsourcing non-core support activities. Traditionally it has been known that there is a tendency for firms to engage in vertical integration when capacity bottlenecks start appearing as the top of the business cycle comes closer. When bust conditions loom at the horizon, acquisitions tend to be divested. However, what evolved during the 1990s was that disintegration continued throughout an unusually long period of strong demand. Additionally, the tendency to resort to external suppliers can also be explained by reduced costs for specification and monitoring of contracts, again owing to advances in information and communications technology.

If we choose to view contractors as external suppliers, it is no surprise that construction firms during the last ten or fifteen years tend to present the opposite of outsourcing and downsizing. Since the early 1990s, there has been a remarkable series of acquisitions and sometimes mergers that have raised the number of employees in large firms active in a number of countries. Horizontal integration as a growth path is evident not just in construction (Ball 2006, Ch. 12) but also in other construction-related service industries such as security services, facility support services, logistics, and consultancy services. Earlier assumptions that technical regulations issued by governments and chasms between national cultures were major obstacles to the growth of multi-national service giants have been falsified by events. We may now observe an increase in firm size in construction and related services, in some countries proceeding until a ceiling imposed by competition legislation and policies is reached. Available estimates of concentration in the British construction sector (McCloughan 2004) show that there is significant variation in concentration among specialist trades; where entry is less easy and capital more important, concentration is predictably higher, and rose sharply in the late 1990s. In general, and sooner or later, the position of the largest firms will resemble one of government-accorded privilege under competition regulations, a position comparable to ownership of intellectual property and infrastructure concessions. Competition law is a field where economic theory is actually applied by government and crucial for the competitive situation of firms.

Turning to economic theory, there are developments that are relevant to the future of construction economics. As Joseph Stiglitz (2000) writes in his overview of how the economics of information has developed: 'it is now recognized that information is imperfect, obtaining information can be costly, there are important asymmetries of information, and the extent of information asymmetries is affected by actions of firms and individuals.' The insight that conduct influences industry structure – and vice versa – is fundamental to our present understanding of competition in markets; while government policies reflect earlier concerns with static conditions, as expressed in market shares for particular firms, researchers today would concentrate attention to the contestability of markets, in other words the conditions facing new entrants (Audretsch *et al.* 2001).

The study of asymmetries of information includes how firms and individuals engage in signalling when direct observation of qualities is costly or impossible for a buyer (Riley 2001). And the label of New Institutional Economics can be useful to collect studies that share three assumptions: (i) that individuals suffer from cognitive limits (bounded rationality), (ii) that complex contracts are fundamentally and unavoidably incomplete, and (iii) that individuals have a capacity for conscious foresight (Williamson 2000). On these foundations, it is possible to gain new insights into how incentives for firms and individuals affect issues such as innovation and quality of construction, issues that are of considerable interest to both industry and academia.

A wider application of assumptions and arguments typical of current theories of industrial organization should be fruitful not only for providing ideas for restructuring commercial relationships in the sector, but also for predicting the relative sustainability of new patterns.

INDUSTRIALIZING CONSTRUCTION ECONOMICS

Given the changes in both industry and theory, there are three topics that should be given more attention in the years to come. These are integration and innovation, signalling in real-estate markets and developing public procurement.

Integration and innovation

By definition, outsourcing implies that the firm has once produced with its own employees what it now buys over the market. Instead, the pattern found in construction is characterized by subcontracting of services that frequently lack a history of having been produced in-house (Costantino and Pietroforte 2002, 2004). On the other hand, construction contractors often reveal an interesting tendency to diversify into a wide range of activities that appear to defy an unambiguous identification of their core business (Casson 1987; Cho 2003). At least two theories of the firm are ready to supply explanations here, related to contracts (transaction cost economics) and the resource-based view; both of these can be brought in to explain how construction firms integrate vertically (Bridge and Tisdell 2004). A crucial question when applying transaction cost analysis is how to model the effect on production costs of alternative modes of governance (Chang 2006; Bridge and Tisdell 2006). It is now possible to detect a move towards vertical reintegration in the British construction sector (Cacciatori and Jacobides 2005), and it is interesting to speculate on the nature of the long-term consequences in national and global markets.

The complexities of construction firms doing business internationally has led Ofori (2003) to plead for more than one approach to strategy analysis. Horizontal integration of construction activities across national boundaries may include an element of vertical integration when firms develop their foreign engagements; Cuervo and Pheng (2005) found that protecting the reputation of the firm and managing the quality of service to clients were perceived as important reasons for Singapore contractors to internalize their foreign activities. There is a link between international strategy research and integration issues that could be exploited further: Ling *et al.* (2005) found that foreign contractors entering the Chinese market appear to need to combine a strategy of differentiation with one of low cost rather than choosing between these alternatives. This combination of strategies recurs, albeit on a regional level, in a study of how Alicante housebuilders perform (Claver *et al.* 2003).

In recent years, the role of innovation and technology for the dynamics and evolution of industries has moved to occupy the centre stage of industry economics (Malerba 2007). There are numerous explanations why construction firms at least appear to be – and probably are – less innovative than high-technology manufacturers (Reichstein *et al.* 2005). Enforceable intellectual property rights are scarce; competitors easily gain access to and imitate any innovations, and the service nature of contracting or construction-related technical consultancy services are two reasons. Lack of return on investments in research and development is often evident for construction contractors, and part of the explanation will be given below in the context of quality signalling. If individuals and firms in an industry exhibit 'satisficing' behaviour rather than utility or profit maximizing, their behaviour can be interpreted as reflecting bounded rationality or as a symptom of risk aversion, a wish to receive safe returns. Both interpretations should direct us to consider the effects of changes in institutional settings, whether by government intervention or by concerted industry action. An indication of the potential is given by the variety of construction sector and institutional traditions within major European countries and the consequences for innovation (Miozzo and Dewick 2004).

The difficulty of predicting long-term consequences of new technologies affects not only component development but also contracting; site equipment that is not built-in gives its producer greater opportunities for managing or disregarding long-term risk, but innovation there will be classified under manufacturing and not under the construction sector. Surely, the disappointing low activity in construction innovation something could be raised if construction is reclassified statistically along the value chain (Winch 2003)? An alternative approach is to view construction as primarily an industry of service producers and to define innovation not only as narrowly technological but also including organizational novelty. Already in the preface to their *Economics of the Modern Construction Firm*, Gruneberg and Ive (2000) list several distinct characteristics of construction firms that affect their *modus operandi*. Most of these factors, including a high degree of project uniqueness, point clearly to innovation in the service sector (Miles 2005) and not to manufacturing as the obvious paradigm. If we persist in viewing construction as akin to manufacturing, we have to acknowledge that the rate of construction technology innovation was perhaps higher in ancient Rome (Lancaster 2005) than today and that we are dealing with an industry that has an exceedingly long life cycle. Nevertheless, we should note that the long-time perspective is far from unique to many innovations in construction technology, and firms that wish to exploit advances in the life sciences have to live with severe regulation intended to minimize health risks for patients and even for future generations.

Construction quality and signalling in the real-estate markets

'The theory of market signalling and screening is a cornerstone of the new economics of information' (Riley 2001). Signalling deals with overcoming adverse effects of asymmetric information in markets. While this theory can illuminate knowledge-sharing practices associated with partnering in construction projects and many other phenomena, the application outlined here is how signalling creates incentives for higher construction quality. Whoever has built a facility is likely to know more about its hidden faults and technical characteristics, including its potential for sustainability, than the typical buyer in the real-estate market. Also, anybody with some experience of running the facility will know more than a prospective buyer. There is thus a strategy choice in commercial relationships: am I as a seller paid a premium for facility characteristics that are difficult or impossible to observe? What might cause this premium to emerge in the market?

Bon (2001) argued that construction economists should concern themselves more with monitoring buildings over their life cycles, offering strategies and tools for dealing with change, rather than predicting every possible change. Any implementation of this principle has to take search costs for information and asymmetries into account. Those who design and construct high-quality buildings may follow three strategies. One strategy is passive, continuing to provide good quality and hoping that there will be future although uncertain rewards from a good reputation. The second strategy is to aim directly at the premium and provide easily digested information in a standardized form that would influence the price paid for the facility. The third strategy is to acknowledge that real-estate funds and similar investors are more occupied with the analysis of taxation and incentives for fund managers than with the technical quality of built facilities; the ultimate consequence for builders is then to integrate downstream and reach towards facilities services for, let us say, offices. In fact, embedding information and communications technologies in buildings may provide a reason for component suppliers to involve themselves in design, construction and facilities management (Bröchner 2003).

The second strategy is particularly rewarding as an object of analysis. It is one way of redirecting construction economics towards sustainability issues, which has been called for by Myers (2003). Noteworthy contributions where signalling is in focus have been made by Lützkendorf and Speer (2005) as well as by Lützkendorf and Lorenz (2005) on property performance assessments. However, excessive information efforts can be a drawback of signalling when internal and external requirements for documentation waste project resources. Nevertheless, there are other ways of signalling the almost unobservable quality of the products and services that a firm delivers:

engaging in university teaching and research is one way to emit signals. Competitors in the industry will find that this idea is not costless to appropriate, something that may make it more profitable for the firm than engaging merely in innovative construction technology.

Turning back for a moment to issues of integration, a particular task is to analyse the combined effects of vertical disintegration and horizontal integration on the relation between construction and facilities management. Financial deregulation and improved skills in delivering support services are the two best candidates for explaining why in many countries where firms in the private sector have tended to own the buildings they occupy, having seen real estate as a good collateral and a sign of stability, there is now a process of selling to investors that belong to the financial sector or are more closely related to the investor community (Pottinger *et al.* 2002). Thus, construction firms will increasingly meet highly skilled suppliers of facilities management. Whether the integration of construction and facilities management is a stronger mechanism than signalling for raising the long-term quality and performance of buildings remains to be seen.

Developing public procurement

In contrast to public sector practice in most countries, private clients often consider aspects other than price in the procurement of construction work. Often, lowest-price competition is perceived by researchers as detrimental to economic, social and ecological sustainability in technically and socially complex construction projects. Price competition is usually thought to require that the project is defined in detailed specifications. In many projects, however, needs and circumstances change during the period of construction. New construction projects may run into unexpected geotechnical problems, while in refurbishment projects, the condition of the existing built structure tends to be discovered incrementally as work is carried out. As in all repair activities, there is the problem of 'credence goods' (Dulleck and Kerschbamer 2006) where buyers do not know which quality of a good or service they need. Project scope may change significantly after a contract is awarded, implying that the initial bid, the price asked, is a bad predictor of the total project cost. The traditional approach, based on detailed specifications and lump-sum contracts awarded on the lowest-price criterion, has been at least partly abandoned in many countries today (Waara and Bröchner 2006), although its reintroduction is occasionally brought up (Dorée 2004). Traditional routes of procurement are believed to produce adversarial relations and defensive strategies, hampering a smooth and constructive handling of changes and of new circumstances, as well as the introduction of innovative and more sustainable technologies. However, many governments are still focused on price competition and preserving a market situation with numerous competitors for contracts. Such a policy may be warranted if there is no prospect of change in relevant technologies.

Studies of tendering and auction theory have had a late revival through the interest created by web auctions and telecom licence auctions. Peculiarities of construction tendering and contracts have received new attention. In their theoretical analysis, Bajari and Tadelis (2001) found that cost-plus contracts would be preferred to fixed-price contracts when projects are complex; in an empirical analysis of private non-residential construction contracts from Northern California, Bajari *et al*. (2009) identified shortcomings of auctions as compared to negotiations when projects are complex and contractual design incomplete. Using large volumes of data from Californian highway contracts to analyse markups and the effects of incompleteness, Bajari *et al*. (2010) estimated the relation between adaptation costs and winning bids. Oklahoma Department of Transportation data lie behind an analysis of sequential auctions for construction projects (De Silva *et al*. 2005). Although the last decade has seen a rapidly growing volume of concessions procured in the United Kingdom as public–private partnerships, there has been little analysis of the fundamental issue of under what circumstances it is efficient to procure the construction and the operation of a facility as a bundle. This important gap in our knowledge is only now beginning to be filled by economists (Bennett and Iossa 2006; Martimort and Pouyet 2008).

AN OUTLOOK

How does construction economics contribute to economic, social and ecological sustainability? There is reason to believe that a closer engagement with economic theories of industrial organization will provide both public and private policymakers with a better understanding of incentives for efficient use of scarce resources in the construction and management of facilities.

Investment patterns have not yet found a stable form for accommodating the demographic shift in many developed countries. There is much that speaks for a slow shift towards investing in securities backed ultimately by high-quality properties that result from good construction and are managed responsibly and efficiently. However, this development is fragile given the recurrent crises in many property markets. Government intervention to stabilize markets might lead to complacency, but it is probable that consumer interest will lead to a clear government focus on competition and will create stronger demand for advanced analyses of construction markets and the barriers that face potential new entrants.

There is a widespread insight that specialized knowledge is associated with growth of firms. The very old idea of starting with the division of labour has not lost its attraction (Cheng and Yang 2004). We should not exclude the possibility of economies of scale that only now might emerge within very large firms once they achieve organizing their knowledge supported by modern information technology. Regardless of firm size, we should look for incentives, for firms and for individuals, just as the ancient world can be understood better when incentives are mapped.

Stronger incentives for innovation and growth in construction and construction-related firms should be matched with policies that ensure that there are specialized and skilled people available. Managerial reluctance to engage specialists, whether these are highly educated engineers or craftsmen, can be explained by a vulnerability to local variations in demand for specialized competence. With better information and telecommunications technologies, also accompanied by horizontal integration of both small and big firms, the demand for better and more specialized education can be expected to rise.

There is an added rationale for government action within a modernized competition policy: in order to ensure that incumbents in an oligopolistic market are kept efficient and competitive, just raise the risk that they will be faced with new entrants into construction or facilities management. One way of lowering the entry barrier (cf. de Valence elsewhere in this volume) is that government decides to provide better training on all levels of skills for an industry. Large firms may then try to improve their efficiency legitimately by engaging in training and education, not just for their own employees, but also further upstream in their supply chains. We should be careful not to overestimate the importance of intellectual property rights when we explore the links between knowledge and growth.

Poor countries and rich countries meet with different problems when developing construction and construction-related industries. However, they share a need for providing better and more specialized education on all levels. Construction economists, collaborating across borders, may contribute to raising standards and providing new knowledge that is useful for understanding how local conditions fit into global contexts – and can be changed.

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3 Collusion and corruption in the construction sector

Christian Brockmann

INTRODUCTION

The practice of collusion is illegal. Most capitalist countries have laws safeguarding competition. In the USA, anti-trust legislation prohibits monopolization, restraints of trade, and collusion among firms. The foundation of this legislation was laid 120 years ago with the Sherman Antitrust Act (1890), the Clayton Antitrust Act, and the Federal Trade Commission Act (both 1914). The fundamental idea behind this legislation is that free competition serves the general welfare best by limiting the power of any one party when determining price and quantity through the interaction of supply and demand (Samuelson and Nordhaus 1989). The idea is to protect the weaker market side and therefore to enable a competitive market to develop that is sustainable and efficient.

Competitive markets are perceived as maximizing the welfare of society (composed of all buyers and all sellers) since in them long-run economic profit is zero. Economic profit is the difference between total revenue and total cost. The economic concept of total cost takes into consideration the opportunity cost of any activity, i.e. the value of the best forgone alternative. In other words, total cost includes all self-supplied services priced at the value of the best forgone alternative (Hirshleifer and Hirshleifer 1998). In construction these are especially the income of the owner, interest on equity, and depreciation of plant and equipment. Accounting profit is a different concept as it does not consider opportunity cost.

Summarizing the above, it becomes evident that any treatment of collusion must draw on findings about markets, competition, and price setting mechanisms. However, first we need to consider whether collusion poses a problem in construction. As will be shown, collusion depends at times on corruption and then the question arises whether corruption is problematic as well.

The following section provides theoretical perspectives on construction markets, construction goods and actors, as well as competition and pricing. Then the next section explains the impacts of theory on the practical problems of the construction industry by looking at a specific market, Germany, pricing in sealed-bid auctions, collusion, and the question whether collusion

Table 3.1 Corruption in industry sectors

Sector	*Index*
Public works contracts and construction	5.6
Oil and gas	5.7
Mining	5.8
Real estate and property development	5.9
Heavy manufacturing	6.1
Pharmaceutical and medical care	6.2
Civilian aerospace	6.3
Arms and defense	6.4

is caused by external conditions, i.e. mechanics, or by internal decisions, i.e. ethics. The conclusions summarize the arguments.

Corruption

Corruption can be defined as abuse of entrusted power for private gain. A further differentiation can be made between "according to rule" corruption and "against the rule" corruption. Paying a bribe to receive preferential treatment for something that the bribe receiver is required to do by law, constitutes "according to rule" corruption (Transparency International 2008). An example in construction could be a payment for preferential privileged information that can be used advantageously for the pricing of a project. "Against the rule" corruption exists, on the other hand, when a bribe is paid to obtain services that the bribe receiver is prohibited from providing. In this case, handing over a bidders' list constitutes an example.

Corruption is widespread in construction. The construction industry is, according to Transparency International (2008), the most corrupt industry, easily outpacing notorious sectors such as the defense sector (see Table 3.1). Real estate and property development rank fourth. The lower the index number in Table 3.1, the more corrupt is a sector.

Corruption is also a cultural problem: there are significant differences between countries. A cluster analysis of some industrialized and some newly developed countries by Transparency International yields the results of Table 3.2. In this case, cluster 1 contains the least and cluster 4 the most corrupt countries of the sample.

Benchmarks of the data can be found by interpreting additional survey results. Belgium belongs to the cluster 1 (least corrupt) and still 16 percent of the respondents believe that Belgian companies use familiar or personal relationships "often" or " almost always" to win public contracts.

Table 3.2 Cluster analysis of corruption in selected countries

Cluster	*Countries*
1	Australia, Belgium, Canada, Germany, Japan, Netherlands, Switzerland, United Kingdom
2	France, Singapore, Spain, United States
3	Brazil, Hong Kong, Italy, South Africa, South Korea, Taiwan
4	China, India, Mexico, Russia

Corruption seems to be a basic ingredient of action in the construction sector. It can be employed together with collusion to improve the situation of the seller in the market (i.e. the contractor). Having won the pennant as the most corrupt industry seems to be a very doubtful honor.

Collusion

Collusion is the illegal cooperation of sellers in a market producing a cooperative instead of a competitive market result. When sellers directly talk to each other to determine a market price, this is done by explicit collusion. In construction, we also use the term of bid-rigging. Tacit collusion does not rely on communication but on behavior or non-verbal communication. In this case sellers follow a pattern of price-setting behavior, sometimes following a price leader (Taylor 1995).

Evidence of collusion in the construction sector is as overwhelming as the analysis of Transparency International on corruption. However, there exists no systematic database. As such, the evidence is more anecdotal. It is the sheer number of reports on collusion and their far-reaching statements that are overwhelming. Since collusion is illegal behavior, we must assume that publications about the problem are nothing but the tip of the iceberg.

A short and not even thorough survey on the internet gives the following results:

1 *Australia (cluster 1):* “Australia’s competition watchdog has accused three rival Queensland construction companies of colluding on tender prices in a ploy that may have blown out government project costs” (Hurst 2009).
2 *Canada (cluster 1):* “A grouping of construction firms in the Montreal region nicknamed ‘the Fabulous 14’ control almost 80 per cent of all bids, and have colluded to keep rates high, Radio-Canada reported yesterday. Construction costs for public works projects are 35 per cent higher than they should be in the Montreal area because of the collusion, costing taxpayers millions, according to a Radio-Canada investigation” (Gazette 2009).

3 *Germany (cluster 1):* “Because of suspicions of illegal price-rigging in the construction industry the police have searched 110 apartments, business and public offices” (Abendblatt 2009, translation by author).
4 *Netherlands (cluster 1):* “Several investigations by parliament, cabinet, justice and antitrust authorities have shown a widespread use of cartels and structural bid rigging within the Dutch construction industry” (Dorée 2004).
5 *United Kingdom (cluster 1):* “The Office of Fair Trading today formally named 112 companies that it says colluded to inflate the cost of a wide range of contracts, including tenders for schools, universities, and hospitals” (Wearden and Milner 2008).
6 *USA (cluster 2):* “Six former New York City building inspectors, two reputed Lucchese crime family leaders and more than two dozen other people and businesses were indicted Thursday in a sprawling racketeering case that ranges from construction bribes to gun trafficking” (Peltz 2009).
7 *South Africa (cluster 3):* “Bid-rigging is widespread in the construction industry, Ramburuth told the forum. Firms collude with each other and they decide in advance who will win a tender by the way in which they bid” (Mail & Guardian 2009).
8 *South Korea (cluster 3):* “Six construction companies have been indicted on charges of collusion in a subway construction project” (Park 2007).
9 *Philippines (no cluster):* “Collusion is part of the way contractors do business but it does not mean that public works officials are involved in it, according to Public Works Secretary . . .” (*Philippine Daily Inquirer* 2009).

A word of caution needs to be added: an inductive enumeration of facts can never prove a statement; it can only serve as an assessment of a problem. The above citations are neither representative nor inclusive; they cannot serve as inductive proof. A number of people in a number of countries on five continents state their opinion that collusion and price-rigging are widespread in construction, not more and not less. However, the presented citations on collusion in combination with the data on corruption in the construction sector warrant us to treat corruption and collusion as serious problems.

Theoretical perspectives

This section on construction markets defines the goods traded as contract goods using the framework of New Institutional Economics (NIE). This establishes a principal/agent relationship that can be exploited by the contractor who generally takes on the role of the agent with the client as the principal. Such a perspective also allows a discussion about the type of goods traded. Are these services or products, homogeneous or heterogeneous? A discussion of the market structure will show that contrary to the normal case, the supply side is the weaker market side in construction, definitely a surprising result. The price evolves typically in three stages: bid price, contract price, and final price. This implies that quantity and price are not determined simultaneously when the quantity stays the same throughout the process, again an unexpected insight.

Competition is a core concept in market economies and this will be briefly surveyed. It will be shown that pricing for complex contract goods is a difficult task burdened by errors. The client can make use of different pricing mechanisms, sealed-bid auctions being the preferred option. They provide the best economic outcome for the client.

Construction markets

In markets, buyers and sellers meet to agree on a price and a quantity for a good with *ceteris paribus* applying to quality. Construction goods have a special feature; they can be characterized as contract goods. A transaction comprises exchanges and contracts by definition. On the one hand, an exchange is a transfer of property rights without promises and future responsibilities except warranties. On the other hand, when signing a contract, one party makes an investment and the profitability of this depends on the future behavior of the other party (Alchian and Woodward 1988). As such we can differentiate between exchange goods and contract goods. Construction goods belong to the latter category. When the contract is signed, the seller (contractor) promises to produce and deliver the good without defects as specified in the contract and the buyer agrees to pay without delay. As such, construction goods be they tangible (structures) or intangible (services) are very different from exchange goods that are produced before purchase. Contract goods entail a principal/agent relationship. The principal is making an investment (typically the client) and depends on the behavior of the agent (typically the contractor). The market can take on any form, from perfect competition through imperfect competition and up to monopolistic structures.

It will be shown that it is quite necessary to use different perspectives for the economic analysis of collusion. First, we need to consider an ex-ante and an ex-post perspective for contract goods. To be more precise it helps to define two ex-post perspectives: (1) ex-post signature and (2) ex-post handover. Second, markets are to be split into three levels: national, regional, and project market. Third, we must be aware of long-, mid-, and short-term economic effects. The importance these definitions will become evident in the course of the argument.

Construction goods and actors

The concept of contract goods belongs to the body of knowledge of NIE that also makes use of the assumptions of economic actors who are satisficing,

Table 3.3 Sources of uncertainty for buyers in the construction market

Sources of uncertainty		*Ex-post (after signature)*	
		Principal can watch the agent's action	*Principal cannot watch the agent's action*
Ex ante (before signature)	*Actions of the agent are fixed*	Hidden characteristics Adverse selection	
	Actions of the agent are free	Hidden intentions Hold-up	Hidden action Moral hazard

intentionally rational, and opportunistic (Simon 1957, 1961). Opportunistic behavior is defined as self-interest seeking with guile (Williamson 1985). Under these assumptions sellers have a number of options before (ex-ante) and after (ex-post signature) signing a contract and so do the buyers. Among the possible opportunistic actions are: hidden characteristics, adverse selection, hidden intentions, hold-up, hidden actions, and moral hazard. All these constitute sources of uncertainty for the buyer as the principal (Table 3.3). The concepts were developed within the principal/agent theory of NIE.

Collusion is a form of a hidden action ex-ante and it can lead to adverse selection through the buyer by not choosing the optimal contractor and contract price. During the tender phase – i.e. before signing the contract and thus also ex-ante – the agent can make use of hidden characteristics or intentions in his offer. In the framework of NIE a principal must expect that the agent will act with guile and possibly resort to collusion. This is a first theoretical perspective to support the anecdotal evidence of the previous section.

In this book, Chapter 10 on construction markets offers a variety of ideas about the characteristics of construction goods, discussing whether they are products (i.e. tangible goods) or services (i.e. intangible goods). A seminal approach to defining services is by introducing the concepts of the degrees of materiality and integrativeness where the latter term means the degree of interaction between buyer and seller (client and contractor). Products are material and non-integrative, services are immaterial and integrative (Engelhardt *et al.* 1993). Using additionally the tool of the ex-ante and ex-post perspectives the answer is clear: before signing the contract, construction projects take on the form of a service, they are immaterial and highly integrative. During construction they change their form and at handover they are clearly products. The designs have materialized and the integration of the external factor (client) has come to an end except for warranty (Figure 3.1).

Collusion could be used for all goods traded on construction markets whether they are tangible (from an ex-post handover point of view) or

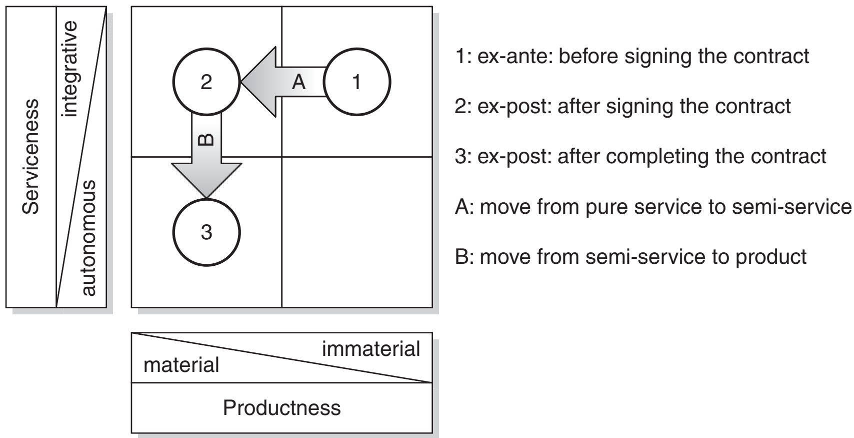

Figure 3.1 Contract goods in construction.

intangible such as engineering services. For the sake of simplicity we will limit the analysis to ex-ante intangible and ex-post handover tangible contract goods. This definition excludes design (an intangible contract good) as well as supplies and equipment (exchange goods). For such exchange goods a different type of argument than the one presented is appropriate. It will prove beneficial remembering that collusion takes place before signing the contract and as such it deals with a service.

Another question discussed in Chapter 10 is whether construction goods are homogenous or heterogeneous. In our analysis, this depends on the focal market and the ex-ante/ex-post perspective. The sellers on the supply side offer ex-ante a performance. We can assume that these performances are heterogeneous. There is a continuum of differentiation for firms and their performances caused by available technology and financial power. A small contractor cannot implement economically a mega-project and a large contractor cannot build economically a one-family home. A look at the built environment proves the heterogeneity of construction goods delivered from an ex-post handover perspective. These two statements are true for national and regional markets. They do not hold true for the project market. Here, the outcome depends on the client's approach. A decision for the lowest bid together with a design–bid–build approach (classical procurement) homogenizes the product. The product design is provided by the client (homogeneity by choice) and the process design is not considered (homogeneity by neglect). A design–build approach together with a differentiated evaluation of the bids will provide for a very heterogeneous product and process offer by the contractors. Since we are concerned with sealed-bid auctions, we are discussing a homogenized product on the project market. Homogeneity is a key to enable collusion.

Table 3.4 Market types

	Many buyers	*Few buyers*	*One buyer*
Many sellers	***Perfect competition***	***Oligopsony***	***Monopsony***
Few sellers	Oligopoly	*Two-sided oligopoly*	*Limited monopsony*
One seller	Monopoly	Limited monopoly	*Two-sided monopoly*

Market structures

Market structures are found in our economies ranging from highly competitive to deterministic in such a sense that one side of the market determines the outcome to a much larger degree than the other. For ease of analysis there exists a typology as shown in Table 3.4. For the discussion of collusion we will not need the type "monopolistic competition" as introduced in Chapter 10.

In Table 3.4, the market forms in italics can be found in the construction sector. Those emboldened are prevalent. As it is important to distinguish an ex-ante and an ex-post perspective for contract goods, it is also imperative to differentiate between different market levels: there is one national market for each economy, many regional ones and even more projects markets. Regional markets can have different structures than the national market. Whatever we have learned about construction markets in the past ten years, it certainly also reinforced the idea that the different national markets around the world are much diversified and the same holds true for regional markets. Every economy has its own business cycle; there is no linked global interaction. Culture also influences preferences and behavior. Therefore, we should be cautious when making general statements. Typically, national construction markets are highly fragmented with regard to demand and supply. The five biggest contractors in the USA have a market share of 3.7 percent; in the European Union it amounts to 5.9 percent. Alone, Japan is an exception with a value of 10.9 percent (Mawhinney 2001).

Before we can expand the argument further we need a definition for a market. As such, the one used by the Federal Trade Association (FTC) in the USA is helpful. This market definition encompasses the types of goods and services traded and the geographic extend. If in a market all sellers hypothetically increase their prices by 5 percent and as consequence gain higher profits, we face a market. There is no alternative to the buyers and they have to accept the price increase (Taylor 1995). With regard to construction we can observe that there are no possible alternatives to offices, houses, bridges, or tunnels except to delay the investment. Thus, price increases will have to be accepted by clients and we face a market. The geographical extent of the market depends on the demanded goods. It will be small for one-family homes, larger for heavy civil engineering projects, and global for mega-projects.

Based on the data of market share, the national markets in the USA, Europe, and Japan are certainly in perfect competition; there are many buyers and sellers. However, a general statement in the construction industry is that markets are regional. This statement applies to most demanded goods. A builder from Oklahoma will seldom join a bidding contest for a shopping mall in Maine. The same holds true for smaller construction markets such as Germany. Overall and most of the time these regional markets will also be in perfect competition. In sum, national and regional markets for general contracting are mostly in perfect competition. Data to support this assessment are given below for Germany.

Oligopsonies exist in regional markets. Roads and railways are examples. The clients are public, be it federal, state, or local authorities. There are just a few active on any regional market (3–5). The contractors are more numerous, typically from 10 to 20 in number. If for some reason the number of contractors drops to around 3–5, the market structure is a two-sided oligopoly.

Monopsonies also exist. Fellows *et al*. (2002) cite motorways and nuclear power stations as example. There are others like the Transrapid trains in China, however, with a difference on the supply side: there are not many but just a few sellers, establishing a limited monopsony. Two-sided monopolies exist always once a contract is signed (ex-post signature). Ex-ante two-sided monopolies are hard to imagine.

On the other hand, there are no examples for oligopolies, monopolies, or limited monopolies except for some unimportant exceptions. The structure of construction markets provides the buyer with a considerably higher market power in oligopsonies, monopsonies, and limited monopsonies. This constitutes a notable deviation from most other markets. While treatment of monopolies and oligopolies is found in most standard texts on economics or in the more specialized literature on industrial organization, this does not hold true for monopsonies or oligopsonies (e.g. Tirole 2000).

Anti-trust regulation was passed to protect the weaker market side, typically the buyer. We face in construction the strange situation that the structurally stronger market side is protected by law, while the weaker is exposed to exploitation.

However, a discussion of market structure in construction needs still to be expanded for the fact that demand is very specific, there exists no mass production. With the exception of prefabrication, buyers are not willing to trade between goods. Homes, offices, sports facilities, churches, bridges, and tunnels are individually designed by the client with the help of architects and engineers. Contractors are then requested to implement the design. This applies to the traditional design–bid–build procurement method as well as to design–build where the contractor in addition becomes responsible for the detailed design. The conceptual design, i.e. the product idea, is still provided by the client. Few, if any clients will accept a change in their design so that a contractor can build the same tunnel again as the one just finished. The thought becomes absurd when we think of projects like the Channel Tunnel.

The implications of the argument are that the vast majority of designs by the client create a single market for this designed product: one buyer opens a market for a specific product and determines the market conditions by open tendering (monopsony), selective tendering (limited monopsony) or direct negotiations (two-sided monopsony). If we apply the FTC market definition and hypothetically imagine a rise in prices for a project by 5 percent, it most likely will be accepted by the client. He has only one alternative: to abstain. Additionally, how is he to detect the rise in prices by 5 percent? There is no accurate benchmark to measure it against; he faces price intransparency. This whole argument started with the anecdotal evidence on collusion. While we were not able to present conclusive data on the extent of collusion, it became clear that collusion is to a certain degree part of business in construction. The point of collusion consists in raising prices that the client will accept. Based on the FTC definition, this is only possible if there are project markets.

In sum: while contractors offer their performance ex-ante in perfect competition, oligopsonies, or monopsonies, they always face for the focal project a monopsonistic situation once they have submitted their offer. Since they are producing contract goods, this is only true until signing of the contract. During execution the situation becomes a two-sided monopsony (Figure 3.2). In Figure 3.2 we use the terms "performance" and "product" in a somewhat different way than previously. Before deciding on a bid, a supplier of contract goods can only signal his willingness to compete based on his ability to perform. After this decision, he is in possession of a design (be it a conceptual or detailed design) that allows him to focus on a product. From the supply side he offers a future product, while from the demand side the client receives an offer for a service (the willingness to construct the product).

The typical situation in sealed-bid auctions will be a move through three phases: in the beginning, before the decision to bid, there is an anonymous market with no direct contacts, just the basic willingness to supply and demand construction goods. With the submission of this bid, all bidders accept the obligation to uphold the offer as is for a specified time, while the client is free to accept any one or no offer at all, establishing a monopsony situation. In many cases he can negotiate the price with a bidder using information from others. After signing the contract both sides agree to fulfill the contract entering into a two-sided monopsony.

The price also changes during the process. The bidders submit the tender price. Due to negotiations in the monopsony the price generally will be reduced to become the contract price. Due to changes and variations from the client's side during construction the contract price is renegotiated in a two-sided monopsony to become at the end the final project price.

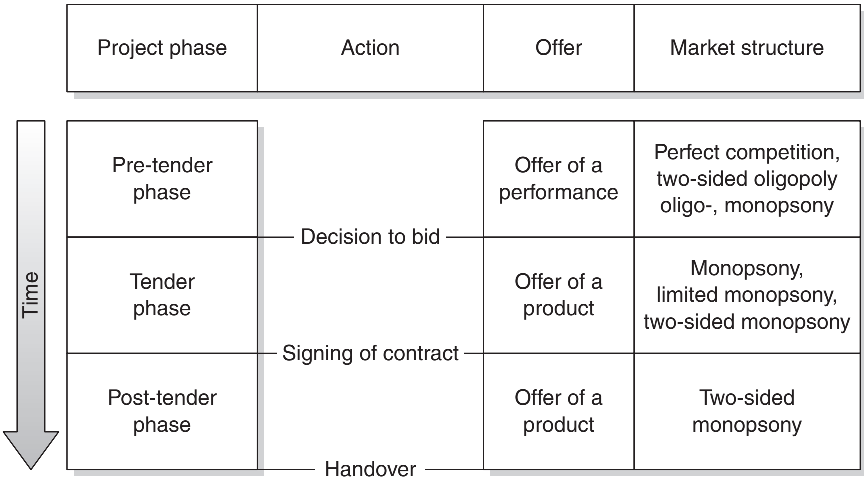

Figure 3.2 Market structures on the project market.

Competition

Competition is seen in economics as a mechanism guaranteeing efficient use of resources. However, this rests on three assumptions: (1) rational consumers following self-interests; (2) rational firms maximizing profits; (3) perfect competition as market structure (Stiglitz 1999). We have already discussed a different model of man by using the framework of the NIE and Simon's work on bounded rationality. This is in contradiction with the basic assumption for the competition/efficiency mechanism. More troublesome is the lack of perfect competition in the construction market as discussed above. Tirole (2000) speaks about the "competitive paradigm" and formulates as a key property that each good is sold at marginal cost. Marginal cost is defined as the cost for the last unit produced out of a large number of units. This concept is not easily applied to single-unit production.

The case of collusion in the Dutch construction industry in 2002 led to a renewed adaptation of the "competition is good" principle (Dorée 2004) without a thorough treatment of the functioning of the construction market. It must have been assumed that the relevant markets are in perfect competition.

Looking at the discussion of the market structures in construction, we face the question how the weaker market side (sellers) is to be protected against exploitation and how behavior of the stronger side (buyers) can be regulated. It seems evident that the described situation is not sustainable.

Pricing

Sealed-bid auctions are only one of many pricing possibilities in procurement. These possibilities are discussed in general next, followed by a treatment of sealed-bid auctions.

Contract goods are very different from exchange goods; they are fabricated after signing a contract, are most often single units, and are of considerable complexity. This implies three major problems for estimating construction projects: (1) there is no repetitive production of the same good and thus no direct learning about pricing. When someone produces a million pencils, it is of little importance whether the initial price is correct, it can be adjusted with time. In single-unit production the initial price cannot be changed because the contract is signed and binding before production starts; (2) the inherent complexity of many construction projects makes it hard to consider and judge all relevant facts; (3) there is no control over the production conditions; productivity is influenced by the environment as well as by the process evidence of the client. As construction is a highly integrative process with the client being an important external factor of production, he must know what is required of him (process evidence). Thus, productivity also depends on him.

Milgrom (1989) discusses two premises in conjunction with pricing of complex contract goods: the private and the common values assumption. The private values assumption states that contractors can determine their cost correctly (labor, materials, equipment, subcontractors, indirect cost) and Milgrom does not accept this assumption to hold. He assumes estimating errors by all bidders (ε_i) with a normal distribution about the mean (i.e. no bias). All detailed analyses of single estimates and the bid-spread of submissions support the statement. The estimating approach takes this into consideration and deals with the problem by detailing a structure into a widespread work breakdown schedule. Judgment mistakes occur for most items; however, they are not systematic. Over a large amount of items these cancel each other out and there is a tendency towards a mean value. In an example of a post-construction analysis of a construction project, the differences in single items reached almost 300 percent (planned vs. actual) while the overall difference was only 3 percent. The contractor was lucky; he had overestimated the total cost by this amount (Birol 2008).

The second assumption is accepted by Milgrom: all companies face approximately the same cost (C), the common values assumption holds. In different segments of the market companies of equal size tend to compete against each other, therefore the purchasing power of the companies is the same. Short-term advantages of one competitor (i.e. use of cheap foreign labor) must be imitated by the others due to the competitiveness of the market. Another argument is put forward in Chapter 4 of this book. Since all contractors use the same subcontractors and almost all works are executed by subcontractors, construction prices can vary only due to the efficiency of the management processes. This argument might be true in some countries, in others it is not. It is possible to define countries with a trading orientation (many Asian countries) and those with a crafts orientation (e.g. Germany). The value of subcontracting as percentage of the total production value has never exceeded 32 percent over the past 30 years in this country. Yet, subcontracting also contributes in such a case to the tendency towards a common value.

With these considerations Milgrom can formulate $X_i = C + \varepsilon_i$. While the estimating error (ε_i) is unbiased overall, this does not hold true for the successful bid. The lowest bid lies below the mean value and therefore below the mean price P_0.

Pricing mechanisms

There are a number of pricing mechanisms. A first group is used when selling a good (Dutch auction, inscription, auctioneer-controlled auction, bidder-controlled auction) a second one when buying a good:

- Selling:

  Dutch auction: A seller offers a good. He starts with a low-price request and gradually increases the price until the high bidder acquires the good.
  Auctioneer-controlled auction: A seller offers a good. The auctioneer decides about his price increases starting with a low-price request. The high bidder wins.
  Bidder-controlled auction: A seller offers a good. The bidders decide about their offers and increases during the process. The high bidder wins.
  Inscription: A seller offers a good. He accepts bids by buyers and chooses the highest bid.

- Buying:

  Dutch licitation: A buyer announces as a monopsonist that he wants to buy a specific good. He starts with a low-price offer and gradually increases it. The award goes to the first bidder to accept.
  Auctioneer-controlled licitation: A buyer announces as a monopsonist that he wants to buy a specific good. He also announces his maximum price. Then he lowers the price by amounts chosen by him. The award goes to the low bidder who is the last remaining.
  Bidder-controlled licitation: A buyer announces as a monopsonist that he wants to buy a specific good. He also announces his maximum price. Then the bidders lower their prices by amounts chosen by them. The award goes to the low bidder who is the last remaining.
  Sealed-bid auction: A buyer announces as a monopsonist that he wants to buy a specific good. He accepts bids by sellers. The award goes to the low bidder.

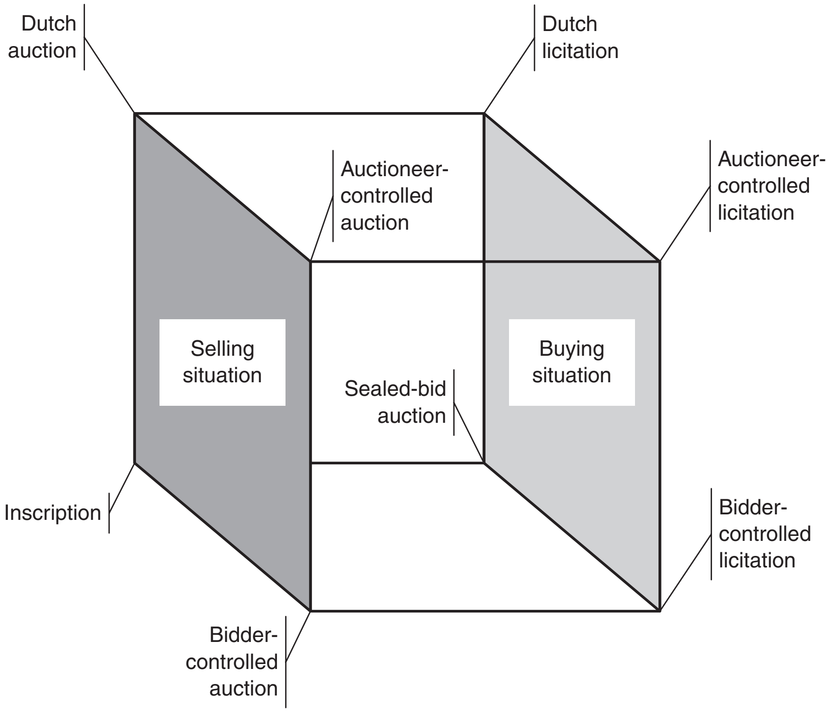

Figure 3.3 Pricing mechanisms.

The client is the overall entrepreneur in construction. He must have a project idea, a parcel of land, and financing to begin with. Then he initiates the design and chooses a pricing mechanism which is accordingly structured to serve his purpose. It is a buying situation. The discussion of the selling situation is discussed above for completeness only (Figure 3.3).

Analyzing all the eight options, there are two with much control from the initiators side: inscriptions and sealed-bid auctions. In both cases, the other side must react with absolutely no knowledge gained from the process, they have one-shot opportunities. In all the other six options information is gained on the behavior of the competitors in the bidding process. When selling a construction good in a sealed-bid auction the contractor must submit a bid without having any clue of the others' behavior except for historical records of past behavior: it is the worst situation a seller can be in.

Sealed-bid auctions

The result of sealed-bid auctions is a monopsony market structure for any given project. Assuming the prevalence of Milgrom's formula $X_i = C + \varepsilon_i$, the individual bid X_i is unbiased because the estimating error ε_i is normally distributed. With this assumption we can calculate the expectancy values of winning a bid depending on the number of bidders. The expectancy value of a bid $E(b)$ for a number of contractors (n) depends on this number n and is in all cases except for $n = 1$ below the price level of the equilibrium price P_0 in competitive markets (Leitzinger 1988). The equilibrium price is the price resulting from the interaction of demand and supply under the conditions of perfect competition, i.e. the ideal postulated under "competition is good" and it serves as benchmark. The larger the number of bidders is the smaller are the chances to win an auction by submitting the equilibrium price. Winners are faced with a price below equilibrium in competitive markets (see Table 3.5).

PRACTICAL IMPLICATIONS

In this section we discuss the practical implications of the previous theoretical treatments. First of all, data are presented describing a specific construction market. As an example the German construction market is chosen, the biggest one in Europe, and a regional market in Germany, Bremen. It follows a debate of the problems facing contractors in sealed-bid auctions with their consequences regarding pricing. Next, the mechanics of collusion are laid out. In the end two points of view are briefly compared: Is collusion a structural or an ethical problem?

Characteristics of construction markets

Analyzing data of the German construction market will show that on the national and regional level perfect competition prevails. Oligopsonies as well as monopsonies exist but no oligopolies or monopolies. The sellers (contractor) are either in a position of equal strength or weaker. What holds true for the German construction market is most likely typical for advanced industrialized nations. Yet, it needs to be backed-up by using data from other countries. The same lack of comprehensive published data can be deplored for newly industrialized and least-developed countries. In such countries, the market volume is in general larger and the industry structure might not be mature. As such, there might not be enough construction firms active in some sectors, contradicting the statements above on oligopolies or even monopolies.

Characteristics of the German construction market

The borders of Germany define this construction market geographically. It is determined by national laws and norms as well as those of the European Union. The preferred language is German. These facts still make entry a bit difficult for international contractors.

Table 3.5 Expectancy values for bids in sealed-bid auctions

Number of contractors	*Expectancy value E(b)*
1	±0.00
2	–0.56
3	–0.85
4	–1.03
5	–1.16
6	–1.27
7	–1.35
8	–1.42
9	–1.48
10	–1.54

We can use the Herfindahl–Hirschman Index (HHI) to check the fragmentation and thus the competitiveness of the market. The HHI is used by the FTC in the USA to evaluate the impact of mergers on the competitive structure of a sector. Above 1800 points the FTC would consider refusing a merger because it could create a highly concentrated market. Below 1000 points the FTC will take no action. In between, action is to the discretion of the FTC (Taylor 1995). The German Monopoly Commission has calculated the value for the German construction industry in its report on 2006/2007. For the year 2005 it is 4 points, which gives strong proof of the highly fragmented structure. A comparative value for the same year and the tobacco industry amounts to 2.695 points (Monopolkommission 2008).

The overall German national market can be considered highly fragmented based on an HHI value of 4. This holds true for large, medium-size, and small projects. Megaprojects can constitute an exception. The Monopoly Commission stopped in 1995 the acquisition of a large stock package of Ph. Holzmann (at the time the biggest German contractor) by Hochtief (number two in size) exactly for this reason (Deutscher Bundestag 1996). Such or similar cases are a rare exceptions from the fragmentation in all aspects.

The German construction market experienced a long recession from 1994 to 2005 (Table 3.6). With the exception of 1999, the volume of construction investment contracted continuously by a total of 25 percent (Hauptverband der deutschen Bauindustrie 2003 and 2007).

The market reaction to this contraction is not easy to estimate. In a perfectly competitive market, we expect to see a price reduction along with the demand shift. While the difference in volume equals 264 {min} 207 = 57 billion euros, the price effects are not clear because they would have to be expressed as an index value for residential, commercial and heavy civil engineering structures. Such an index (comparable to the consumer price

Table 3.6 Construction investment in Germany, 1994–2006

Year	*Investment (€bn)*
1994	264
1995	259
1996	251
1997	248
1998	245
1999	249
2000	242
2001	230
2002	217
2003	213
2004	206
2005	198
2006	207

Table 3.7 Price indices for residential buildings in Germany, 1994–2006

Year	*Price index (%)*
1995	104.9
1996	103.8
1997	102.2
1998	100.9
1999	100.2
2000	100
2001	98.9
2002	98.1
2003	97.7
2004	98.8
2005	99.0
2006	101.5

index) is not available. However, values for housing are available (Table 3.7). There has been a slide in overall prices from 1995 to 2003 with a small consolidation from 2003 to 2006 (Huss 2008). This is the expected price reduction in a perfectly competitive market.

Table 3.8 Number of firms and employees, 1995–2008

Size of firms (number of employees)	*Number of firms*		*Change (%)*	*Employees*	
	1995	*2008*		*1995*	*2008*
1–19	57,216	67,606	+20	391,557	336,842
20–49	10,866	4,807	–49	328,584	143,191
50–99	3,575	1,391	–57	246,305	94,503
100–199	1,524	541	–62	207,342	73,238
200 and more	672	190	–69	259,658	67,274
Total	73,853	74,535		1,433,446	715,048

The volume together with the price reduction must exert a strong pressure on capacities. Accordingly, insolvencies rose from 2.609 (1994) to 4.220 (1996). Then they stayed relatively stable at 4.400 per year until 2004 with a maximum value of 4.909 in 2001 (Huss 2008). With the increase in insolvencies we would expect a decrease in the number of firms but this did not happen. The total number of firms increased and the market became more fragmented. The decrease in number of firms per category in Table 3.8 is the larger the bigger the companies are with a marked increase for very small companies.

Small firms produce cheaper in contracted markets and can better survive the price pressure. In a recession the number of small firms increases as in booms the number of big firms (Hauptverband der deutschen Bauindustrie 2009). Whatever happens, the market stays fragmented with a correction mechanism in place. Again, all this is perfectly compatible with a market under perfect competition.

All data presented give proof that the German construction market is in perfect competition on the national level. Not yet discussed is the demand side. In 2008 permission was given for the construction of approximately 180,000 residential buildings alone. This is certainly enough to qualify as back-up for the label of "many" buyers.

Regional construction market: Bremen, Germany

The business cycle in the city of Bremen developed similarly to the national German one. The boom peaked in 1995 and from then on the turnover of the construction companies went down. There are no major discrepancies between the German national construction market and the regional market in Bremen. This holds true, although the data in Table 3.6 present the demand side (investment) and those in Table 3.9 the supply side (turnover).

Table 3.10 displays the number of sellers and buyers for the period from 1993 to 2001 in Bremen (Bauindustrieverband Bremen, 1997, 2002). The data show that from boom to recession the market structure was characterized by perfect competition.

Table 3.9 Construction turnover in Bremen, 1995–2001

Year	*Turnover (€m)*
1995	930
1996	857
2000	810
2001	747

Table 3.10 Supply and demand for buildings in Bremen, 1993–2001

	Buyers		*Sellers (contractors)*
	Residential buildings	*Commercial buildings*	
1993	739	142	~130
1994	746	116	~130
1995	482	126	~130
1996	565	119	~130
1998	817	211	~130
1999	922	209	~120
2000	925	203	~120
2001	751	151	~120

Table 3.11 Percentage of construction activities by contractors within a given radius from city center of Bremen

Radius (km)	*Activities (%)*
<25	49
<50	21
<100	18
<200	6
>200	6

Table 3.11 shows a high concentration of the contractors' activities within a radius of 25 km from the city center. Forty-nine percent of all construction activities were carried out in this range and it increased to 70 percent within a radius of 50 km. These data give proof of the existence of a regional construction market in Bremen and they raise the question whether in such a small market contractors can easily collude.

Table 3.12 Percentage of identical competitors for bids in Bremen

Identical competitors (%)	*Bids (%)*
ca. 80	27
ca. 60	33
ca. 40	30
ca. 20	6
<20	4

Project market

Finally, Table 3.12 shows the percentage of identical competitors for different bids. In Bremen there are no bids where the same contractors meet frequently. In 27 percent of all bids there are 80 percent of identical contractors, i.e. also 20 percent of new competitors. For the remaining 73 percent there are less than 80 percent of identical competitors. This is an indication that even on the project level there is a rather large degree of competition between the contractors vying for a specific project.

Table 3.12 supports the idea that for the construction market in Bremen, clients are able to organize a project market where there are numerous and different sellers willing to submit bids. This establishes the monopsonistic market structure discussed before.

Conclusions on market structures

From the discussion above we can conclude that three different levels of markets with different structures are relevant in the construction industry:

1 *Macro-level or national construction market:* In most capitalist countries the number of construction companies competing for jobs is very large. Construction investment is high and the average job size is small relative to the overall investment (while still being a large sum per se). Both facts mean that there are many suppliers and buyers: The market is in perfect competition.

2 *Mezzo-level or regional construction market:* In most cases and dependent on the business cycle, both supply and demand are characterized by a large number of players. The market is in perfect competition, except for a few abnormalities.

3 *Micro-level or construction project market:* The structure depends on the choice of the client (demand side). In the most common case of sealed-bid auctions, the structure can be characterized as a monopsony where the client has complete price information and companies are

ignorant except with regard to their own offer. The client has considerable market power at this level. After signing of contract this structure will shift into a two-sided monopoly, but this is irrelevant for collusive behavior because it ends latest with the signature.

Competitive markets on the macro- and mezzo-level deny each single construction company the ability to have an influence on quantity or price; therefore they act as quantity and price takers.

Pricing in sealed-bid auctions

Pricing in construction depends on the procurement method chosen by the client as buyer. There is a large number of different procurement methods. To simplify the discussion, we will concentrate on the most common one, the conventional method (Masterman 2002) in the form of a sealed-bid auction and award to the low bidder. In many countries this is the prescribed procurement method for public clients. Sealed-bid auctions with award to the low bidder are characterized by a price bias, an information bias, and an uncertainty bias. The first two are a result of the monopsonistic power of the client, the last one is an estimating bias for complex contract goods. Additionally, technology advance plays a role. The effects of pricing in sealed-bid auctions are summarized.

Pricing bias

Milgrom's formula $X_i = C + \varepsilon_i$ rested on the assumption that the estimating error is normally distibuted and unbiased. The award to the low bidder will, however, favor the company with the largest estimating error (winner's curse). Assuming the normal distribution, we can calculate the expectancy value of winning a bid at the market equilibrium price as it would develop in competitive markets by the interaction of supply and demand. The values are shown above in Table 3.5 and they depend on the number of bidders. Except for the case of just one bidder, the values are negative, i.e. the bidders have to expect a price below market equilibrium. Within the paradigm of "competition is good," this is an unwanted result. The option of the buyer to use sealed-bid auctions puts the sellers at a clear disadvantage. While the theoretical reasoning might not be clear to the contractors acting as sellers, the results are all the clearer to them. They must make sure that the estimated profit is larger than the possible difference between market price and sealed-bid auction low bid price.

Information bias

In many cases, private clients use their complete information of all unit prices of all different bidders to further negotiate the price downward.

Theoretically we face a turnaround of the typical principal/agent relationship. In Chapter 2 the concept was introduced with regard to the construction contract. In such a contract, the client acting as principal appoints the contractor as an agent to implement the project on his behalf. During the implementation the contractor (agent) gains a lot of information that is not available to the client. This establishes an information asymmetry favoring the contractor. In many cases he will use this asymmetry for his gain. This happens after signing the contract when the two parties have entered into a two-sided monopoly. Before signing the contract, however, the situation is reversed. The contractors as principals endow the client as agent with the task to agree on a contract. They have no influence on the decision-making process once they have submitted their bids. Information asymmetry is favoring the client. The actions of the client as an agent are free, there are no restraints on his behavior and the principal (each single contractor) cannot watch the actions. According to Table 3.3, this allows the client to take hidden actions and to exploit a moral hazard situation. The latter situation arises when the agent faces no risks for acting in his own self-interest.

The asymmetric information, the moral hazard situation, and the possibilities for hidden action allow the client to play one bidder against the next. False information about the price of one bidder given to another one cannot be detected by either bidder during a round of simultaneous negotiations. Only at the end of the negotiation can the bidders exchange and check the client's information. This strategy by the client is legal. Certainly, it will be seen as unfair by the contractors. It is also seen as unfair in many countries by legislation. In Germany for example, public clients are not allowed to discuss the price during negotiations, thus making it impossible for the client to use his asymmetric information. However, private clients are free to negotiate the contract price. Making use of false information is often not even perceived as an ethical problem but as shrewd negotiation tactics.

The above paragraph describes the outcome of the monopsony situation on the project level. Yet the consequences of enacting a monopsony are as detrimental to the overall welfare on the national market level as it is perceived to be true for monopolies. Monopsonies are seen as the opposite of monopolies in textbooks. As monopolies increase prices while reducing quantities, monopsonies decrease prices while also reducing quantities. The result is not equivalent to the optimum of a market in perfect competition.

In a general fashion, results of information asymmetry are shown in Figure 3.4 (Bülow *et al.* 1977). Depending on which side is in possession of privy information, there will be a shift of the mean price in that direction. During the negotiation process, the advantage of asymmetric information is with the client. Once a client and a contractor have signed a construction contract, the information advantage shifts to the contractor. He will in general make use of this advantage for claims and it is to be expected that prices for claims are above market equilibrium price.

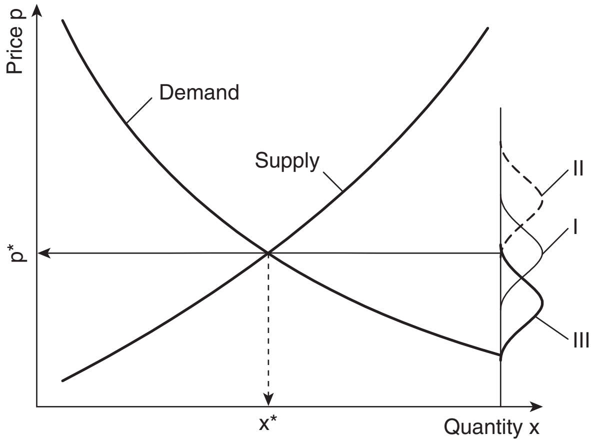

Figure 3.4 Influence of asymmetric information on price.

Uncertainty bias

The uncertainty bias of estimating should not be confounded with Milgrom's estimating error ε_i. It is closer to what Flyvbjerg *et al.* (2003) describe as optimism bias on the client's side. According to these authors clients have a tendency to underestimate costs and to overestimate benefits of megaprojects.

Something similar happens when estimating complex projects. We use the term uncertainty bias to differentiate the phenomenon from the above although it is also driven by optimism. One-of-a-kind projects are hard to estimate because there are no experiences relating directly to the problems they pose. The biggest ones are the evaluation of productivity rates for labor, the performance rates for equipment, and the completeness of the estimate. Textbooks typically give values ranging from 100 to 200 percent for productivity rates (e.g. for concrete pouring, a range from 0.4 h/m^3 to 0.8 h/m^3). In a highly competitive bid, estimators know that they have to produce a low price and they develop a tendency to use values on the lower side for productivity and performance. It was explained before that estimated values are never correct but that mistakes are unbiased, thus having in tendency to balance out. The strain of perceived especially high competitiveness introduces a bias to choose low values and thus bias the estimated values based on optimistic assumptions.

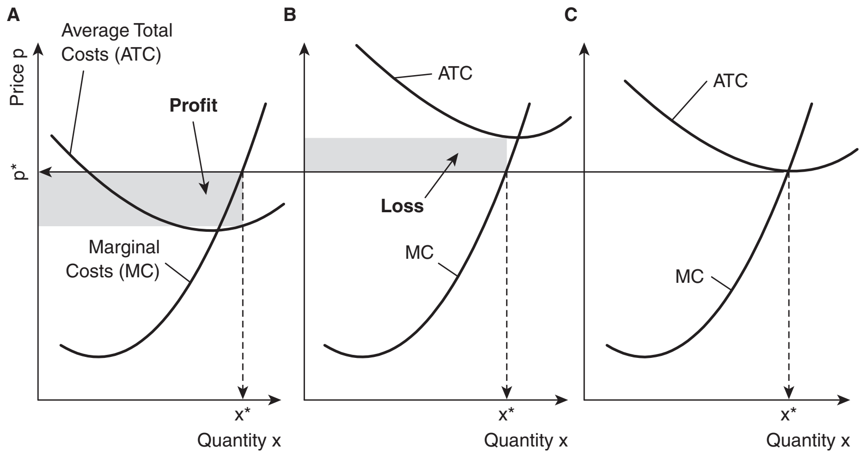

Figure 3.5 Average total cost, marginal cost, profits and losses.

Technology advance

The next question to be treated is what happens with companies that have a competitive edge through an advanced technology. Let us assume some companies to be technologically advanced and others to be lagging behind. According to economic theory, companies stop producing once marginal costs (MC) equal market price. Average total costs (ATC) for each company now depend on technology and these differ between contractors. The ATC of contractor A of Figure 3.5 with an advanced technology are below market price, resulting in a profit. For contractor B, who is lagging behind on technology, the inverse is true and the contractor will lose money. Case C shows the average contractor who does neither achieve an economic profit nor suffer a loss.

It can be assumed that the costs are normally distributed around a mean determined by the intersection of marginal and average total cost. There are some companies with high, some with low cost and most are found close to the mean (Heuß 1965). This allows us to draw a theoretical curve of the planned cost. All companies want to cover at least the average variable costs; this sets the lower boundary of the normal distribution (see Figure 3.6).

Whether we assume estimating errors or technology differences, the result is the same: there is a normal distribution around a mean value. When the low bidder is being awarded the contract, then the auction results are biased. In one case we have the winner's curse, in the other case the technologically most advanced company wins. However, the company cannot reap profits from its advance but must hand over most of it to the client. This does not only decrease the incentives to innovate it also takes away the necessary means.

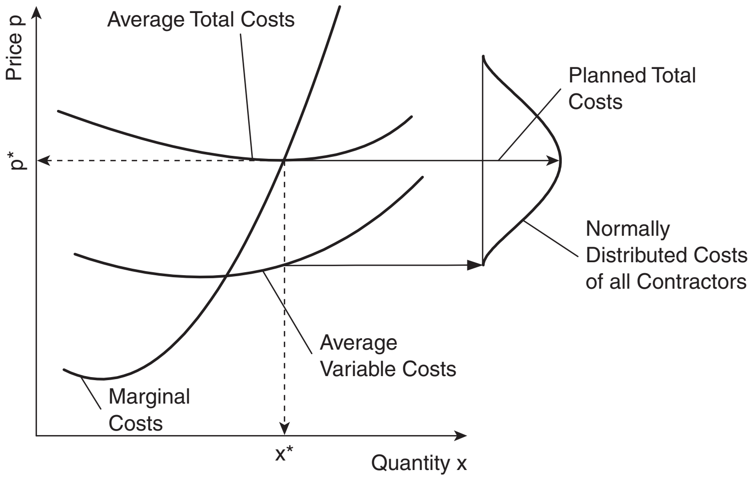

Figure 3.6 Normally distributed cost of all contractors in a bid.

Effects of sealed-bid auctions

Initial perfect competition in construction markets combined with sealed-bid auctions and followed by a monopsony situation with an asymmetric information advantage assures the market power of the client. The contractor is confronted with four factors:

1 Sealed-bid auctions as institutions are biased with regard to estimating errors, driving the low-bid award price below equilibrium price.
2 Sealed-bid auctions as institutions are biased with regard to information, driving the low-bid award price below equilibrium price. This holds especially true in a two-phase award process, when the auction is followed by price negotiations.
3 Sealed-bid auctions as institutions are biased with regard to uncertainty, resulting in over-optimistic assumptions and driving the low-bid award price below equilibrium price.
4 Sealed-bid auctions as institutions are biased with regard to technology, driving the low-bid award price below equilibrium price.
5 All effects will overlap and aggregate. In the worst case, the technologically most advanced contractor commits the biggest estimating error, is being taken advantage of during a negotiation phase, and uses over-optimistic assumptions.

Accordingly, contractors feel to be continuously pressed into an unfair pricing system in comparison to competitive market structures. Their only chance to counter the asymmetric information advantage of the client is through collusive cooperation. In terms of game theory it can be stated that the payoffs for a non-collusive outcome of a sealed-bid auction are negative in comparison with the equilibrium price that is accepted as being fair. The incentives in the auction game are not set in a way to keep the contractors interested in keeping the rules. Anti-trust laws are required to keep them in line. However, these are not always successful.

The game of collusion

Collusion is not an innocent game and this is not what the above title means to suggest. It is a game theory approach that is taken to analyze the mechanisms of collusion. The game of collusion being played by contractors wrests the information edge away from the client and transfers it to the contractors. There are two possible environments where collusion can thrive. On the one hand (naturally caused collusion) there are natural niches where the number of players is limited and these set up an oligopoly or even a duopoly as in the following introductory example. On the other hand (artificially caused collusion) information from the client is required and bribery is used to get the information.

Collusion in duopolies

Collusion in duopolies is the typical case used in textbooks to introduce this practice. While duopolies are practically non-existent in the construction industry, a duopoly allows understanding the basic mechanics of the process. The following example is from Taylor (1995) and uses game theory for analysis.

Two companies called Bageldum and Bageldee produce rather homogenous products, bagels. They have a choice of charging the competitive price where they will earn no economic profit as marginal cost equals price or they could collude and charge the monopoly price making a profit of 2 million dollars each. There is also an incentive to defect from the collusion by undercutting the monopoly price just slightly (thus becoming competitive with a price above marginal cost) and by selling a large volume of bagels with a comfortable profit (4 million dollars in the example). The other company then will make a loss equal to fixed cost ({min}1 million dollars). The payoff matrix shown in Table 3.13 resembles that of the well-known prisoner's dilemma.

In the prisoner's dilemma, communication is physically impossible, while in the case of a duopoly price, communication is illegal but possible. The incentive to defect is large and an innocent Bageldum might choose this option. Bageldee would in such a case have no other choice but to follow in reducing the price, otherwise it will be wiped out. Thus, both arrive at the competitive price. Bagels are sold continuously and the game is repeated over and over again, contrary to the prisoner's dilemma, which is played

Table 3.13 Payoff matrix for the bagel duopoly

	Choices	*Bageldee (A)*			
		Competitive price		*Monopoly price*	
Bageldum (B)	*Competitive price*	A: $0	B: $0	A: –$1m	B: $4m
	Monopoly price	A: $4m	B: –$1m	A: $2m	B: $2m

just once. Bageldum and Bageldee will get the idea sooner or later and collude to charge the monopoly price. If the game is played often enough, there is not even need for explicit collusion. Understanding the mechanics, both companies will converge towards the monopoly price by tacit collusion that is not illegal. It is well established that the results of monopoly pricing are quantities supplied below equilibrium quantity Q_0 and prices charged above equilibrium price P_0, definitely a suboptimal outcome with regard to overall welfare (Varian 1999).

The difference between the prisoner's dilemma and duopolistic collusion is due to two facts: in the case of duopolies, communication is possible and the game is repeated. As a duopoly is highly unlikely to be found in the construction industry, we need a model of market structures for the construction industry to advance the argument.

Naturally caused collusion

Oligopolies exist because there are some factors limiting competition. One possibility is a limited regional oligopoly; another is a long-term oligopoly in a niche of the construction sector. Deep-water dredging is one example of the latter. Dredgers are undoubtedly required resources, they are visible and the whole interested world knows who owns them. Competitors for large deep-water dredging contracts are thus known and they form a naturally caused oligopoly. Market entry is limited by the high investment for dredgers.

Tacit collusion is not possible because there is not a large quantity of goods being supplied to the market as is the case for bagels (or refinery products such as gas, etc.). Instead, the goods traded are defined by large single-unit contracts being awarded by sealed-bid auctions. These games are not repeated often enough to establish market equilibrium at monopoly prices. In addition, the size of a single contract offers considerable incentives to defect from collusion and this is facilitated because the contract prices are always made public to all competitors at submission. Except for abstaining from collusion altogether and accepting the biased sealed-bid auction price, the competitors can only engage in explicit collusion.

The ensuing process is driven by two mechanisms. First, the colluding contractors must agree on a selection mechanism and second, they must decide on a price-setting mechanism. Also – but not necessarily – a profit distribution mechanism needs to be established. Bribery is not required to gain information; the competitors are known by possession of the limiting factor (in the case above, by the dredgers).

The selection mechanism must allow determining whose term it is. This can either be based on statistical data, such as market share at the beginning of collusion, phantom book-keeping, or on argumentation where a bundle of criteria might be considered.

The price-setting mechanism depends on three options: companies can either generate their own profits once they have been chosen, they can give back part of the profit to the others, or the whole profit will be shared by all colluding contractors. The first case sets the stage for a two-phase game that is cooperative in the first phase and competitive in the second. Here, the chosen contractor wants to establish the highest reasonable price possible, while all the others want to limit his profits, since he will still be a competitor in other areas or at other times. The price will shift from below equilibrium price upward. How much upward depends on the price effect of the collusion. In an older study (Bülow *et al.* 1977), the price effect was found to amount to 2.5 percent as part of return on turnover for all projects (competitively and collusively bid). Since the total return on turnover during the same period was smaller than 2.5 percent, there would have been prices below equilibrium without collusion.

The second and third cases also bring about a two-phase game, but both phases are cooperative. Since all companies are interested in the profit from the focal transaction they have a tendency to charge the highest price possible, which is the monopoly price. The monopoly price decreases welfare due to the overall deadweight loss; it is not a desirable result (Varian 1999).

For considerations about the collusive outcome on social welfare, this distinction between these two types of scenarios is of utmost importance. The argument on pricing was that sealed-bid auctions force the contractors to except prices below equilibrium and this lowers overall welfare. The effect is shown in Figure 3.7. The auction price is below the equilibrium price and this has two results: (1) it augments the clients' surplus (C) by the same amount that it reduces the contractors' surplus. (2) In addition there is a decrease in both surpluses ($A + B$), a deadweight loss. This deadweight loss measures the reduction of social welfare. Since only the quantity x_a is produced, there still remains a willingness to pay from the clients' side that will not be served by the contractors since they will not provide the additional quantity at price p_a.

Artificially caused collusion

An example of a widely published collusive scheme is that of the Dutch construction industry from 2002 (Dorée 2004). It was all-pervasive and thus not a niche problem. All companies involved had a claim account that was recorded in phantom book-keeping. During the collusive meeting, contractors could bid for the focal contract by offering a financial compensation to

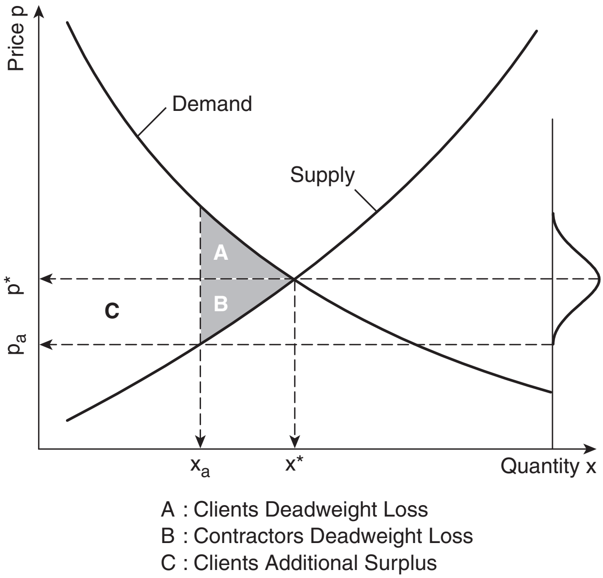

Figure 3.7 Deadweight loss due to sealed-bid auctions.

the other bidders. The high bidder would be the winner of the collusive part of the game. The price was decided upon jointly and therefore competitively. This is an example of the two-phase game with the first phase being cooperative and the second competitive. The compensation to be paid also introduced some competitiveness into the first phase. No money changed hands but money spent and received was recorded in the phantom accounts.

Dorée also discusses factors supporting the proliferation of collusion based on a literature review and the Dutch case study. Among the supporting factors are: undifferentiated products (as they exist on the project market), price-oriented competition (sealed-bid auctions), similar cost functions (common values assumption), high rate of risk and uncertainty (uncertainty bias), high concentration of buyers (monopsonies on the project market), risk of the winner's curse (price bias), and a predictable selection process. The list includes other factors that cannot always be found in the construction industry such as a high concentration of sellers. Some factors are based on culture such as social homogeneity and therefore differ from country to country.

Clients basically have three options in arranging a market through procurement:

1 A perfect competition/monopsony by letting all interested contractors submit a bid. The number of players in the game is large and the participants are unknown to everybody (open bidding).

2 A perfect competition/limited monopsony by preparing a bidders list. The client knows the number and names of the bidders (selective bidding).
3 A perfect competition/two-sided monopoly by negotiating with just one contractor. In this case knowledge is symmetric (direct negotiation).

Case 1 does not provide enough information for collusion. In order to enter the game, there must not only be an incentive but also the knowledge of all participants. The Dutch case was an exception as it was almost all-encompassing.

Case 2 is the classical set-up for collusion in a market that is generally in perfect competition. In order to get the information contained in the bidders' list, contractors must bribe someone in the organization of the client. A principal/agent relationship is an absolute prerequisite for bribery. The agent in such relationships can profit at the expense of the principal. In a private company, the owners are the principals and all employees are agents. Accordingly all employees with knowledge of the bidders' list are possible targets for bribery. The taxpayer is the principal in public companies, all employees are agents and therefore all of them are possible addressees of bribes.

Case 3 does not lend itself to collusion because of lack of players. Bribery is still a possibility to get access to information for the negotiation process and to create an asymmetric information situation.

Bribery in construction is facilitated by the large contract sums and the imprecise knowledge of prices. One million dollars more for a contract of 10 million dollars cannot be easily detected as being excessive. A bribe of 100,000 dollars out of the extra million is in most cases enough to convince a morally weak agent.

For a collusion scheme to work there must be repeated tenders, preferably an infinite number. Then and only then can the contractors play repeated collusive games among themselves. It is not necessary that all contractors are always invited. The group playing the repeated games can be larger than the bidders for one contract. The collusive arrangement must, however, include all contractors that have been or will be invited.

Mechanics or ethics of collusion?

The presented argument has stressed the mechanisms leading to collusion. The model of men of the NIE on which the argument is based is not an ethical one. It supposes that all actors are opportunistic (acting with guile). While this model is basically sound as is proven by the fact that Simon and Williamson both received a Nobel Prize for their respective works, it remains ethically unsatisfying.

Zarkada-Fraser and Skitmore (2000) presented a study looking at the ethical side of collusion. They conclude: "The results show that collusive tendering, in all its forms and variations, is a result of a decision with moral content, and generally perceived as necessarily unacceptable in Australia." The problem with these findings is that the whole study has serious flaws. Estimators are the chosen focus group; however, they are not the ones taking part in collusion primarily. Collusion is a business decision and the players are the business unit managers. This becomes clear when analyzing documents on the prosecution of perpetrators. Collusion is illegal and it carries serious punishment. Nobody will ever acknowledge taking part in it freely. To be against collusion is the socially accepted answer.

The case of the Dutch collusion scheme shows that collusion is not only a problem of individuals but of a large group. Therefore, group dynamics have also to be considered when discussing the problem. As has been shown, it is most of all a structural problem. These statements do not deny the responsibility of each individual involved, they have to make a decision whether they want to act according to law or whether they want to risk acting against it. The predicament is that an ethical decision by individuals will not change the structure. Individuals have only the chance to walk away from the game as this will continue to be played by others.

There are also the ethical problems on the other side of the table: Why is it ethically acceptable that buyers have such market power? Why is it acceptable that they can use "shrewd" negotiation tactics? Collusion is both an ethical and a structural problem. It will persist as long as the institutions of procurement are not changed, giving both market sides equal power and reinstituting perfect competition on the project market through regulation of the buyer's behavior.

CONCLUSION

The line of the complete argument can be found in a condensed form in Figure 3.8. There are strong incentives in the construction industry to engage in collusion. The main argument is that widely used sealed-bid auctions with award to the low bidder produce outcomes below equilibrium price. This is unacceptable to the bidders and economically undesirable since it produces an overall deadweight loss to society.

Depending on the mechanisms chosen in collusive games, the result will be monopoly pricing (economically undesirable) or a price not far away from the equilibrium price (economically desirable). The first will be produced by structures that include repeated games by a group, cooperative behavior when predetermining the winner of the bid, and cooperative behavior when setting the price because all players participate in the profit. The latter depends on repeated games and cooperation predetermining the winner. The price is restrained by a competitive phase when agreeing on the profit that accrues only to the winner.

A change of the institutional arrangements of procurement processes is required if collusion is to be avoided; legislation is not sufficient.

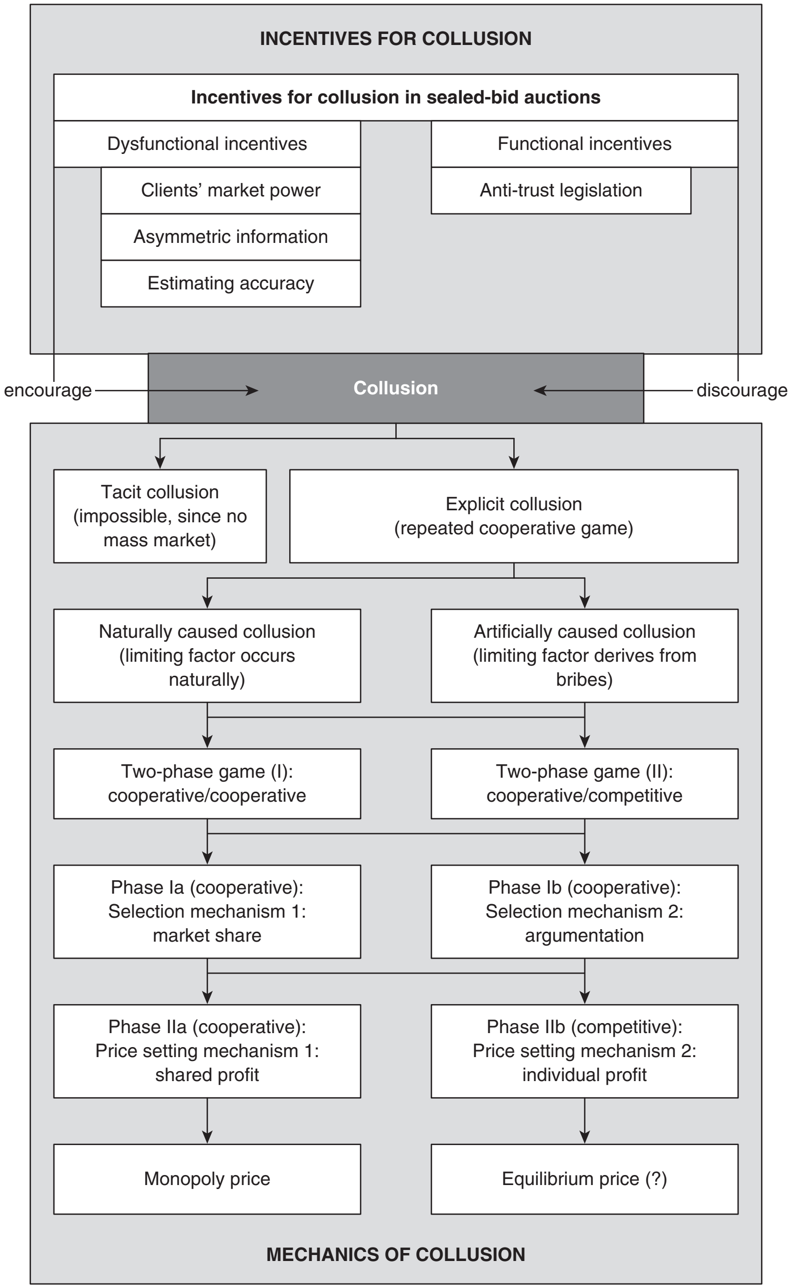

Figure 3.8 Incentives for and mechanics of collusion.

A word of warning is warranted at the end. Putting aside all arguments, collusion is an illegal practice. Prison sentences are not uncommon when collusion is uncovered.

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4 Competing in construction auctions

A theoretical perspective

Derek S. Drew

INTRODUCTION

The construction industry is largely demand driven with construction clients creating the demand for construction work. Clients vary from individuals and small firms, who may only use the services of the construction industry once or a few times in their lifetime, to developers, large international corporations and governments who are regular users of the construction industry. Contractors meet the demands of construction clients by supplying an assembly service, that is, to assemble a building or structure. Although contractors can act in the role of a developer, much of their work comes from contracting. This involves a customized design being constructed with the roles of the client and contractor being defined according to the conditions of contract. The most important of these are that the contractor constructs a building in accordance the drawings and specification and in return for payment by the client. Construction contracting has been defined as "a service which is related to individual construction packages, each one of which may be likened to a firm with a relatively short and finite life" (Cannon and Hillebrandt 1989a).

Competition between construction contractors often takes place within an auction. Allocating resources via auctions is commonplace and ranges from open auctions of property and art to sealed-bid auctions for oil-drilling rights and construction contracts. Sealed bidding is the conventional mechanism used in the construction industry for allocating construction work to willing contractors. It is called sealed bidding because competing contractors submit their bids to a client in sealed envelopes by a date and time stipulated by the client. The client then opens the envelopes and usually awards the construction contract to the contractor who has submitted the lowest bid (i.e. the most competitive price). The lowest bid is also known as the first price and this particular auction method is referred to in the literature as a descending first price sealed-bid auction.

The overall aim of the vast majority of competing contractors is to (1) win the right to construct the building or structure and (2) eventually construct the building or structure for a profit. The most important and difficult decision facing contractors is deciding on what price to submit to the client. This is important because the bidder must choose a price high enough to make a profit, yet low enough to have a chance of winning the job and to also ensure that a sufficient volume of construction work is generated from the many bidding competitions it takes part in so that it can remain in business. What makes the decision difficult is that at the time of bidding there is considerable uncertainty about the prices being bid by its competitors. The problem confronting the contractor is that the chance of making a profit increases with a higher bid yet the chance of winning the competition reduces.

NATURAL AND ECONOMIC COMPETITION

Competition is defined as "emulous striving for the same object; the struggle for existence or gain in industrial and mercantile pursuits" (Hayward and Sparkes 1986). Competition theories can be found in the fields of economics and biology. Basic economic competition has been defined as

> when a good or service is consumed, utility is created which has a value. Competition gets [to] that value … the buyer wants to pay as little as possible for the product, while the seller wants to get as high a price as possible. Both are competing for the value created by the production and consumption of the good or service.
>
> (Czepiel 1992)

Natural competition occurs where organisms compete for their necessary life resources. Organisms that more effectively obtain sustenance and that more efficiently process it take those resources away from their competitors, thereby weakening their competitors. At the same time those resources are strengthening the organism. Over time, this process leads to the extinction of the less effective competitor through the process known as natural selection (Henderson 1983) (i.e. survival of the fittest).

The fundamental difference between natural and economic competition is that natural competition just happens through natural selection and mutation, with those possessing the characteristics needed for continued existence surviving, while those that do not eventually disappear. Economic competition, however, undertaken through strategic decision making, is marked by carefully considered and tightly reasoned actions with long-term survival of the firm being largely dependent on the strategies being employed (Czepiel 1992).

ECONOMICS AND COMPETITION

The competition theory of firms has its roots firmly embedded in economics. The nature of competition and market structure are the outcome of interaction between supply and demand. Two extremes of competition are monopoly and pure competition. Intermediate levels of competition are classified as imperfect. The concept of demand elasticity is usually regarded as the basic indicator of the nature of competition, where elasticity is a measure of the degree to which a change in price will result in a change of demand. Price elasticity informs the analyst exactly how much quantity is likely to change for each 1 percent movement in price.

The study of competition places increasing emphasis upon the choices made by participating firms and the impact which these have upon both the fortunes of their competitors and market structure. In making such choices, firms have to operate within multi-dimensional constraints which are common to them all. Microeconomic aspects of supply are concerned with the behavior of the firm. In economics, the theory of the firm adopts a number of simplifying assumptions in order to provide a benchmark against which to compare the real-world behavior. This includes the assumption that the objective of each firm is to maximize profits, although it is recognized by many economists that firms in fact seek to satisfice rather than seeking to maximize. Most firms satisfice in the sense that they see survival as the primary objective and growth as the secondary objective. In order to both survive and grow, firms also tend to take the line of least resistance by seeking to operate in those markets with the largest and most stable demand.

MANAGEMENT AND COMPETITION

Some management theorists have developed a systems approach to model the competitive behavior of firms based on an input–conversion–output model. Such theorists see firms as organizations. Organizations can be defined as arrangements of people or roles operating within a particular environment where they must interact to survive. Organizations obtain inputs from their environment in the form of human, physical and financial resources and export outputs to the environment in the form of products, services and less tangibly, behavior and attitudes. The environment constrains the organization through, at least, political, economic, social and technological pressures. Organizations receive feedback from their environment about the acceptability of their products or services, expressed for example in terms of purchasing patterns or financial support, which enables managers to make adjustments to inputs and the conversion process. They may exist in a steady state or increase in size and range of activities through increasing inputs and outputs. Systems thinking has been modified with the emergence of the contingency theory approach to management "which argues there is no single best way to run a business and that managers must adapt their style and methods to suit the circumstances" (Fryer 1990).

Management is essentially concerned with relationships, with management theory being centered on business strategy, organization theory and the management of human resources. It has emerged from a composite of ideas drawn from many areas including economics and, certainly in its behavioral

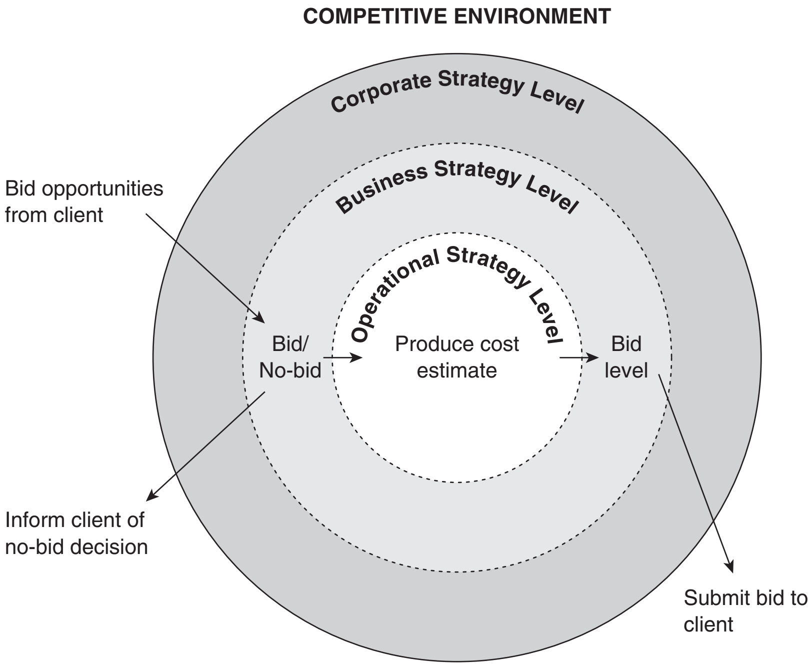

Figure 4.1 Systems approach applied to construction bidding.

aspects, quite heavily from psychology. However, it seems to be deficient in the sense that "there is no body of management theory in the way that there is an economic theory of the firm, in which all the component parts are interrelated to a total system" (Cannon and Hillebrandt 1989b).

Construction organization systems are seen by proponents of systems theory to comprise: (1) strategic system, (2) information system, (3) organizational system, (4) social system, and (5) management system. The management system is central to the whole organizational operational system, while the strategic system performs the task of deciding and managing the long-term direction of the organization (Newcombe *et al*. 1990). This can be related to contractors competing for construction work. Figure 4.1 shows the competitive environment and the construction organization and that the organization's strategic system operates at three levels: (1) corporate strategy level, (2) business strategy level, and (3) operational strategy level. The external boundary between the construction organization and the competitive environment is denoted with a solid line, whereas the internal boundaries within the organization are shown with a dotted line. Contractors first decide within which markets to compete at the corporate strategy level. Construction clients within these markets will then provide contractors with numerous opportunities to compete for construction work. Contractors decide which of these projects to bid for at the business strategy level and, if bidding, will produce an estimated cost of the building or structure at the operational strategy level. The cost estimate is then fed back to the business strategy level where the contractor decides on the actual bid figure, which is then submitted to the client.

Management theory, with a systems approach, appears to be more comprehensive at modeling strategic behavior within firms, while economic theory, with different types of markets ranging from perfect competition to monopoly, seems to be more developed at modeling competitive behavior between firms. Since competitive relationships between firms are based on management decisions within a firm, the competitive behavior of contractors may be viewed as the outcome of strategic management decisions undertaken in an economic setting.

DEFINING THE CONSTRUCTION MARKET

Contractors compete for construction contracts either on the basis of (1) direct negotiation (2), competition, or (3) competition followed by negotiation. Many small contractors obtain much of their work from individuals by submitting quotations or by direct negotiation. Larger contractors, on the other hand, tend to get a lot of their work from the industrial and commercial sector and from public sector clients. In such cases, where the construction work is larger and expensive, clients tend to allocate the work through a process of bidding.

The price agreed between the client and contractor becomes the market price. A bid is an estimate of the market price since, during the course of bidding, each competing contractor is attempting to estimate the market price. The winning bid becomes the market price. Bidding (or tendering as it is often known) is a mechanism used by clients to allocate construction work to willing contractors. It establishes (1) the market price and (2) identity of the contractor who is to undertake the assembly process of constructing the building or structure.

The term "market price" is used because, although contractors operate within the construction industry, they compete for work within a market. Confusion often arises between the terms "industry" and "market". An industry has been defined as a branch of trade or manufacture (Fowler and Fowler 1986). Examples include car, aerospace, and food and beverages. Table 4.1 shows some of the fundamental differences between the construction industry and the car manufacturing industry. Since many individual buildings and structures are largely unique, the exact cost to the contractor and client is not known until the construction is completed. This is unlike car manufacturing where, because of the highly repetitive nature of assembling cars in batches, the cost of cars is known prior to assembly. There are also differences between the construction industry and car manufacturing industry in terms of completion time and working

Table 4.1 Comparison of construction and car manufacturing

	Car manufacturing	*Construction*
Plant and equipment	Fixed	Mobile
Output	Mobile	Fixed
Location of site	Fixed	Variable
Variability of output value	Small	Large

Source: Ostwald (2001).

environment. Although a car can be assembled in a matter of weeks, it may take years to construct a new building or structure. Also, cars are normally assembled in a factory, whereas a significant proportion of construction work is undertaken outdoors.

The term "market" has a narrower meaning than that of industry. A market may be defined as "a meeting place for buyers and sellers" (Fowler and Fowler 1986). Clients buy an assembly service from contractors, and contractors, in turn, sell their assembly service to clients. In the case of the construction market the client may decide to (1) negotiate directly with one or a few contractors or (2) encourage contractors to compete for construction work through a process of bidding.

Direct negotiation with one contractor is likely to result in a higher market price. Entering separate negotiations with a number of contractors is likely to be time consuming, particularly for larger-scale construction work. Encouraging contractors to bid in direct competition with each other normally overcomes these two disadvantages.

OPEN AND SEALED-BID AUCTIONS

Bidding takes place in an auction. An auction can be defined as "a sale in which goods (e.g. purchasing a property) are sold to the highest bidder or services (e.g. constructing a building) are sold to the lowest bidder." If bidders are consumers (e.g. purchasing a property) then the supplier normally sells to the highest bidder. If bidders are suppliers (e.g. constructing a building) then the consumer usually buys from the lowest bidder. In a typical goods auction there is a single supplier (seller) and a number of possible consumers (buyers). In a typical auction for services there is a single consumer (buyer) and a number of suppliers (sellers). In construction the single consumer (or buyer) is the client and the suppliers (or sellers) are the contractors who compete for the right to service the construction contract.

The two main types of auction are open auctions and sealed-bid auctions. Open auctions are often used for items that are unique and have special buyer appeal such as an ideally located property, while sealed-bid auctions are ideally suited for the purchase of large and valuable items that require some form of post-bid assembly (Shubik 1983) such as construction work. In such cases contractors provide a service to the construction client by organizing and managing the construction of a building or structure in return for payment.

An open auction is controlled by an auctioneer who calls out the bids and in doing so tempts an assembled group of interested buyers to bid against each other and eventually sells the goods to the highest bidder at the drop of a gavel. Bidding in an open auction is easier than bidding in a first price sealed-bid auction. This is because in open auctions (1) bidders have numerous chances to bid and (2) the bid price of the second highest (or lowest) bidder is known at the time of bidding. Consider this example: Suppose we had an ascending first price open auction (highest bidder wins at the highest bid price) with four bidders. Since this is an open ascending auction, each bidder is likely to enter the competition with a maximum bid price in mind. This is commonly referred to as the bidder's private valuation, since this value is only known to the bidder at the time of entering the competition. Let's assume there are four bidders labeled A, B, C, and D, whose private valuations are $100, $90, $80, and $70, respectively. Bidder D might start the bidding at $60; Bidder C then bids $65; Bidder B then bids $70, at which point Bidder D drops out the competition, since its private valuation is reached. Bidder C bids $75; Bidder A then bids $80, at which point Bidder C drops out, since its valuation has also been reached. Bidder B bids $85; Bidder A then bids $90, at which point Bidder B, the second highest bidder, drops out. Bidder A therefore wins the competition at $90, which is a net gain of $10 over Bidder A's private value. This example demonstrates that (1) bidders have numerous chances to bid and (2) the bid price of the second lowest bidder of $90 is known to all bidders at the time of bidding.

It can also be seen that all the bidders have bid to their private valuation. This is in accordance with the auction literature which states that the best strategy in an open auction is to bid only up to your private valuation (Dixit and Skeath 1999). Many people in an auction, however, do not stick to their private valuation and bid beyond it. They get carried away with the atmosphere of the auction which is built up by the auctioneer who describes the goods to be sold in a flattering way with statements like "This is a once in a lifetime opportunity to purchase this magnificent item," and so on. Indeed, a measure of a good auctioneer is the extent to which he/she can tempt the bidders to bid beyond their private valuations.

Now let's compare the ascending first price open auction with a descending first price open auction (i.e. lowest bidder wins the competition at the lowest bid price) with four bidders labeled A, B, C, and D (see Table 4.2). Since the auction is an open descending auction, each bidder is likely to enter the competition with a minimum bid price in mind. Let's again assume there are four bidders labeled A, B, C, and D, whose private valuations are $100, $110, $120, and $130, respectively. Bidder D might start the bidding at $140; Bidder C then bids $135; Bidder B then bids $130, at which point

Table 4.2 An example comparing the outcome of best bidding strategies for three different auction methods

Private values	*Auction method*		
	Open descending auction *Bidding sequence (from bottom to top)*	*First price sealed-bid auction* *Bid prices submitted (after adjusting)*	*Vickery auction* *Bid prices submitted (without adjustment)*
A $100			A $100
B $110	A $110 (B drops out)	A $110	B $110
	B $115		
C $120	A $120 (C drops out)	B $120	C $120
	C $125		
D $130	B $130 (D drops out)	C $130	D $130
	C $135		
	D $140	D $140	
Result	Bidder A wins at $110	Bidder A wins at $110	Bidder A wins at $110

Bidder D drops out the competition since its private valuation is reached. Bidder C bids $125; Bidder A then bids $120, at which point Bidder C drops out since its valuation has also been reached. Bidder B bids $115; Bidder A then bids $110, at which point Bidder B, the second lowest bidder, drops out. Bidder A therefore wins the competition at $110, which is a net gain of $10 over Bidder A's private value. It can be seen that the $10 net gain is identical in both ascending and descending first price open auctions.

Now compare this with a descending first price sealed-bid auction where bidders submit their bids in sealed envelopes. Bidding in a first price sealed-bid auction is harder than bidding in an open auction because (1) bidders only have one chance to bid and (2) the bid price of the second lowest (or highest) bidder is not known at the time of bidding. Consider the same four bidders labeled A, B, C, and D and same private valuations of $100, $110, $120, and $130, respectively (see Table 4.2). At the time of submitting the bid each bidder believes it has a chance of submitting the lowest bid, otherwise there would seem little point in entering the competition in the first place. The best strategy in sealed-bid auctions is for bidders to bid their estimate of the second-lowest bid, assuming theirs is the lowest bid (Dixit and Skeath 1999). This is because each bidder is trying to get as close as it can to the second-lowest bid. In other words, each bidder is trying to reduce the difference between the lowest and second-lowest bid (commonly referred to as "money left on the table"), since this difference represents lost revenue to the winning bidder. Given that bidders only have one chance to bid and assuming that all bidders bid according to their best strategy, this means that Bidder D might adjust (i.e. shade) its bid from $130 to $140 in the (mistaken) belief that it is the lowest bidder and that $140 is the second-lowest bid price. By the same logic, Bidder C might shade its bid from $120 to $130, Bidder B from $110 to $120, and Bidder A from $100 to $110. Bidder A would therefore win the competition at $110, which is a net gain of $10 million over Bidder A's private value.

SECOND PRICE SEALED-BID AUCTIONS

Raising the bid close to the second lowest bid is extremely difficult to do because (1) bidders only have one chance to bid and (2) the price of the second lowest bidder is unknown at the time of bidding. The problem facing contractors in first price sealed-bid competitions is that increasing the bid too little results in lost revenue to the contractor while over-compensating means losing the competition. To overcome this, the economist and 1996 Nobel Prize winner William Vickery (1961) proposed using a second price sealed-bid auction where, in the case of construction contracts, the lowest bidder is awarded the contract at the second-lowest bid price. This is sometimes referred to as a Vickery auction.

Table 4.2 shows a worked example of a Vickery auction where the lowest bidder is awarded the contract at the second-lowest bid price. Again suppose we have the same four bidders and the same four private valuations. The best strategy in a Vickery auction is for the bidders to simply bid their private valuation (Dixit and Skeath 1999) (i.e. similar to an open auction). In other words, Bidder A submits $100, Bidder B $110, Bidder C $120, and Bidder D $130. No difficult pricing adjustments are needed. Bidder A wins the competition at $110, which is a net gain of $10 over Bidder A's private value.

Revenue equivalence theory

Upon certain conditions being met, Vickery (1961) contends that buyers (i.e. clients) can, in the long run, expect to pay approximately the same amount to sellers (i.e. contractors), irrespective of whether contracts are awarded to the lowest bidder at the lowest bid price or to the lowest bidder at the second lowest bid price. This is referred to in the auction literature as the revenue equivalence theory. Relating this to construction, the contention is that clients and contractors would be no worse off financially, irrespective of whether a first price sealed-bid auction or a Vickery auction is used, yet it would be easier for contractors to bid in a Vickery auction than in a first price sealed-bid auction, since no difficult price adjustment to the second-lowest bid is needed.

The worked examples, illustrating the three descending auction methods in Table 4.2, show Bidder A winning at identical values of $110 with an identical net gain of $10 over its private valuation, thereby demonstrating the rationale behind the revenue equivalence theory.

Cripps and Ireland (1994) tested the applicability of the revenue equivalence further by comparing three different price–quality auction designs to see if assessing quality and price at different stages of the competition process would yield a revenue equivalence result. In other words, would buyers, in the long run, expect to pay approximately the same amount to sellers irrespective of when the different quality plans and bids were submitted? In the first design a quality plan was submitted and evaluated before bidding commenced. In the second design, bids were submitted prior to undertaking quality tests, while in the third design, quality and price were considered simultaneously. Cripps and Ireland concluded that the three price-quality models yielded a revenue equivalence result. In addition they pointed out that it is more difficult for the competitors to collude in situations where price and quality have to be notified at the same time.

Truthful auctions

Apart from introducing the revenue equivalence theory, Vickery (1961) identified that awarding contracts to the lowest bidder at the second-lowest bid price forces bidders to be truthful. This is because the dominant strategy in Vickery auctions is for bidders to bid without the need to make a competition adjustment. Hypothetical examples can be used to explain this phenomenon. Suppose a contractor is bidding in four separate competitions where the cost estimate for each competition happens to be exactly $10 million, the minimum mark-up margin (including profit) is 10 percent. The contractor's bid without adjusting for the competition becomes $11 million. A Vickery auction is used and the lowest rival bid in each of the four competitions is $10.6, $10.9, $11.3, and $11.8 million, respectively. Table 4.3 shows that if the contractor submits its bid of $11 million the additional profit over the four competitions amounts to $1.1 million. If, however, the contractor submits a more competitive bid of $10.8 million, it can be seen that the profit actually reduces by $100,000 to $1.0 million (because the contractor loses the $10.9 million contract) and if the contractor decides to increase its bid to $11.6 million the profit reduces further to $0.8 million. Therefore the best strategy, in the long run, is for contractors to bid without making any adjustments for the competition; in other words, to bid their private valuation.

Limitations of second price sealed-bid auctions

On the face of it, Vickery auctions seems an attractive alternative to first price sealed-bid auctions because (1) of the revenue equivalence theory and (2) it produces truthful bid competitions. The attraction is that construction clients should, in the long run, pay the same to contractors, yet it would be

Table 4.3 Example showing that the best strategy in a Vickery auction is for contractors to bid without competition adjustment

Rival bid	*Contractor's bid (without competition adjustment) $11.0*					
	Contractor bids $11.0		*Contractor bids $10.8*		*Contractor bids $11.6*	
	Profit/ loss	*Outcome*	*Profit/ loss*	*Outcome*	*Profit/ loss*	*Outcome*
$10.6	0	Lose competition: No profit / no loss	0	Lose competition: No profit / no loss	0	Lose competition: No profit / no loss
$10.9	0	Lose competition: No profit / no loss	–0.1	Win competition: Loss –0.1	0	Lose competition: No profit / no loss
$11.3	+0.3	Win competition: Profit +0.3	+0.3	Win competition: Profit +0.3	0	Lose competition: No profit / no loss
$11.8	+0.8	Win competition: Profit +0.8	+0.8	Win competition: Profit +0.8	+0.8	Win competition: Profit +0.8
Overall	+1.1		+1.0		+0.8	

easier for contractors to compete since they do not need to make any difficult pricing adjustments. In the absence of any real world data, the likely effects of using second price auctions for construction work have been examined experimentally by Drew and Skitmore (2006). This involved the participation of a group of experienced construction bidders over 60 identical first and second price construction auctions. Interestingly the bids for the second price arrangement were significantly higher, indicating that revenue equivalence theory is unlikely to occur in practice in construction bidding. In other words, the results show that construction clients are likely to pay more if second price auctioning is used in the construction industry.

This result perhaps is not surprising, given the number of conditions that need to be fulfilled for the revenue equivalence theory to hold. This includes bidders (1) behaving rationally, (2) having independent estimates, and (3) being risk neutral. Behaving rationally essentially means bidding in accordance with the best strategy as suggested by auction theory (i.e. bidding the estimate of the second lowest bid, assuming yours is the lowest bid). This is unlikely to occur in practice, since not all contractors will attempt to adjust their bid price to the second lowest bid price (since many believe this is to difficult to do) and may have other objectives in bidding (such as submitting a cover price because they do not want to offend the client if they decline to bid). A bid is an estimate of the market price and having independent estimates means that each bid is compiled independent of each other. This, however, is unlikely given the high levels of subcontracting within the construction industry, with the same subcontractor quoting identical or similar prices to competing contractors. Risk neutral means treating risk and reward on an equal basis (Flanagan and Norman 1993). However, not all contractors are likely to be risk neutral. For example, given that the lowest bidder wins at the second lowest bid price, a contractor might adopt a high-risk strategy in deliberately submitting an unrealistically low bid in the hope that it would be awarded the contract at a higher price level, whereby it can still make a profit.

Vickery auctions are not as robust as first price sealed-bid auctions (Rothkoph *et al.* 1990) and only seem to work when trust prevails among buyers and sellers. Although Vickery auctions are often used in postage stamp auctions, where traders trust one another and are seeking fair prices rather than exorbitant ones (Kambil and van Heck 2002), it seems extremely unlikely that Vickery auctions would replace first price sealed-bid auctions for construction work. This is especially so with the huge sums of money involved, which is likely to increase the temptation for contractors and/or clients to cheat. For example, contractors may be tempted to cheat by colluding with other competing contractors – they may be taking it in turns to bid low. Clients, on the other hand, may become dissatisfied with the second lowest price, once the lowest (or highest) price is discovered. It follows that contractors may worry that once their bid is submitted the client may unscrupulously act as if another lower bid were received.

COMMON- AND PRIVATE-VALUE AUCTIONS

Two extreme types of auction are (1) private-value and (2) common-value auctions. Private-value auctions are those in which each bidder places a different value on the object being auctioned. The differences in the values being placed by each bidder are often quite subjective, being heavily influenced by individual preference and taste. A commonly quoted example of a private-value auction is the auction of oil paintings by famous artists. How much somebody is willing to pay for a particular painting is usually influenced by preference and taste.

Private-value auctions may be therefore defined as having a *different known* value for each bidder. That is, each bidder has a different value and there is no uncertainty surrounding the value. In statistical terms, this is equivalent to saying that, for each bidder, the error in estimating value always has zero mean and zero variance.

On the other hand, common-value auctions are those in which the object being auctioned has the same value to all bidders but its true value is unknown at the time of bidding. A commonly quoted example is auctioning an old glass jam jar containing a large number of coins which have different values. Each bidder can see what the jam jar contains but at the time of bidding does not know the true value of the coins. Each bidder can only estimate that value. Each bidder's estimated value is likely to be set at a level whereby the winning bidder pays less than the true value of coins and therefore makes an eventual profit.

Common-value auctions may be therefore defined as having the *same unknown*, but probabilistic, value for each bidder. That is, each bidder has a different estimate but of the same value. In statistical terms, this is equivalent to saying that, for each bidder, the error in estimating value may have a non-zero mean and/or non-zero variance.

So are construction auctions classified as private-value or common-value auctions? Dyer and Kagel (2002) state:

> Construction contract bidding is usually treated as a common value auction. In a pure common value auction the value of the item is the same to all bidders. What makes the auction interesting is that bidders have different estimates of the true value at the time they bid. Assuming that bids decrease with decreasing cost estimates, the low bidder faces an adverse selection problem, as he/she wins only when he or she has one of the lowest estimates of the cost of construction. (p. 349)

It would seem that construction auctions are not a pure form of common-value auction because the bid price submitted by competing contractors normally comprises the total sum of the subcontracting packages, which make up the bulk of the bid, plus an on-cost and profit for organizing and managing the construction work. (e.g., a survey (Lai 1987) of 17 Hong Kong building contracts showed that the work subcontracted out was never less than 92.5 percent). The subcontracting packages can be considered in terms of the coins in the glass jar. However, although all the coins in the jar are identical, some subcontractors used by the competing contractors will also be identical but others will be different. The different combinations of subcontract packages used plus different on-costs means that the actual cost of constructing the work to each contractor is likely to be similar but not identical.

In assembling the various combinations of subcontract packages, different contractors will achieve different levels of cost efficiency. The task at hand is to produce an efficient cost combination of subcontract packages, since this increases the chance of winning the contract.

WINNER'S CURSE

Given that the winning bidder is the bidder with the highest estimated value in a first price ascending auction (or lowest estimated value in a first price descending auction), it stands to reason that the more bidders there are in the competition, the bigger the largest estimated value is likely to be. The bigger the estimated value, the greater the chance that the largest estimated value exceeds the actual value of the object being auctioned. In such cases the winning bidder makes a loss. This phenomenon is referred to in auction literature as the "winner's curse". Nagle and Holden (1995) point out:

> The bids you win are not a random sample of the bids you make. You are much more likely to win jobs for which you have underestimated your costs and are unlikely to win those for which you have overestimated your cost. Consequently, the expected profitability of a job, conditional on the fact that you have won it, is much less than the expected profitability before winning. The difference between conditional and unconditional probabilities increases with the number of competitors against whom you must bid.
>
> (p. 205)

McCaffer calls this "the margin lost in competition" (Harris and McCaffer 1989). He points out that each contract is assumed to have a likely cost and the range of estimates produced by each contractor is going to be "likely cost" plus or minus *A* percent, where *A* percent represents the accuracy of the estimator's prediction of likely cost. He states "the estimator who produces the lowest cost estimate, say likely cost minus A% gives his (her) company the best chance of winning the contract" and that this supports the cliché "The estimator who makes the biggest (negative) mistake wins the contract."

Nagle and Holden (1995) say that the only solution is to add a "fudge factor" to each bid to reflect an estimate of how much you are likely to have underestimated your costs if you actually win a bid. This view is supported by Fine (1974) who identifies out that, in order to at least break even, contractors should increase their mark-up in line with an increase in the number of competing bidders. This, of course, goes against the natural tendency to decrease the mark-up in order to compensate for the reduced probability of winning. Decreasing the mark-up as the number of bidders increases actually enhances the difference between conditional and unconditional probabilities, thereby increasing the prospects of the winning bidder making a bigger loss.

The term "winner's curse" was first used in a paper by Capen *et al.* (1971) who used it to describe the outcome of common-value auctions in which large petroleum companies were competing for drilling rights. The volume of oil contained in the well underground is the same for all bidders, but at the time of bidding none of the competing bidders knew its true value and some bidders eventually made a loss.

Dyer *et al.* (1989) undertook a bidding experiment to compare inexperienced student bidders with experienced construction executives. Much to their surprise they found that both sets of bidders suffered from the winner's curse. They identified that although this occurred in the experiment, in the real world there are mechanisms for escaping the winner's curse. This includes contractors (1) withdrawing bids on public projects without penalty when the bid contains "arithmetic errors," (2) reducing losses by squeezing subcontractors, and (3) cutting losses through tough negotiation on change (i.e., variation) orders. Points (2) and (3) essentially mean contractors being more aggressive in claiming against subcontractors and clients. They conclude that the winner's curse phenomenon is robust across auction form, market size, and subject population.

The winner's curse phenomenon can put contractors in a difficult financial position and may lead to client dissatisfaction with poor quality work and on occasion the contractor becoming bankrupt. It would, however, seem that the impact of the winner's curse phenomenon is being reduced in the construction industry with the trend of awarding more construction contracts on a multi-criteria basis (such as price and quality) rather than just price, coupled with a move away from the conventional design–bid–build arrangement to other arrangements such as bid–design–build, private finance initiative (PFI) and public–private partnerships (PPP) where the competition usually contains fewer competing contractors.

CONCLUSIONS

Competition can be related to economics and management theory. Using a systems approach, management theory seems to be more comprehensive at modeling strategic behavior within firms whilst with types of markets ranging from perfect competition to monopoly, economic theory appears to be more developed at modeling strategic behavior between firms. Bidding is a mechanism commonly used by clients to (1) allocate construction work to contractors and (2) establish the market price.

Competing for construction contracts usually takes place within a descending first price sealed-bid auction where the lowest bidder wins the contract at the lowest bid price. Open auctions are compared with sealed-bid auctions. It is more difficult to bid in a sealed-bid auction than an open auction because (1) bidders only have one chance to bid and (2) the bid price of the second lowest bidder is not known at the time of bidding. The best strategy in a first price sealed-bid auction is for bidders to bid their estimate of the second lowest bid assuming theirs is the lowest bid. This is extremely difficult, if not impossible, to do and to overcome this, Nobel Prize winning economist William Vickery suggested using a second price sealed-bid auction (where the lowest bidder wins the contract at the second lowest bid price). He also introduced revenue equivalence theory whereby, upon certain conditions being met, clients would, in the long run, pay the same to contractors irrespective of using a first or second price sealed-bid auction. However, it is very unlikely that all the conditions would be met in the real world of construction contracting. Auctions can be classified as private value (where each bidder places a different value on the object being auctioned) and common value (where the object being auctioned has the same value to all bidders but its true value is unknown at the time of bidding). Given the high levels of subcontracting used within the industry, construction auctions can be treated as common-value auctions. Common-value auctions are especially prone to the winner's curse (where the eventual cost is higher than the bid price, thereby causing the bidder to make a loss) which is more likely to occur in competitions containing larger numbers of contractors.

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5 On theory of production in economics and production management

Lauri Koskela

INTRODUCTION

All built environment, as well as all the artifacts we are daily using in the framework of it, exists because it has been *produced*. It is the ability to produce that distinguishes between the rich and the poor nation. It is the ability to produce in a sustainable way that seems to determine the fate of mankind. Without debate, production is of central significance for human societies. However, this invites the question: What do we know about production? What determines the outcome of production? Why are some factories, nations and industries more productive than others? Given that sciences tend to present their most fundamental knowledge in the form of theories: What is our theory of production?

A promising place to assess the status of the theory of production is such a disciplinary domain where the phenomenon of production accentuates. Undoubtedly, the construction and real-estate sector provides such a domain: buildings and other constructed facilities come about through a lengthy process of production, and in turn, during their use, they produce services over a long time period. Beyond production, the only other interesting event is in the form of transactions, changes of ownership, but even these phenomena are based on assessments on the productive capabilities in question. There are two academic disciplines looking at construction, construction economics and construction management.

Thus, what kind of theories of production can we find in construction economics and construction management? Regarding construction economics, we encounter problems at the outset, as it turns out that construction economics has not had a unitary approach to economic theory (Ofori 1994) or to its subject in general. The view that construction economics should use the concepts and methods of mainstream economics was pioneered by Hillebrandt (1985). However, in her seminal book (Hillebrandt 1985), she does not treat production theory at all, obviously following the view that it is not useful for the tasks at hand in construction. In contrast, newer treatments (Cooke 1996; Myers 2004; Ive and Gruneberg 2000) present the economic theory of production and try to apply it to construction. Another view holds that construction economics equates to accounting. This view is evident in many traditional books on construction economics. However, as in accounting, there is no explicit theorizing on production.

Regarding construction management, a considerably widely subscribed view holds that it is a daughter discipline of management, which falls within social science (Bon 1989). In this understanding of construction management, there is not much place for theorizing on production. Another understanding holds that construction management is a subfield of production management, but even in the literature related to this understanding, theorizing on production is scarce.

Thus, in both disciplines, the position of production as a theoretical topic is vague, at best, or non-existent, which provides a stark contrast to the major role of the phenomenon of production in their subject field.

The search for a theory of production from a place where we would expect it to flourish provides thus a puzzling disappointment. However, the search gave a hint for a further direction. Both construction economics and construction management have practically inherited their theories of production from their mother disciplines,[1] i.e. economics and operations management, which have focused on production on a generic level.

Thus, the task is to critically assess theory of production in economics and production management. As production management always occurs at the micro level, we focus the consideration of economics also mainly on the micro level. Let's also note that in this context the focus is on the established core doctrines, as they are taught and practically applied, of the disciplines considered, rather than on the frontier of knowledge.

The chapter is structured as follows. First, production in the doctrine of economics is considered. Then, the ways of understanding production in operations management are discussed. Next, the production notions in these two disciplines are compared and critically discussed. Finally, conclusions are presented.

PRODUCTION THEORY IN ECONOMICS

Production in the doctrine of economics

There is hardly a better starting point for investigation of the doctrine of economics than the well-known textbook by Samuelson and Nordhaus (1985, 1998). Since 1948, 15 editions of this book have been published, and more than four million copies sold (*The Economist*, 23 August 1997, p. 60). The book has been translated into 41 languages. According to this source:

> Economics is the study of how people and society choose to employ scarce resources that could have alternative uses in order to produce various commodities and to distribute them for consumption, now or in the future, among various persons and groups in society.

Thus, production is clearly one of the subjects of economics.Accordingly, the textbook referred to has a section titled 'The theory of production' (p. 579):

> The theory of production begins with specific engineering or technological information. If you have a certain amount of labor, a certain amount of land, and a certain prescribed amounts of other inputs such as machines or raw materials, how much output of a particular good can you get? The answer depends upon the state of technology: if someone makes a new invention or discovers a new industrial process, the obtainable output from a given factor inputs will go up. But, at any given time, there will be a maximum amount of output that can be produced with a given amount of factor inputs.

The technical law relating inputs to outputs, called production function, is defined as follows:

> The production function is the technical relationship between the maximum amount of output that can be produced by each and every set of specified inputs (or factors of production). It is defined for a given state of technical knowledge.
>
> (Ibid.)

Further, an example of a production function for generating electricity is given:

> A book of blueprints shows the combination of plant, turbines, cooling ponds, and labor needed to produce 1 million kilowatts of power. On one page is a blueprint for an oil-fired plant – whose capital costs are low and whose fuel costs are high. On the next page would be the blueprint for a coal-fired plant: high capital costs (in part to remove the noxious emissions), but much lower fuel costs . . .. When all the different blueprints for 1985 are put together, these form the production function for electricity generation for 1985.
>
> (Ibid.)

This, in substance, is what this enormously influential textbook has to say on production. Indeed, both the practitioner and the scholar of production will be utterly puzzled: what is said in the textbook represents a very narrow view on the challenges of realizing production, and the electricity plant example seems just naïve. The production expert is well aware of the analysis of division of labour by the founding father of economics, Smith, and wonders what would be the current view of economics on these pertinent issues of production.

However, further reading reveals that the theory of production is not treated in the textbook of Samuelson due to the intrinsic interest of production, but rather 'as a prelude to our general discussion of distribution of income'. This is not a different position given to the theory of production in comparison to the classical economist who contributed to the establishment of the production theory (Walras 1952). He explains that by means of the production theory, he aims to clarify the determination of prices of production factors: '*par la théorie de la production, la determination des prix des matières premières et services producteurs*'.

Thus, the theory of production is used for predicting and explaining the determination of prices of production factors at the level of the national economy. This means that the primary use of the theory of production in mainstream economics is actually not related to production as such.

However, there have been other proposed uses for the theory of production. In his book on production theory, Frisch (1965) develops the production theory further towards specific applications. In many ways he follows the general doctrine, and thus defines production as transformation and the production function as a function showing the technical relationship of dependence between the product quantity and the factor quantities. He clarifies the economic angle to production in a useful way: 'By production in the economic sense we mean the attempt to create a product which is more highly valued than the original input elements.'

Frisch states that production as a rule passes through a stage of rising and then a stage of diminishing returns, if one factor is varied while allowing the others to remain constant. The chief subject of the modern theory of production is, according to Frisch, *to study such multidimensional (raw material, labour, energy, etc.) variations of factors from the point of view of optimal output*. The goal is thus to find the best combination of production factors. Our production management expert would accept this as one question in production.

However, our production expert would pinpoint the general definition of production by Frisch and ask what economics says about how to organize production in the economic sense, to produce products that are more highly valued than the production factors. He would also pinpoint the question of the reasons why productivity in one country, company or plant[2] is higher than in another.[3] The mainstream textbook is oddly silent on these questions, which have a great practical significance.

Thus, the situation is puzzling: production theory in economics is not about production as such, and the key issues of production in economic sense seem not to be systematically covered. In order to understand the reasons for this situation, we have to take a look at the history of economics.

The invisible paradigm shift: is economics about wealth or scarcity?

The original focus of economist thinking was on wealth and its determinants. However, the idea of scarcity as the main focus has run in parallel to the history of economic thought; it started to be elaborated around 1870 and won a dominant position in the second half of the twentieth century. Simultaneously, the prior name 'political economy' was substituted with 'economics'. One key promoter of the scarcity idea was Lionel Robbins, who published in 1932 the influential 'Essay on the Nature and Significance of Economic Science'. His book gives an illuminating picture on the paradigmatic change underway.

Robbins describes the earlier view on economics as follows:

> Economics has been divided into two main divisions, the theory of production and the theory of distribution, and the task of these theories has been to explain the causes determining the size of the total product and the causes determining the proportions in which it is distributed between different factors of production and different persons.

Robbins does not appreciate these research questions, and presents a new vision on the task of economics, focusing on the scarcity of means to fulfil given ends. In his vision, the subject matter of economics is a series of relationships between ends and means. In this scheme, the technical arts are definitively outside the ambit of economics, only taken as given factors influencing the relative scarcity of different economic goods. In association with this, production as such is not focused upon by economics, but only in the framework of the whole economy:

> In the modern treatment, discussion of 'production' is an integral part of the theory of equilibrium. It is shown how factors of production are distributed between the production of different goods by the mechanism of prices and costs, how given certain fundamental data, interest rates and price margins determine the distribution of factors between production for the present and production for the future.

Robbins wants to purge economic theorizing from all discussion about the technical, as becomes evident when he discusses the old view, to be rejected:

> It should not be necessary at this stage to dwell upon the inappropriateness of the various technical elements which almost inevitably intrude into a system arranged on this principle. We have all felt, with Professor Schumpeter, a sense of almost of shame at the incredible banalities of much of the so-called theory of production . . .

The idea of economics as a science focusing on scarcity, and the underlying thinking of Robbins, was increasingly accepted by economists in the latter half of the twentieth century, and along with it, the denial to address issues related to production as such. This 'marginal revolution[4] 'can be well characterized as a paradigm shift in Kuhn's (1996) sense. The difference between old and new has been characterized as that between an economics focusing on production and that focusing on exchange (Vaggi and Groenewegen 2003). The questions rejected were about the total product, that is, the wealth of nations (as focused on by Smith), and the distribution of output to various classes in a growing economy (as addressed by Ricardo), and the new question concerned the optimum resource allocation under static conditions (Vaggi and Groenewegen 2003).

However, as it typically happens, after the new paradigm has settled, the paradigm shift becomes invisible – it is disguised in textbooks, for several reasons (Kuhn 1996). This seems also to have been the case regarding economics.[5]

PRODUCTION THEORY IN PRODUCTION/ OPERATIONS MANAGEMENT

There is no commonly accepted theory of production in production/operations management (Koskela 2000). There are at least three reasons for this state of affairs. First, production models, like mass production or lean production, have diffused at a practical rather than a theoretical level. Second, the prevailing theory of production has not been explicit and so it has not been possible to make direct comparisons with rival theories or to validate it. Third, the significance of a theoretical foundation of production has, by and large, not been acknowledged in the doctrine of production/operations management.

Thus, we have to clarify what theories have been put forward by scientists and what theories have actually been used in practice. Conclusive evidence shows that during the last century, production has mostly been conceptualized as a transformation of inputs to outputs. For example, Starr (1966) formulates:

> Any production process can be viewed as an input-output system. In other words, there is a set of resources which we call inputs. A transformation process operates on this set and releases it in a modified form which we call outputs . . .. The management of the transformation process is what we mean by production management.

There are a number of principles, by means of which production, viewed as transformation, is managed. These principles suggest, for example, decomposing the total transformation hierarchically into smaller transformations, or tasks, and minimizing the cost of each task independently. However, this foundation of production is an idealization, and in complex production settings the associated idealization error becomes unacceptably large. There are two main deficiencies: it is not recognized that there are also other phenomena in production besides transformations (called waste in operations management), and it is not recognized that it is not the transformation itself that makes the output valuable, but that the output conforms to the customer's requirements. The transformation view is instrumental in discovering which tasks are needed in a production undertaking and in getting them realized. However, the transformation view is not especially helpful in figuring out how not to use resources unnecessarily or how to ensure that customer requirements are met in the best manner. Therefore, production, managed in the conventional way, tends to become inefficient and ineffective. In practice, methods based solely on the transformation model are increasingly rejected.

There has existed, since the 1920s, another concept of production, namely the view of production as flow. The introduction of time as an input in production was one major difference in comparison to the transformation concept. The following quotes from Ford (1926) show that time can be understood perfectly well as one production factor among others:

> The time element in manufacturing stretches from the moment the raw material is separated from the earth to the moment when the finished product is delivered to the ultimate consumer.
>
> Time waste differs from material waste in that there can be no salvage. The easiest of all wastes, and the hardest to correct, is this waste of time, because wasted time does not litter the floor like wasted material.

This view was first translated into practice by Ford. However, the mass production template provided by Ford was in this regard misunderstood, and the flow view of production was further developed only from the 1940s onwards in Japan, first as part of war production and then at Toyota. Currently, the flow view is embodied in lean production. This concept views production as a flow, where, in addition to transformation, there are waiting, inspection and moving stages. Queuing theory, which applies to such flows, teaches that variability is the crucial determinant of the behaviour of flows (Hopp and Spearman 1996). Production management equates to minimizing the share of non-transformation stages, waste, of the production flow, especially by reducing variability.

Yet a third view on production has existed since the 1930s. Shewhart (1931) formulated this view at the outset of the quality movement as follows:

> Looked at broadly there are at a given time certain human wants to be fulfilled through the fabrication of raw materials into finished products of different kinds. These wants are statistical in nature in that the quality of a product in terms of physical characteristics wanted by one individual are not the same for all individuals.
>
> The first step of the engineer in trying to satisfy these wants is therefore that of translating as nearly as possible these wants into the physical characteristics of the thing manufactured to satisfy these wants. In taking this step intuition and judgement play an important role as well as the broad knowledge of the human element involved in the wants of individuals.
>
> The second step of the engineer is to set up ways and means of obtaining a product which will differ from the arbitrarily set standards for these quality characteristics by no more than may be left to chance.

Table 5.1 The three theories of production

	Transformation theory	*Flow theory*	*Value generation theory*
Conceptualization of production	As a transformation of inputs into outputs	As a flow of material, composed of transformation, inspection, moving and waiting	As a process where value for the customer is created through fulfilment of his requirements
Main principles	Getting production realized efficiently	Elimination of waste (non-value-adding activities)	Elimination of value loss (achieved value in relation to best possible value)
Methods and practices (examples)	Work breakdown structure, MRP, organizational responsibility chart	Continuous flow, pull production control, continuous improvement	Methods for requirement capture, quality function deployment
Practical contribution	Taking care of what has to be done	Taking care that what is unnecessary is done as little as possible	Taking care that customer requirements are met in the best possible manner

Source: Koskela (2000).

In the value generation view, the basic thrust is to reach the best possible value from the point of view of the customer. Production management equates to translating the customer needs accurately into a design solution, and then producing products that conform to the specified design. Especially the quality movement has endeavoured to translate this view into methods and practices useful in the industry. Principles related to rigorous requirement analysis and systematized flowdown of requirements, for example, are put forward.

Thus, there are three major theories of production[6] (Table 5.1), and each of them has produced practical methods, tools and production templates.

COMPARISON OF PRODUCTION THEORIES IN ECONOMICS AND OPERATIONS MANAGEMENT

It is easy to note that the idea of production as transformation is shared by economics and operations management. In both cases, the transformation is characterized through its inputs and outputs. However, the use of this conceptualization is different. In economics, the main interest is towards finding the optimal set of inputs, whereas in operations management, the goal is much wider, to discover what must be done and which inputs are needed. Surely, the economic aspect is included in the operations management concept of transformations.

Thus, superficially, we have found these two disciplines sharing a fundamental conceptualization, which seemingly would provide a bridge between these disciplines. However, the transformation theory is only one of the three theories of production used in operations management. Let us recall that the main benefit of the flow theory is related to the explanation of the formation of costs (especially costs due to waste), while the value generation theory contributes to the explanation of how value is formed. In the logic of operations management, the transformation theory is not capable of adequately explaining cost or value.

Now, the serious and troublesome question arises: Is the economic theory of production capable of explaining the formation cost and value in the production process? After all, according to Frisch, the economic viewpoint of production is how to achieve a product which is more highly valued than the original input elements, and thus the explanation of both costs (of the input elements) and value (of the product) would seem to be a central task for economics.

Thinking in terms of production management, the inevitable answer is no. The production theory, supported by the idea of input–output transformation, is fundamentally limited by its conceptualization, and does not catch the major phenomena that play a role in the formation of costs and value. The costs are to a considerable part caused by inefficiencies in production – waste is ubiquitous in production. To understand the formation of costs, we need to understand the causes of inefficiencies and waste. Similarly, value in production cannot be seen as a given, but as an emergent phenomenon, the cultivation of which requires explicit managerial attention and work.

However, this argument, based on the body of knowledge in production management, will not be sufficient for an economist – rather, the shortcomings in the economical theory of production have to be pinpointed in the framework of economical conceptualization itself. This will be addressed next.

CRITIQUE OF THE ECONOMIC THEORY OF PRODUCTION

It is appropriate to consider why this bizarre situation, where mainstream economics has little to say on the productive processes that create valuable artefacts, has emerged. The situation seems to have been caused by the foci and assumptions of the ‘marginalist turn’: elevation of scarcity to the main topic, refusal to consider any internal organization of production than that caused by process and costs, assumption of efficiency, assumption of ends as given, assumption of momentary production as well as the isolation of economic phenomena from other phenomena. Let us consider each in turn.

The scarcity view of economics

As mentioned above in connection with the doctrine of economics, the production theory was not originally developed for analysing production as such, but as an auxiliary tool for analyses of wider phenomena (Robbins 1935). As a consequence, this discussion of production is not addressing the determinants of the total product of production (a question which was rejected). Further, as the total product, that is, output, is needed for calculating productivity, also all explanatory discussion on productivity is swept away from consideration.

However, the simple fact that the economic theory of production is not really about production seems not to be generally known. This is proven by the numerous attempts to use that theory of production in the production context.[7] Thus, for example, the long-standing productivity gap between the United Kingdom and other leading industrialized countries has been approached using the theory of production (for instance, Delbridge *et al.* 2006).

The explanation of this missing understanding of the nature of mainstream economic doctrine lies in the invisibility of the paradigm shift, as discussed above. This has resulted in a counterproductive and confusing situation, when the old questions pop up, and users of economic understanding, not knowing that they are rejected questions of the old paradigm, tend to use the concepts and methods of the new paradigm to analyse these old questions. Unfortunately, the new paradigm will not be appropriate for answering the unconditionally rejected questions of the old paradigm – if it were appropriate; those questions had not been rejected but subsumed into the new paradigm.

Thus, a focus on scarcity is not a problem as such. Rather, the problem is that the resulting conceptualization of economics has been used to address issues which are beyond scarcity.

Internal organization of production

Robbins (1935) says:

> We may take as an example of the advantages of this procedure the modern treatment of organization of production. The old treatment of this subject was very unsatisfactory: A few trite generalizations about the advantages of the division of labour copied from Adam Smith, . . . [. . .] But it is perhaps as well to state definitely its considerable positive deficiencies. It suggests from the point of view of the economist 'organization' is a matter of internal industrial (or agricultural) arrangement . . .. At the same time, it tends to leave out completely the governing factor of all productive organization – the relationships between costs and prices.

Here, Robbins argues that the productive organization is essentially determined by the relationships between costs and prices, and that any internal industrial arrangements can be abstracted away, at least from an economic analysis. The problem here is that arguably the output of production is dependent on two sets of factors, first, the technology,[8] as proposed above by Samuelson and others, but also the theoretical basis and quality of implementation of production management (which determine the amount of waste), that is, the internal arrangements. The huge differences in the impacts of production management have been commonly known at least from the 1920s (Anon. 1921). Research shows that even within one company, performance differences may be as great as 2:1 (after controlling for other differences in age, technology, etc.) between the best and worst plant (Chew *et al.* 1990). However, economists have failed to act upon this knowledge[9] – obviously, because the matter of internal industrial arrangement has been paradigmatically excluded from economic consideration.

Interestingly, a recent analysis (Delbridge *et al.* 2006) on the UK productivity problem concludes:

> Our core argument is that, while Government policy stresses two aspects of context (macro-economic management and the regulatory environment), the key to productivity remains what happens inside the firm and this is something of a 'black box'. The further benefits that may be achieved from pulling levers that impact on the inputs to, and context of, operation are limited.

In view of this, the first key message (of two) of this report, focusing on areas where new thinking is needed is, as follows (Delbridge *et al.* 2006): 'Attention to the black box of productive performance requires a local focus on the specific mechanisms and processes involved in the translation of inputs into productive activity.' Thus, ironically, the significance of the internal organization of production is acknowledged again, over seventy years after Robbins denied it.

Ends as given

Robbins (1935) says of ends:

> Economics, we have seen, is concerned with that aspect of behaviour which arises from the scarcity of means to achieve given ends. It follows that Economics is entirely neutral between ends; . . .. Economics is not concerned with ends as such. It assumes that human beings have ends in the sense that they have tendencies to conduct which can be defined and understood, and it asks how their progress towards their objectives is conditioned by the scarcity of means – how the disposal of the scarce means is contingent on these ultimate valuations.

Thus, the assumption is that ends are given[10] and that they are separate from means. This can be challenged. The industrial practice reveals first that ends, i.e. client requirements, are not immediately clear and stable, but rather implicit and evolving. Second, ends and means are intimately interrelated: often ends emerge only when the corresponding means have been developed or the client has been made aware of them. Thus, a conversation between means and ends is needed. Third, most often ends cannot be realized in one pass (decision), but a multilayered ends–means hierarchy[11] is needed. Thus, ends cannot be seen as static, fixed starting points, but as a moving target that has to be managed.

Thus, the production function does not explain how the value of the output of production comes to be. For the example given by Samuelson above, electricity, this is not a major problem, but for most products, it is crucial which are the functionalities and whether there are defects.

The traditional project and construction management has largely tended to assume ends as given. This has been detrimental as in resulting practice the project realization process inadvertently runs parallel to the discovery of ends. Surely, it is not clear how much economics has influenced this situation.

Momentary production

The mainstream economics subscribes to the starkly idealized notion of 'momentary production'. Frisch defends the view on 'momentary production' as the main approach:[12]

> Consequently, in many cases we are justified in studying the production process as though it took place in a single moment of time. In developing a theory of momentary production, we do so, not because a major portion of production actually takes place in this way, but because this theoretical approach throws light on many important aspects of the problem, without involving us in unnecessary details and complications.

Unfortunately, it is not true that a major portion of production would take place in the fashion of momentary production. But neither is any minor portion of production momentary. In reality, production always requires time – mankind has never produced anything through momentary production. This was well understood already by Walras (1952) in the nineteenth century:[13] '*Mais il y a une seconde complication. . . . La production exige un certain délai. Nous résoudrons cette seconde difficulté en faisant ici purement et simplement abstraction de ce délai.*'

This idea of momentary production is implicitly used in connection to the concept of productivity or task. It is difficult to estimate how ideas have diffused, but probably the example of economics has contributed to the general uptake of the idea of momentary production. However, as the flow theory of production teaches us, the time required for production provides a universal metrics for assessing production management. By viewing production as momentary, we exclude at the outset this important metrics from consideration. So common and deeply ingrained was the view on momentary production that Stalk and Hout (1990) wrote in their seminal book on time-based competition: ‘The search for what has become time-based competition began in 1979. In that year, many of us were startled by some data shared with us by a client.’ The data in question was about differences in productivity, quality, inventory, space, and, remarkably, throughput times, which in the final analysis explained the former differences.

As analysed by Koskela and Kagioglou (2005), the conventional concepts of production as transformation have been based on thing metaphysics (rather than process metaphysics). The view on production as momentary falls exactly into the realm of thing metaphysics. Unfortunately, among the problematic features associated with this conceptualization of production, attributable directly to the underlying metaphysical assumptions, are the following: (1) tasks are considered as black boxes; (2) tasks are considered similar by nature; (3) tasks are considered (nearly) independent (Koskela and Kagioglou 2005). Arguably, all these assumptions lead to idealization error in their industrial application, and typically to counterproductive practices.

Assumption of the best possible productive efficiency

In his book on construction economics, Myers (2004) says:

> In any free market economy businesses will never waste inputs. A business will not use 10 units of capital, 10 units of labour and 10 units of land when it could produce the same amount of output with only 8 units of capital, 7 units of labour and 9 units of land.

Unfortunately, just the opposite of what Myers claims prevails in reality: businesses always waste inputs, more or less. As Womack and Jones state it, ‘*muda*[14] is everywhere’. Similarly regarding construction, it has been argued that high levels of waste and value loss are a normal phenomenon in this industry (Koskela 2000), and that waste is omnipresent in construction supply chains (Arbulu and Tommelein 2002). Surely, if one assumes that the whole economy is producing with maximal efficiency,[15] waste will not be visible and the reduction of waste cannot be perceived as a worthwhile way of increasing efficiency.

Isolation of economic phenomena from other phenomena

When characterizing the connection between the economics and the technical arts of production, Robbins (1935) says: ‘The technical arts of production are simply to be grouped among the *given* factors influencing the relative scarcity of different economic goods.’

As he formulates in a footnote related to this passage, an equivalent formulation is that 'technique in relation to economics is simply so much *data*'. Thus, economic and technical phenomena are separate, and there is just one way influence to economical phenomena from the given data, provided by 'the technical arts of production'.

In reality, technical and economic phenomena are tightly interconnected and in mutual relationship. For example, all services and products bought for production have certain reliability. Any shortcoming of reliability, increasing variability, will directly influence the costs of production. Thus, production inputs have always to be procured based on a simultaneous consideration of both economic and technical factors.[16]

A later example of isolation of production from the economic object of investigation is offered by transaction cost economics. The concept of near decomposability is a starting point in transaction cost economics (Williamson 2000). Simon (1969) defines near decomposability as follows:

> In a nearly decomposable system, the short-run behavior of each of the component subsystems is approximately independent of the short-run behavior of the other components; In the long-run, the behavior of any one of the components depends in only an aggregative way on the behavior of the other subcomponents.

Thus, if purchasing and production are component subsystems, it is assumed that they, and their costs, are approximately independent at the short run. This view can be challenged (Koskela & Ballard 2006).

The generalized question whether it is possible to isolate economic phenomena totally from other phenomena, as assumed in economics, has earlier been raised by Georgescu-Roegen (1970). He argues that economic theorizing should be based on the understanding of the biophysical and social context of consumption and production. Unfortunately, it seems that these views of Georgescu-Roegen have not found resonance in the mainstream of economic thinking. Interestingly, in the framework of production, the flow theory describes the physical context of material movements. The value generation theory endeavours to explain the social and physical efforts towards creating products that fulfil customers' requirements.

Summarizing discussion

The preceding considerations make it painfully clear that in pursuing towards a coherent conceptualization of the machinery of the whole economy, the marginalists have been compelled to adopt assumptions which are not helpful, but rather even counterproductive when it comes to understanding production (Table 5.2). In addition, the questions related to production as such have been deleted from the purview of economics.

Table 5.2 The problematic assumptions of the economic theory of production, their critique and their dysfunctional impacts

	Scarcity	*Efficiency*	*Ends as given*	*Internal organization of production*	*Momentary production*	*Separation of economic phenomena*
Core assumption	The central issue of economics is scarcity	All economic actors behave in the most efficient way	Ends are separate from means; ends are known	The internal organization of production is determined by the prices of production factors	Production is momentary	Economic phenomena can be separated from technical phenomena
Critique	While scarcity is an ubiquitous feature, there are other significant issues, such as creation of wealth	There is waste everywhere	Ends evolve; ends depend on the means available	The internal organization depend on the theory of production adopted	Production has always a duration	Economic, technical, social and ecological phenomena are tightly interwoven
Dysfunctional impacts	Prevents seeing other economic issues	Prevents seeing waste	Prevents from seeing the need for value management (in a broad sense)	Prevents seeing the whole issue of internal organization of production	Prevents seeing waste; leads to thing metaphysics	Prevents from taking other than 'economical' issues into consideration in decision making

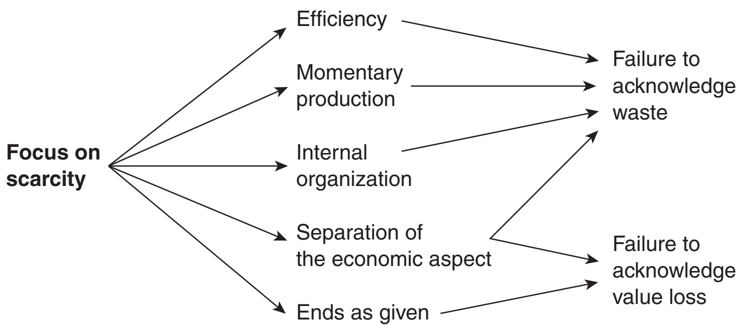

Figure 5.1 The contribution of the different assumptions of the economic theory towards the failure to acknowledge waste or value loss.

Nevertheless, the marginalist economic concepts have been used for explaining production related matters, especially productivity.

The assumptions have especially contributed to two major failures, namely with respect to acknowledging waste and value loss (Figure 5.1). Economics has focused on the scarcity of given means to fulfil given ends. However, the means are not given, but we usually waste part of them. Similarly, ends are not given, but we can influence their emergence and realization in design and production. Thus, it is not enough to find the best means towards an end – rather we have also to address the evolution and attainment of the end, as well as the reduction of wasted means.

Given the considerable authority of economics, its conceptualizations have also influenced other fields, such as project management, organizational theory and contracting. Unfortunately, the counterproductive assumptions have at the same time been diffused to these fields, where they often have played an equally damaging role as in economics.

In many cases, the original prescriptions of the marginalists have been withdrawn or rejected by a part of the economist community. Thus, for example, the new growth theory has reinstated the position of the question of the causes of the total production, even if only at the macroeconomic level. However, the often implicit assumptions related to the marginalist turn seem to have survived in mainstream economics.

CONCLUSIONS

Comparison reveals that the economical theory of production broadly equates to the transformation theory of production, as used in production management. In production management, the transformation theory of production has been the underpinning of the mainstream thinking in the major part of the twentieth century. It is only in the last decades of that century that the two other theories, flow theory and value generation theory, have started to challenge the transformation theory. However, today, the transformation theory is in many production management circles rejected as the sole theory of production. This is causing a theoretical rift between economics and production management.

The current theory of production in economics started to be developed around 1870, and became the dominant view in the second half of the next century. Robbins (1935) asks whether the conception of economics he is advocating[17] runs the danger of tipping the baby out with the bath water, that is, 'excluding from the subject-matter of Economics just those matters where economic analysis is most at home', namely production. Unfortunately, it seems that this very danger, so vehemently denied by Robbins, has been realized.

It is thus opportune to suggest that also economics should critically assess its prevailing theory of production, and adopt more valid theories. In his analysis of the future of construction economics, de Valence (2006) identifies five possibilities. This presentation leads to a sixth option, namely the resurrection of the political economy and its focus on the creation of wealth.

NOTES

1 As already discussed, this can be challenged both regarding construction economics and construction management. Regarding construction economics, one understanding holds that it is a discipline that equates to accounting rather than to economics. Regarding construction management, a considerably widely subscribed view holds it as a daughter discipline to management, which falls into social science. However, neither accounting nor management has any explicit theory of production.
2 The operations management scholars Schmenner and Swink (1998) state 'it is difficult to embrace microeconomic theory as a complete explanation for the productivity differences between the factories. Too many of the details of factory operation are ignored and the implications about technology and scale are too ambiguous to test.'
3 A related question is the longitudinal explanation to productivity increase or decrease in a company, sector or country.
4 As termed by Vaggi and Groenewegen (2003).
5 In Chapter 1, Samuelson and Nordhaus (1998) give seven definitions of economics – none of them connects to the earlier understanding of this discipline's subject matter, determinants of wealth. One definition comes somewhat near that earlier understanding, but is inspired by newer concerns and hastens to embed the issue into the framework of efficiency: 'economics looks at growth in developing countries, and proposes ways to encourage the efficient use of resources'.
6 That there are three angles to production has been alluded to also in the economic literature. Bon (1989) considers production as conscious and purposive intervention by men into the process where natural forces transform matter. Based on this general framework, he characterizes production first, as conversion: 'Viewed as a

physical phenomenon, human productive activity is only a conversion of matter into more advantageous forms.' He also views production as a flow: 'The ability to move matter is the key to harnessing natural forces for human purposes.' Third, he links production to mental processes towards understanding causal processes of nature: 'Our capacity for production depends on our intellect.' This can be understood as alluding to the mental processes required in value generation. Unfortunately in no case does Bon explicate a related conceptualization.

7 One example is provided by Frisch, discussed above.

8 In the sense of technical knowledge and its physical embodiments.

9 It has to be noted that it would have been easy to formulate economic problems on the basis of the insight that the nature and level of operations management is a major determinant of production. As Moskowitz (1993) has formulated, one problem is how an enterprise should allocate its resources among production activities and process improvement activities, given that the latter cost the firm because of loss of production and other costs. Another problem is the allocation of resources for new technology or process improvement.

10 This view goes back to Arisotle, who in Nichomachean Ethics famously says:

> We deliberate not about ends but about means. For a doctor does not deliberate whether he shall heal, nor an orator whether he shall persuade, nor a statesman whether he shall produce law and order, nor does any one else deliberate about his end. They assume the end and consider how and by what means it is to be attained; and if it seems to be produced by several means they consider by which it is most easily and best produced . . .

11 Aristotle continues (see the previous footnote), 'while if it is achieved by one only they consider how it will be achieved by this and by what means this will be achieved, till they come to the first cause, which in the order of discovery is last'.

12 The dominance of 'momentary production' is not rubbed by the fact that also dynamical production theories have been advanced. Frisch (1965) shortly discusses dynamical production theories in his book, with the following motivation:

> . . . a theory of time shaped production must be developed. This theory will prove of importance e.g. in production processes where work is carried out with large fixed capital plant, and where effective exploitation thereof depends on certain practical processes being correctly coordinated in time, e.g. that certain raw materials should be made available at the right moment, and that semi-finished products should be moved at the right speed (conveyor belt system), etc.

Another initiative towards a specific production theory is provided by Georgescu-Roegen (1970). He contends that the momentary view on production is wrong at the outset, and proposes a new form of production function that describes production over its duration. One motivation for him is to consider – similarly to Frisch – how to minimize the periods of idleness of production factors such as man, capital equipment and land.

13 Translation (by the author of this chapter): 'But there is a second complication. . . . Production requires a certain duration. We solve this second difficulty here by simply abstracting this duration away.'

14 Japanese word for waste.
15 In (Samuelson and Nordhaus 1998), the only exception to this assumption is at the macro level: lack of demand, etc., which compels firms to run under their capacity.
16 This is in contrast to what Robbins (1935) says in a footnote: ‘Of course the question whether the roof shall be of slate or tiles, for instance, may well depend on the relative prices of these materials and therefore have an economic aspect. Technique merely prescribes certain limits within which choice may operate’. Again, his argument is based on the assumption that the economic aspect can be isolated from the technical aspect.
17 Especially regarding the technical as mere data.

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6 Competition and barriers to entry in the construction industry

Gerard de Valence

INTRODUCTION

The importance of industry structure is based on the way that structure determines both the intensity of competition and the competitive strategies of firms in an industry. This is based on the structure–conduct–performance (SCP) approach to industry analysis that originated in the United States in the 1930s with the work of Mason (1939) and Bain (1959). Factors that SCP considers include the number and size of firms and type of product or products in a market and the extent of control firms have over prices. Related issues are the way the process of competition affects prices and profits, the ease of entry of new firms into an industry or frequency of exit of firms from an industry, the impact of demand shocks (i.e. the business cycle) and the effects of new technologies. To date there have been few applications of the SCP framework to construction; Fleming (1993) and Ive and Gruneberg (2000) are two examples.

The key factor in the dynamics of industry development over time is the effect of entry and exit to and from the industry. Entry into an industry is the process where firms decide to become participants, undertake the necessary preparation and investment, and then compete with established market players. Exits are those firms that decide to withdraw from the market due to lack of profits or prospects, get taken over or fail financially.

The difficulties faced by entrants, and potential entrants who might decide to enter at some point in the future, are known as barriers to entry and were first identified by Bain (1956). There are now a number of different approaches to this idea. Some are based on the mobility of resources (see Geroski *et al.* 1990), while Shepherd and Shepherd (2004: 192) list 13 external and nine internal sources of barriers. McAfee (2004) found seven distinct definitions of barriers to entry and divided them into those that are economic in nature and those that are 'antitrust' (the US name for competition policy). Some industries have high barriers to entry (automobiles, chemicals, supermarkets) some have low barriers to entry (restaurants, cleaning, many trades).

Although barriers to entry are clearly important there has to date been limited consideration of their role in the construction industry. Previous research by Ezulike *et al.* (1997), Gruneberg and Ive (2000), and de Valence (2003) showed that barriers do exist, and established that they play a role in the industry. However, that research did not go on to specifically address two basic questions about barriers to entry in construction: how do they operate, and what is their significance to the industry? This research builds on that earlier work and addresses those questions.

Although this discussion is about firms and their ability to enter (and exit) markets the theory of the firm and the determinants of competitiveness are not covered. These are important areas in their own right, with extensive literatures and a range of approaches to both the nature and functions of the firm (see Moran and Ghoshal 1996). The starting point for the analysis here is that firms exist and survive or fail in markets that can be differentiated by their structure (the number of competitors and their relationships, as described by Porter 1985). Development of the theory of the firm was surveyed by Kay (1991), and how these have led to changes in the way firm organisation and behaviour is analysed was the focus of Putterman and Kroszner (1996). Eisenhardt and Martin (2000) discuss how a firm's dynamic capabilities and competitiveness are a barrier to potential competitors.

The rest of the chapter is structured as follows. The next section defines the four market types found in microeconomics and their main characteristics, including the height of the barriers to entry found in each type. This is followed by a discussion on the question of product homogeneity in construction. Evidence for the existence and significance of barriers to entry in construction is found in concentration levels in the industry. Barriers to entry specific to construction are then identified, followed by a discussion on how they operate, which leads to an analysis of their significance (high, medium or low) in different market types. That analysis is the contribution this research makes to deepening our understanding of the construction industry.

MARKET TYPES AND MARKET STRUCTURE

In many construction or building economics texts the starting point for discussion of markets is the neoclassical model of perfect competition. For example, Warren (1993), Cooke (1996), Hillebrandt (2000), Runeson (2000), Gruneberg and Ive (2000), and Ive and Gruneberg (2000) all have chapters on markets in construction and all begin with the characteristics of perfect competition. In Warren and Cooke there is no linking of construction industry characteristics to these market types, and there is an emphasis on perfect competition. The characteristics of a perfectly competitive industry are many small firms with no control over price, producing the same product under conditions of perfect information and no barriers to entry (see Table 6.1). The other industry model found in neoclassical economics is the monopoly, where a single firm is the only producer.

Because many industries do not have these characteristics and fall between the extreme cases of perfect competition and monopoly the alternative models of monopolistic competition and oligopoly were developed. The 'monopolistic competition revolution' of the 1930s developed theories of imperfect competition based on the work of Chamberlin (1933) and Robinson (1933). Under monopolistic competition there are many small firms with limited control over price, producing differentiated products supported by brand names and marketing with some (often important) barriers to entry. Cooke (1996), Hillebrandt (2000), Runeson (2000), and Gruneberg and Ive (2000) all discuss monopolistic competition in construction markets.

A second monopolistic competition revolution occurred in the 1980s after Dixit and Stiglitz (1977) developed a formalised model of imperfect competition incorporating product diversity and consumer choice. The Dixit–Stiglitz model has been applied in international trade, growth theory and economic geography, and has led to renewed interest in issues associated with economies of scale, market power, information and uncertainty (the impact of Dixit–Stiglitz is reviewed in detail in the book by Brakman and Heijdra (2004: 2–3)).

The fourth market type is oligopoly. The key characteristics of an oligopoly are a few large (but not necessarily the same size) firms and the significant barriers to entry first identified by Bain (1956), discussed in detail below. The modern theory and definition of oligopolistic markets was developed in the 1950s (e.g. Modigliani 1958) 'as a result of two processes of economic change: the process of concentration (the market share of the largest four, six or eight firms) and the process of differentiation' (Sylos-Labini 1987: 701). Industries that became concentrated oligopolies produce homogenous product (steel, cement, basic chemicals, electricity), while differentiated oligopolies are found in consumer goods markets. Sylos-Labini describes industries that are concentrated but have differentiated products as mixed oligopoly, such as computers, automobiles, banking and insurance. Sylos-Labini's review found that barriers to entry can substitute the 'competitive mechanism' for distributing benefits of technical progress (falling prices, stable nominal incomes) by the 'oligopolistic mechanism' (stable prices, increasing nominal incomes). Income in this case includes both wages and salaries and profits, and both can became above-normal depending on industry price rigidity and levels of competition (Sylos-Labini 1987: 704).

Thus economics has a framework of four models of market structure, each one having a set of distinctive characteristics. Table 6.1 shows the relationship between the four models of market structures and the characteristics of each type. The extent of control over prices is determined by the intensity of competition in a market, which is determined by the number of firms and type of product. The degree of monopoly power exercised by the largest firms in an industry is the concentration ratio, the degree to which an industry is dominated by the largest firms. A monopoly has one producer, therefore the

Table 6.1 Market structures and characteristics

Characteristics	*Perfect competition*	*Monopolistic competition*	*Oligopoly*	*Monopoly*
Number of firms in market	Very large	Many	Few	One
Product	Identical, standardised	Differentiated	Identical or differentiated	Unique, no close substitutes
Barriers to entry	None	Few	Significant	Very high
Firm's control over price	None	Limited	Constrained	Considerable, often regulated
Non-price competition	None	Emphasis on brand names, trademarks	Through product differentiation	Use of PR and advertising
Concentration ratio	0	Low	High	100
Information and mobility	Full customer information and mobility	Limited customer information and mobility	Restricted customer information and mobility	No effective choice or alternative
Examples	Agriculture, dry cleaning, commodities	Household and electrical goods	Automobiles, chocolate bars, aircraft	Water, gas and electricity utilities, railways

Sources: Adapted from McTaggart, Findlay and Parkin (1999: 13.4) and Briscoe (1988: 101).

Note

Developments in regulation and deregulation of monopolistic industries with large network effects, such as utilities, communications and railways, have challenged the idea of these monopolies as unavoidable (Braeutigam 1989 on introduction of competition into markets where a natural monopoly exists, and for Australian government businesses in rail and water see PC 1999: 142–46).

concentration ratio is 100 per cent, while under perfect competition there are many firms, none of which has any market power and the concentration ratio is zero.

Although the significance of barriers to entry as one of the key factors in distinguishing between different market types has been recognised since Bain's (1956, 1959) pioneering research, there are different ideas on how barriers operate and a range of definitions used. McAfee *et al.* (2004) surveyed the history of the concept of barriers to entry and found seven 'principle definitions of an entry barrier' including the two fundamental definitions: Bain's 'advantage of established sellers in an industry' (1956) and Stigler's 'cost borne by firms seeking to enter … not borne by firms already in an industry' (1983). McAfee *et al.* then introduced another four definitions as a new classification of entry barriers: economic barriers (cost based); antitrust barriers (a cost that delays entry); primary barriers (operate on their own); and ancillary barriers (reinforce others). As a consequence of this diversity, Carlton (2004) argued that disagreement over definitions can lead to problems when applying the concept of barriers to entry in competition policy (antitrust in the United States) or regulatory determinations (as in decisions on mergers and acquisitions by the Australian Competition and Consumer Commission).

RUNESON ON CONSTRUCTION AS PERFECT COMPETITION

Is there an argument to be made that the building and construction industry is an example of a perfectly competitive industry? Fleming (1993: 190–193), for example, argues that the different forms of contractor selection reflect different forms of competition.[1] It seems obvious that, because construction uses the tendering system as the basis for price determination, a competitive tender that uses price as the winning factor must represent perfect competition. In fact, this is not the main argument found in the literature.

Runeson (2000: 138–139) examines the structure of the industry and the level of competition based on the idea that market structure determines conduct, which in turn determines performance. Three operational measures of competition are used. The first is number of firms in the industry, based on the ABS Construction Industry Survey of 1996-97, and finds the typical firm small with little expenditure on capital. Second is the concentration ratio, and the share of the largest building firms is found to be 'not sufficient to convey the impression of much market power'. Third is profit levels, with a rate of profit of 4.3 per cent of turnover, below most other industries, and a high proportion of business failures indicating a very competitive industry.

In summing up previous research on competition in markets for building, the conclusion was that firm behaviour is the determining factor:

> the large number of firms in typical markets, the ease of entry and exit, the perception of the participants of the market as being very competitive, the speed of adjustment of prices in response to changes in demand, and the low rate of profit all seem to indicate that whatever the actual situation really is, firms behave as if they were operating in a very competitive market where price is determined by the competition. That is all that is required for the markets to be defined as perfectly competitive.
>
> (Runeson 2000: 142)

Runeson suggests that there are three characteristics of the building industry (or the market for building management services) that need to be examined to apply a model of perfect competition. These are uniqueness of projects, competitive tendering where prices are determined before actual costs are known, and the size of individual projects is large relative to the capacity of the firm (Runeson 2000: 145–149).

After analysing the factors that affect price determination in the market for buildings, Runeson concludes that the

> most appropriate model is that of perfect competition. In most cases there is a low level of profit and the perception of a very competitive market, and as long as the participants perceive the market as competitive, they will act as if it is.
>
> (Runeson 2000: 170)

This is a strong argument, based on the behaviour of contractors. A different view is based on the role of barriers to entry. Perfect competition requires free entry (and exit); if this condition is not met then some other form of competition is found.

BARRIERS TO ENTRY

The key factor determining market structure that was identified by Bain (1956) was the effect of barriers to entry. These barriers protect a firm from competition and allow it to enjoy above-normal rates of return, so Bain's definition was entry conditions allowing for an elevated long-run price (i.e. $P >$ marginal cost). A particular market structure will remain concentrated if there are barriers to entry and exit. But where new firms can and do enter the industry, market structure can change over time in response to the effects of competition and concentration will be reduced (structure improved), firm efficiency will be increased (conduct improved) and monopolistic influences reduced (performance improved in terms of allocative efficiency). Bain (1956) explained barriers to entry in terms of four factors: economies of scale, product differentiation, absolute cost advantages, and large capital requirements.

1. Economies of scale give large firms advantages over smaller firms. When the economies of scale are considerable, firms need to be large in order to reap such benefits, and this enables one or a few firms to dominate the industry. When the low-cost domination of the industry by incumbent firms prevents new entrants, the structural concentration of incumbent firms is perpetuated.
2. Product differentiation exists when customers perceive that one branded product is sufficiently different from another as to have uniqueness. When customers become loyal to a branded product manufactured by a particular firm, then it becomes difficult for new firms manufacturing a similar product to enter the market, because the new entrants have to win over customers loyal to brands marketed by established firms.

3 Absolute cost advantages are a barrier to entry to the extent that existing firms have control over production inputs that cannot be cost-effectively substituted by potential new entrants. Such monopolisation of inputs can arise from a backward vertical integration that enables control over raw materials, such as happens in the Australian steel industry, as well as through control over skilled labour and management.

4 When large upfront capital investments are required for profitable entry into an industry, the investment risks involved are likely to deter new entrants. Baumol *et al.* (1986) identified conditions for 'freedom of entry'. Freedom of entry exists when the potential entrant suffers no cost disadvantage compared with the incumbents. Without sunk costs, assets are easily saleable or reusable, thus facilitating 'costless' entry and exit, and opening the market to 'hit-and-run' entry. Significant sunk costs can be a barrier to entry as well as exit. Barriers to entry give existing firms scope for monopolistic pricing, depending on the height of the barrier. Where this was possible, firms in that industry would use a limit price, which is a maximum entry-forestalling price, to make above-normal profits and yet impede the entry of new firms. When incumbent firms attract to their industry more, or fewer, resources than is economically optimal, it is evidence of allocative inefficiency. In such a situation resources in the economy would not be used as efficiently as possible, causing GDP to be smaller than it would otherwise be, with potential welfare benefits lost to the general community.

A major development based on Bain was the 'Five Forces' model of Porter (1980). This has been widely used, particularly in business strategy and management courses. The five forces work together to create the competitive environment for firms in an industry, and each factor or force can increase or decrease the competitive intensity. The five forces are: the bargaining power of suppliers; the bargaining power of clients or customers; the threat of new entrants to the industry/market; the threat of substitute products; and rivalry between existing firms. Porter also added two more significant barriers to entry to the four of Bain:

1 Access to distribution channels. The new entrant must secure distribution of the product or service. A new food product, for example, must displace others from the supermarket shelf via price breaks, promotions, intense selling efforts, or some other means. The more limited the wholesale or retail channels are, and the more that existing competitors have these tied up, obviously the tougher entry into the industry will become. Sometimes this barrier is so high that, to surmount it, a new contestant must create its own distribution channels, as Timex did in the watch industry in the 1950s.

2 Government policy. The government can limit or even foreclose entry to industries with such controls as license requirements and limits on

access to raw materials. Regulated industries like trucking, liquor retailing, and freight forwarding are noticeable examples; more subtle government restrictions operate in fields like ski-area development and coal mining. The government also can play a major indirect role by affecting entry barriers through controls such as air and water pollution standards and safety regulations.

PRODUCT HOMOGENEITY

Another approach to market structure is to base the distinction on product homogeneity (sameness) or heterogeneity (differentiation). Using this approach monopoly, homogeneous oligopoly and perfect competition are similar, with homogeneous products, and differentiated oligopoly and monopolistic competition are similar, with differentiated products (Scherer and Ross 1990: 17). The unit of analysis used by Scherer and Ross is the industry, not the market or the firm. This avoids the major problem found when trying to apply market models to particular industries. In the one-product perfect-competition market model the relationship between firms, industry and markets is relatively straightforward. Firms belonging to the same industry produce a single identical product, which they all sell in the same market. In this framework the industry and the market are identical because each has the same group of firms as producers. However, this identity does not exist where firms are large and produce a range of products, many of which are not close substitutes, and sell in more than one market.

In construction there are two views on this. On the one hand, the industry produces buildings of many different types (residential, commercial, industrial etc.), on the other it manages the process of building. In answer to the question 'Can the standard concept of a homogeneous product be applied to construction?' Gruneberg and Ive suggest that 'In construction, product markets can be seen as sets of projects, clients and producers' (2000: 106). Also, there are no 'clear product markets' or 'a tendency towards homogeneity within product markets or a single product market unit price' (Gruneberg and Ive 2000: 107). Runeson (2000) and other researchers' answer to this is that the industry is the market for building management services, not for products called buildings (Hillbrandt (2000) has a similar view). The Gruneberg and Ive model is therefore distinctive, in that it sees construction output as a product rather than a service. Services are clearly homogeneous, while products can be differentiated. There is some agreement with Gruneberg and Ive from those who classify markets by statistical data collections based on building types (for example, Shutt 1995 and Briscoe 1988).

In this chapter the approach taken uses the distinction between homogeneous and differentiated products based on the ability of contractors to specialise in specific markets or types of projects (see de Valence 2003). Ezulike *et al.* (1997) also found that significant barriers to entry existed for

Private Finance Initiative (PFI) projects in Scotland and some large contractors were specialising in these projects.

CONCENTRATION IN CONSTRUCTION

The construction industry is predominantly made up of small firms, so the typical analysis based on the number of firms and extent market power reveals a fragmented, diverse industry of small firms with low barriers to entry (Fleming 1993). This supports the view of the industry as being an industry with the characteristics of perfect competition (Runeson 2000). However, here is also evidence that the largest firms in the industry in many countries account for a significant share of industry turnover.

Studies on the market share of the largest contractors for different countries include Australia (de Valence 2003), South Korea (Yoon and Kang 2003), Japan (Woodall 1996) and Hong Kong (Chiang *et al.* 2001). These all found significant concentration at varying ratios, with the largest firms accounting for up to 70 per cent of industry turnover.

In one of the few studies that specifically addressed industry structure, McCloughan (2004) analysed trends in concentration in the British construction industry at three levels. First, aggregate concentration is low in the British construction industry with the largest 100 private contractors accounting for 20 per cent of activity and 15 per cent of employment. This share has been declining since 1971, when these values were 29 and 25 per cent respectively, with wide annual fluctuations. Second, the five-firm concentration ratio (C5) is estimated for what McCloughan (following the statistical categories) calls the 'main trades'. For 1998 these estimates are general builders at around 10 per cent, building and civil engineering contractors around 20 per cent and civil engineers 15 per cent. He concludes that 'in the context of a national geographic market, the main construction trades are fragmented (i.e. low concentrated) markets' (2004: 986).

Third, McCloughan divided specialist trades into a labour-intensive, low-capital, easy-to-enter category (including plumbers, plasterers, carpenters and painters) that deals mainly with private customers, and a second group of more concentrated trades that work for commercial and government clients. The trades and C5 estimates in the concentrated category were: scaffolding specialists 56 per cent; asphalt and tar sprayers 40 per cent; constructional engineers 36 per cent; insulation specialists 39 per cent; and demolition specialists 31 per cent. McCloughan suggests that 'If regional size distribution data become available, it is not unlikely that some or all such specialist trades … would register as highly concentrated (C5 >70%)' (2004: 987).

Data from the annual *Construction 100*: *Australia's 100 largest commercial contractors* compiled by HIA-Reed Construction Data (latest 2004–05) gives the market share of the top 10 and top 20 contractors, shown in Figure 6.1. Although the levels vary from year to year, these firms typically

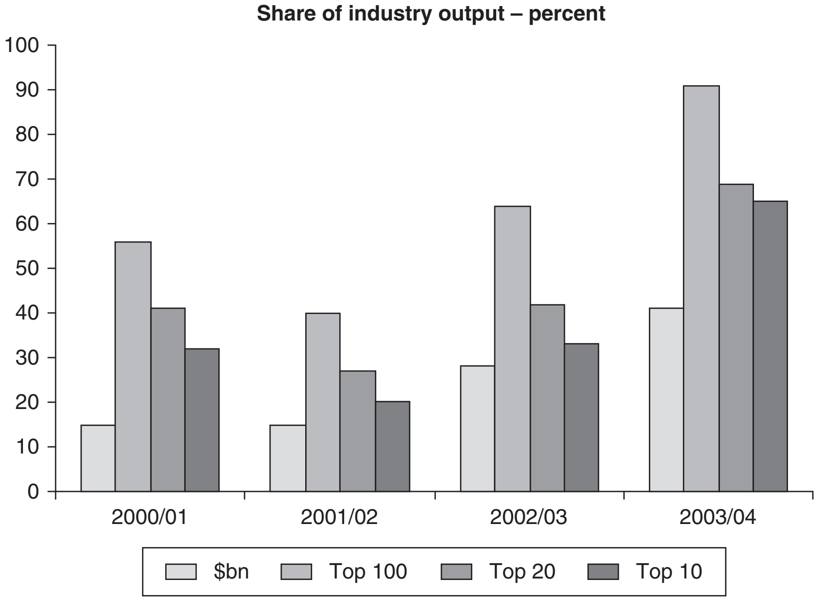

Figure 6.1 Australian construction industry output and turnover of largest firms.

Source: *Construction 100: Australia's 100 largest commercial contractors*, HIA-Reed Construction Data, various years.

account for 30–50 per cent or more of industry turnover. These figures support earlier data from the Australian Contractors Association (ACA), which represents the largest contractors. The 1997–98 *Annual Report* of the ACA gave total turnover of the then 18 members as over $15 billion, or over half total non-residential construction for that year, and employment of over 49,000 (ACA 1998). The 2001 *Annual Report* stated 'members account for around 40% of total construction activity in Australia' (ACA 2001: 24).

If concentration levels like these are found in an industry there must be barriers to entry that help create and preserve them. What these barriers are and how they operate are covered in the next sections of the chapter.

WHAT ARE THE BARRIERS IN CONSTRUCTION?

Ezulike *et al.*'s (1997) study of contractors in the PFI market identified six barriers to entry: lack of appropriate skills; high participation costs; high project values; high risk; lack of credibility and contacts; and demands on management time. The most prominent barrier was incurred costs in bidding and fees paid to financial and legal consultants. Their findings suggested the larger contractors were more able to overcome these barriers and compete in the PFI market, and this leads to a 'two-tier' market where smaller contractors are unable to compete. Although interesting, this study covered limited ground and it is hard to generalise the results, beyond saying that these barriers would apply to many or most large projects in some form and are not unique to PFI projects.

There were six barriers to entry identified by Gruneberg and Ive (2000: 97–101), one of which was unique to construction. The first five barriers to entry are economies of scale, supply chains, incumbent cost advantages, private information (including client relationships), and contestable markets (no sunk costs). These barriers are treated more or less conventionally, albeit with the emphasis on construction firms and markets. The unique barrier is 'client imposed barriers to entry to contract construction markets', based on a view of contractor growth as a series of steps of increasing project size and complexity. If clients shortlist tenderers with experience on similar projects this becomes 'one major limit on the growth rate of construction firms'. Two ways around this barrier are identified: first, clients having different 'project size bands' allows contractors to take advantage of overlaps between them; second, for projects requiring innovation past experience will not be so important and clients may consider firms 'on the basis of the strength of their ideas or methods' (Gruneberg and Ive 2000: 100–101).

The six barriers specific to the construction industry discussed by de Valence (2003) were: the cost of investment necessary to become a participant, ranging from very low (the building industry) to very high (starting an airline, for example); the market power of incumbents; acquisition of the technology, skills and workforce needed; access to equity and debt finance; the state of the market, or the growth rate in and level of demand; and the intensity of competition and margins available. That study found:

> When the building industry is assessed in terms of barriers to entry it is clear that there are two levels in operation. There are currently few significant barriers to entry to the building industry for small firms, and such barriers will continue to be low while the industry maintains current practices based on a large number of small, specialised subcontractors. There are, however, a limited number of contractors capable of managing large projects, and the barriers to entry at this level in the form of prequalification are significant, based on track record, financial capacity and technical capability.
>
> (de Valence 2003: 5)

The conclusion was that specific sectors in the construction industry have the characteristics of an oligopoly. The oligopolistic characteristics of the large contractors in the industry have tended to be overlooked because of the numerical dominance of small firms, which typically operate under conditions of perfect competition. There are significant barriers to entry through client prequalification requirements for technical capability, track record and financial capacity in engineering construction and non-residential, and some specialist trades have few firms capable of taking on large projects. There are only three major manufacturers that supply lifts and building automation systems (BAS), and these are often done as supply and fit subcontracts by the manufacturers. Also, some of the materials and equipment suppliers are highly concentrated, and have been subject to actions by competition authorities in many countries.

Interestingly there is not much overlap between the two approaches cited here. Two of Gruneberg and Ive's barriers, incumbent cost advantages and private information (including client relationships), are collapsed into market power of incumbents by de Valence. Both thus agree on the importance of client procurement processes, but discuss different other barriers. A combination of the two approaches gives a dozen significant barriers to entry operating in construction markets. How do these affect competition?

HOW DO BARRIERS OPERATE?

When the building industry is assessed in terms of barriers to entry it is clear that there are two levels in operation. There are currently few significant barriers to entry to the building industry for small firms, and such barriers will continue to be low while the industry maintains current practices based on a large number of small, specialised subcontractors. There is, however, a limited number of contractors capable of managing large projects, and the barriers to entry at this level in the form of prequalification are significant, based on track record, financial capacity and technical capability. Due to the risk characteristics of large projects a contractor has to have demonstrated the ability to manage and coordinate such works. Because there are only a few large contractors capable of undertaking major projects they tend to develop strong links with these clients, and these relationships are a significant barrier to entry to the types of projects carried out for such clients for other contractors. As prequalification becomes more rigorous and widespread in the industry, this is emerging as the most important barrier to entry.

Monopolistic competition is the market type that covers many of the medium-size firms in the construction industry. The more capital-intensive subcontractors are in trades like excavation and demolition, and heating, ventilation and air conditioning (HVAC). The HVAC part of the industry in Australia has two very large firms (more or less national in scope), a few large firms, and a few dozen smaller firms working in local markets. Medium-size builders that have specialised in particular types of buildings and/or have developed relationships with repeat clients are also in this category.

The parts of the industry that fit the perfect competition model are the small and medium-size contractors that rely on low-bid tendering to get work, and labour-based subcontractors, such as those in formwork, steel fixing, bricklaying and concreting. These firms compete solely on the basis of price.

Table 6.2 Construction industry firms by market type

Construction	*Perfect competition*	*Monopolistic competition*	*Oligopoly*
Subcontractors	Labour-based subcontracting	Mechanical services (HVAC), demolition	Lifts, building automation
Contractors	Many small and medium-sized contractors	Some medium-sized contractors	Large head contractors

The degree of monopoly power exercised by the largest firms in an industry is expressed in the concentration ratio, which typically uses the largest four firms in an industry, ranked by market share or sales as a percentage of total industry sales (other measures are capacity, output, employment or value added) accounted for by the largest firms. The large contractors in the engineering construction and non-residential building sectors have the characteristics of an oligopoly. There are significant barriers to entry through client prequalification requirements for technical capability, track record and financial capacity.

Two subcontracting sectors are also highly concentrated (although these are not subcontractors in the same sense as plumbers or mechanical services). There are only three major manufacturers that supply lifts and BAS, respectively.

SIGNIFICANCE OF BARRIERS

Generally, labour-intensive subcontractors and small contractors can be assumed to operate under perfect competition and are therefore not included in this analysis (i.e. these firms compete on price and offer identical products). Following the division of subcontractors and contractors shown in Table 6.1 above, the breakdown of barriers across the three market types is applied to both in Table 6.2.

In Table 6.3 the first six barriers to entry are from Gruneberg and Ive (2000), the second six are from de Valence (2003). Research and development is found as a barrier in many analyses (see Scherer and Ross 1990) and has been added. The two market types of monopolistic competition and oligopoly are divided into those with homogeneous and those with differentiated products. For each of these market types the significance of entry barriers is identified. In these types of markets, barriers would be expected to be medium or high, and this is shown in the table. The exception is contestability, which is not a characteristic here because there will always be some sunk costs associated with entry; at the minimum these would be bidding costs for the first project.

Capital-intensive subcontractors and medium-sized contractors will typically be in monopolistic competition, and could have either homogeneous or differentiated products, depending on the specific sector they are in and

Table 6.3 Importance of barriers to entry

Barriers to entry	*Monopolistic competition*		*Oligopoly*	
	H	*D*	*H*	*D*
Economies of scale	Low	Medium	Medium	High
Supply chains	Medium	Medium–high	Medium	Medium–high
Incumbent cost advantages	Medium	High	High	High
Private information	Medium	High	High	High
Contestable markets	No	No	No	No
Client-imposed barriers	Medium	High	Medium	High
Cost of investment for entry	Medium	Medium–high	High	High
Market power of incumbents	Medium	High	High	High
Acquisition of technology, skills	Medium	Medium–high	Medium	
Access to capital	Medium	Medium	High	High
State of the market	High	High	High	High
Intensity of competition	Medium	High	High	High
Research & development	Low	High	Medium	High

Note
H = homogeneous; D = differentiated product type.

clients they work for. The type of project and procurement method determines whether large contractors are in a homogeneous or a differentiated market, and subcontractors that have significant R&D, capital intensity and strong client relationships are in a differentiated monopoly.

CONCLUSION

This chapter has surveyed the literature on an important economic characteristic of markets as they apply to the construction industry. The purpose was to assess the role of barriers to entry in the industry. From previous research, both Gruneberg and Ive's six barriers and the six used by de Valence were included in the analysis. Both of these previous studies agreed on the importance of client procurement processes in allowing access to projects for contractors. A combination of the two approaches gave a dozen significant barriers to entry operating in construction markets.

The importance of these barriers depends on the specific market structure, with the two market types of monopolistic competition and oligopoly being divided into homogeneous and differentiated products. For each of these market types the significance of entry barriers was identified, with the barrier being low, medium or high for new entrants. What is apparent in this analysis is that markets with differentiated products generally have higher barriers to entry than those with homogeneous products, and the latter are more capital-intensive than the former.

Viewing the construction industry as predominantly made up of small firms supports the view of the industry as being an industry with the characteristics of perfect competition. However, this is also an industry with a small number of large contractors and some evidence of concentration. At this level the industry has barriers to entry due to the prequalification systems and capability requirements used by clients to select contractors for major projects. Oligopolistic competition focuses on competition through product differentiation, or in the case of building and construction through specialisation in particular types of projects (e.g. bridges, high-rise), forms of procurement (e.g. design and build, negotiated work), finance and PFI-type projects, or relationships with clients (such as alliancing or partnering). Suppliers of lifts and building automation systems are also in this type of market because there are only three major manufacturers of these products.

Between these two market structures there are some firms in the industry that are in monopolistic competition. Those medium-size contractors that have specialised and differentiated their product from others, or have developed ongoing relationships with clients (and thus get a large amount of negotiated work), have clearly broken out of the price-driven competition end of the business. Also, there are subcontractors in the HVAC sector that have developed the characteristics of monopolistic competition.

This breakdown of barriers to entry in construction markets is considerably more detailed than others previously available. The next step would be to allocate these barriers to specific projects, trades and contractor types. From this a standard analysis of competitive behaviour can then be followed when analysing construction firms.

NOTE

1 Fleming is the only author discussed here to raise the issue of collusive tendering where selective tendering is used (1993: 192).

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7 Comparing construction costs between countries

Rick Best

INTRODUCTION

The need to compare construction costs[1] across national boundaries arises in all manner of studies that compare industry productivity and/or performance, in pure pricing studies, and in the production of purchasing power parities (PPPs) as part of exercises such as the International Comparison Program (ICP) run by the World Bank. Money market exchange rates are acknowledged to be an unsuitable means for converting costs to a common base as they reflect changes in the money market but not the value of construction (e.g. Blake *et al.* 2004; Pilat 1996; Vermande and van Mulligen 1999); indeed the whole philosophy behind PPPs is based on the notion of comparing *value* while excluding differences in *price* (Schreyer and Koechlin 2002; Pakko and Pollard 1996; Vachris and Thomas 1999).

ARE COMPARISONS NECESSARY?

Comparisons of performance are common in all forms of endeavour, whether it is in sport or business or any other sort of pursuit. In business the practice of benchmarking performance has become commonplace with 'best practice' being identified and the performance of individual business units being compared regularly. The construction industry in the United Kingdom, for example, now works with an established set of key performance indicators (KPIs) that are intended to support programmes of continuous improvement with an ultimate goal of improvements in industry performance across the board, in areas including reliability of cost and time estimates, adherence to budget, and so on.

Cost performance, particularly in terms of the overall cost to construct, is an obvious comparator, and many studies have been done that compare construction costs in the hope of identifying areas of better (if not best) practice and to highlight projects that have been completed more cost-effectively than others. Such comparisons are difficult even within a single national market due to the nature of the industry and its products. When international comparisons are attempted, the problem of converting costs to a common currency base is added and the problem becomes a great deal more difficult. However difficult it may be, there are a variety of stakeholders in the construction industry who are interested in various sorts of comparisons that include cost in their parameters – indeed few comparative studies do not have cost as part of the equation, and many are based on cost alone. Governments and their agencies, construction companies, and multinational businesses are some of those stakeholders, and the fact that they routinely commission or carry out these comparisons means that there is a need for reliable methods. When international comparisons are attempted then the issue of cost conversion to allow direct comparisons becomes crucial more or less regardless of the method of comparison that is adopted.

WHY ARE CONVERSION FACTORS NEEDED?

Clearly it is not feasible to compare costs unless they are in the same currency. As a mechanism for bringing costs to a common base, exchange rates are too volatile and too much affected by a range of factors such as interest rates and changes of government. PPPs are routinely produced by several agencies but these are intended for use at the level of national economies and GDP and are a dubious tool for comparisons at the level of individual industries. Construction PPPs (CPPPs) form part of the general PPPs, and are published as industry-specific indices, but there is much scepticism regarding their accuracy. The distrust of CPPPs stems from several factors that are a product of the method currently employed to gather construction cost data. That system is based on the standard project model and the criticisms of the method are many and varied; however, one factor is paramount and that is the problem of obtaining purchaser prices for work items that truly represent actual out-turn prices. Generally the standard projects are priced by just one person or agency in each country in each pricing round, and such rounds only occur every 3–5 years. Once again, however, the need is there as these comparisons are made and the results used to inform governments and others, therefore conversion factors of some sort are required. For a variety of good reasons the current method is not accepted as being reliable and some other method, or combination of methods is needed.

PURCHASING POWER PARITY

Although the notion of PPP can be traced as far back as the sixteenth century (Dornbusch 1987; Gunther 2002) the theory does not have universal support (Lafrance and Schembri 2002), and many authors, while accepting the general theory, place various caveats and cautions on their application, particularly in respect of their use in industry specific comparisons (Goodchild and Griffiths 2004; Danish Agency for Trade and Industry 2000; Stapel 2002, 2004).

PPPs are based on the so-called Law of One Price. The basis of this is the notion that the cost of a good or service (or a basket of goods and services), once prices are converted to a common currency, should cost the same in different countries (Rogoff 1996). For some commodities that are traded often, such as gold, the law of one price holds well. It does not hold for construction output (Vermande and van Mulligen 1999) as built facilities are not tradeable[2] (Schreyer and Koechlin 2002), and are produced and consumed locally. Vermande and van Mulligen go on to explain that a large proportion of the cost of a building is made up of labour costs and basic materials such as bricks, sand and concrete. These are mostly produced locally rather than imported and therefore their costs are little affected by exchange rates. It is suggested, however, that for construction 'appropriate expenditure PPPs can be used to convert real output to a common currency' as construction prices are not much affected by trade and transport costs (Pilat 1996: 7). It is generally accepted that sector- or industry-specific PPPs are required if valid conversions are to be made (Stapel 2002; Pilat 1996) but there is considerable concern about the reliability of existing CPPPs (Ive *et al.* 2004; Vermande and van Mulligen 1999), and the derivation of a method for producing reliable CPPPs is the subject of ongoing debate.

THE IMPORTANCE OF COST CONVERSION IN COMPARISONS

The results of many comparative studies that have been published over the past 20 years can be shown to change dramatically when challenged through the application of other conversion strategies to the cost data on which they are based. Best and Langston (2006a, b) revisited studies published over the period 1986–2002 and showed that the use of inappropriate or incorrect conversion methods (most notably the use of money market exchange rates) in most cases produced results that were significantly different to those obtained when other approaches were used. While it is acknowledged that the alternative methods, such as published CPPPs, may also be less than perfect, it is the variability of results that is the issue, and it is this variability that highlights the need for more dependable conversion factors.

SOURCES OF PURCHASING POWER PARITIES

The World Bank publishes PPPs on (roughly) a 3-year cycle as part of the ICP, which was started in 1967, sponsored by the United Nations. OECD-Eurostat PPPs represent a regional subset of the ICP and are somewhat more detailed. The Union Bank of Switzerland (UBS) has also been producing PPP data since 1970, based on a basket of goods and services. Of these only the OCED routinely publishes sector-specific PPPs that include CPPPs.

The OCED-Eurostat has generally used a standard projects approach to the production of CPPPs. The OECD's 1996 comparison (at GDP level) used a list of around 4000 items including consumer goods and services, pharmaceutical products, capital goods, motor vehicles, government services, health and education services, and twenty construction projects (Walsh and Sawhney 2002). Construction prices were gathered by having comprehensive bills of quantities (BQs) priced by estimators in participating countries. This system has been under review for some years not only because there are serious doubts about the reliability of results but because of the level of effort and resources required to gather the data (Dubner and McKenzie 2002; Stapel 2002; Ward 2003). In the Eurostat programme the amount of data collected for construction has been reduced by around 50 per cent in recent rounds. Fewer projects are being priced and the BQs for those projects that are priced have been abbreviated.

THE BIG MAC™ INDEX

The Law of One Price, which provides the foundation for the doctrine of PPPs has been applied in a very simple way since the 1980s in the formulation of the Big Mac Index (BMI). In 1986 *The Economist* magazine first published, somewhat light-heartedly, a comparative index based on a single, tightly specified manufactured commodity, the Big Mac hamburger (Pakko and Pollard 1996).

The idea is simple: the Big Mac is offered for sale, with virtually identical specifications, in around 120 countries. By assuming that the value of this commodity must be equal in all countries, as it is an identical product, it was argued that the cost of a Big Mac in any country could provide a measure of the relative value of various currencies, and so reflected the purchasing power of a unit of currency in each country. For example, if a Big Mac cost, on average, AUD2.50 in Australia, and USD2.00 in the United States, then the exchange rate should be AUD1.00 = USD0.80. If the exchange rate was below USD0.80 then the Australian currency was considered to be undervalued, and vice versa. It was further argued that an exchange rate based on the 'hamburger standard' would be far less sensitive to the short-term fluctuations that characterise open currency markets.

The idea has been expanded in various ways. Gunther (2002) suggests a 'Braten[3] index', based on a simple meal of meat with vegetables, as a means of assessing the purchasing power of people in Europe in the eighteenth century. *The Economist* (2004) compared the costs of a Big Mac in a number of countries with the cost of another standard food item: a 'tall latte' as sold in over 30 countries by the Starbucks coffee company. While they concluded that for 'most main currencies' the two indices gave broadly similar results, in Asia the two measures differed markedly. For example, the Japanese yen appears undervalued by around 12 per cent using the hamburger index, but overvalued by 13 per cent based on the 'coffee standard'.

In essence the Big Mac approach assumes that a single commodity is as representative of domestic consumption as the extensive basket of goods and services used in sophisticated PPP exercises such as the ICP. Pakko and Pollard (2003: 22) suggest that the 'simple collection of items ... does just as well (or just as poorly) at demonstrating the principles and pitfalls of PPP as do more sophisticated measures'.

One researcher, Li Lian Ong from the IMF, has tested the index over a number of years. She concludes (Ong 2002: 23) that the notion of PPP 'as a theory of exchange rate determination is probably the most useful and used of all exchange rate theories, despite its many detractors', and (at 29) notes that empirical tests, utilising the BMI to track exchange rate movements have been 'surprisingly successful'. She concurs with Pakko and Pollard (at 111), saying that, based on her research, the hamburger index is as reliable as 'most other measures of purchasing power parity'.

APPLYING 'BURGERNOMICS' TO CONSTRUCTION

The BMI has been applied in a construction context in only two previous studies (Langston and de Valence 1999; Langston and Best 2000). Croce *et al.* (1999) were scathing in their attack on the use of the Big Mac in the Langston and de Valence study, saying that

> it should be obvious that countries where food production is not based on wheat, sesame seeds, beef, dairy products, dill pickles and potatoes[4] and where a Big Mac is a luxury item, available only in major cities to urban elites mimicking Western tastes, rather than a fast food staple, is not any sort of a 'standard commodity'.
>
> (Croce *et al.* 1999: 21)

As discussed above, there is some support for the index in the literature. It is possible, however, that Croce *et al.* were strong in their criticism of the Langston and de Valence report as it did not present a favourable picture of the Australian industry's position, while their own study, commissioned by three construction industry trade unions with an obvious interest in a favourable result, concluded that in the international context, productivity in the Australian construction sector was very high. As their analysis utilised money market exchange rates to convert costs, their conclusions can be largely disregarded. Langston and Best (2000) converted the costs of 78 completed high-rise office buildings constructed in 12 countries and used, *inter alia*, the BMI to normalise costs; they did this by dividing the construction cost of each project by the cost of a Big Mac (both in local currency) to calculate 'hamburger equivalents', i.e. the number of hamburgers that was equal to the cost of the completed project. By comparing hamburger equivalents, construction costs were compared in real terms. In a more recent study, however, Langston and Best (2005) showed that the BMI did not produce consistent results when statistical analysis was applied to a number of types of construction costs in ten international locations.

More recently the Building Cost Information Service (BCIS 2006) included an affordability index in their comparison of Asian construction costs; in this instance, costs per square metre for various building types in each country were divided by the local cost of one litre of unleaded petrol, so costs could be expressed as a number of litres of petrol. This method is very similar to the Big Mac approach used by Langston and de Valence; however, the appropriateness of the standard commodity selected as a basis for cost comparisons is debatable, as in most locations the petrol will be produced entirely from imported raw material (petroleum) and differences in petrol excise may distort results. It should be noted though that the BCIS call it an index of *affordability* and it is only intended for use as a secondary indicator without any claims being made about its validity as a conversion tool in comparative studies.

THE STANDARD COMMODITY

Use of the BMI as a conversion tool implies that the standard commodity is representative of some much larger basket of goods and services that is characteristic of all consumption in all locations. If used in a construction context then equally it is implied that the combination of materials (bun, meat, pickles, etc.) and labour and other inputs (such as rent, transport and cleaning) embodied in the hamburger is representative of the consumption of inputs in construction.

The commonly described methods for deriving CPPPs are all based on some form of standard commodity, although they are composite commodities in most cases just as the Big Mac is a composite of both physical items (e.g. bun, lettuce) and intangibles (e.g. rent and labour). Meikle (2003) summarised four recognised methods of gathering data for the derivation of CPPPs:

- *Standard projects:* BQs are priced for a number of typical projects, each of which is, in effect, a standard commodity composed of many work items that include all or most of the typical components of construction cost, viz. labour, plant, materials, profit and overheads. The set of projects could be called a basket of projects, and that basket a large standard commodity.
- *Basket of goods and services (BOG):* a set of items to be priced that comprises typical building materials and categories of labour. The size of the basket is variable but it is generally kept relatively small to contain the cost of obtaining prices and/or to allow for more frequent pricing and pricing by more people in more places in each country. This basket is again a type of standard commodity but not as coherent a product as either a complete building or a hamburger.
- *Basket of construction components (BOCC):* this is similar to the BOG except that the constituents of the basket are assemblies or components

(such as pad footings, or cement render of a specified thickness to walls). The major difference is that in this case labour, materials and other factors are included in the cost of the individual components. Once again the basket represents a sort of standard commodity.
- *Single project estimates:* similar to the standard projects approach but on a reduced scale.

Dubner and McKenzie (2002) also identified a range of alternative approaches and compared them to the current OECD BQ-based standard projects approach:

- *Factor costs:* similar to the BOG, comprising a weighted index of the costs of factor inputs, usually labour, materials and plant.
- *Component costs:* similar to the BOCC.
- *Quoted prices:* similar to the single project estimate.
- *Schedule of prices:* similar to the component costs approach but based on rates for actual projects.
- *Matched models:* a simple model based on cost per square metre rates for functionally similar buildings.

In all cases, however, a representative sample is used to produce conversion factors for the whole industry, and these in turn contribute to aggregated PPPs for whole economies (GDP PPPs). In the calculation of CPPPs, data has most recently been gathered under three general headings: residential construction, non-residential construction and civil engineering construction. The proportions of total construction expenditure in different countries in respect of these three categories varies considerably (DLC 2003) as do the expenditure shares of various constituents in any BOG or BOCC. These variable shares must be accounted for in any aggregation of lower level costs to composite PPPs, whether at sectoral or national levels.

COMPARABILITY AND REPRESENTATIVENESS

The point is always made in discussions of comparing costs that the two key characteristics are comparability and representativeness of the costs that are being compared. This may be applied to the basket of goods or standard projects or the hamburger and the costs that are associated with them. The aim is to find commodities (including services) that are as similar as possible so that they can be directly compared (the typical 'apples and apples' concern) and that they are reasonably representative of normal consumption in the location where they are being priced. This problem is by no means unique to the construction sector although the problems are exacerbated in construction as the output of the sector is recognised as being one of the most heterogeneous with most buildings being bespoke, one-off creations and therefore it is always difficult to find buildings even within one country that are truly comparable. The problem is well illustrated by Castles (1995) who noted that in data gathered for the formulation of OECD PPPs of 81 petrol-engined cars priced only five had a capacity of more than 2 litres and none was representative of the most common cars bought in Australia (which were locally produced models of over 3-litre capacity).

At that time, local variants were introduced into the Eurostat programme to make the generic BQs for the standard projects more representative of local practice. Typical variants were insulation thicknesses and cladding to external walls; obviously in Europe quite extreme variations in such components would be expected due to climatic differences. The standard projects include a Nordic house and a Portuguese house that are intended to be representative of such variations at the project level. The inclusion of variants does, however, produce its own problems with DLC (2003) showing very significant cost differences between the standard specification and variants. Ward (2003) warns against taking flexibility in these exercises too far so that all comparability is lost with items of quite different quality being priced in different places.

SELECTING AN APPROPRIATE METHOD

From their analyses Meikle, and Dubner and McKenzie, draw slightly different conclusions. Meikle sees many advantages in the national weighted basket of goods and few disadvantages, while Dubner and McKenzie (2002) suggest that the traditional BQ approach may be best for 'delivering comparable prices ... for a small group of countries', but concede that for larger groups of countries problems are likely to arise due to 'misinterpretation, misreporting and poor quality data' (para. 72). They then note that both the factor cost and component methods may have no worse problems or limitations than the BQ method and have the advantage of being less resource intensive. The cost of implementing any method across many countries is always relevant, as one of the real limitations with the BQ method is that the sheer scale of the pricing exercise in each country has generally limited pricing to a single point in each country, with pricing rounds only occurring about every 3 years.

While Meikle favours the weighted basket of goods he does note that this method has some drawbacks:

- Input prices do not include contractors' margins and therefore do not reflect actual prices paid for construction work.
- It does not provide sectoral level price indicators.[5]
- It is considered simplistic and has been dismissed as unsuitable in the past.
- Input/output tables used to weight items in the basket are not always available or up to date.[6]

Dubner and McKenzie suggest that while margins need to be estimated, this could be done by means of a survey, and they point to many other advantages that may outweigh this concern. Stapel (2002) is one who believes that the method is too simple, and cites problems with differences in labour productivity between countries that are not accounted for by this method. Walsh and Sawhney agree on this. Meikle (2003), however, specifically notes as one of the perceived advantages that it is 'possible to account for labour productivity differences', presumably by variations in the labour/material mix and this appears to have been addressed in the initial Eurostat exercise described below. For this to effectively address the problem, however, labour/material ratios are needed for each location included in any pricing exercise. Indeed, if figures are to be established for the three categories of construction then labour/material ratios are required for each category in each location. Such data may be difficult to obtain but could be derived by using first principles estimating and referring to published labour constants. The civil engineering sector would, however, present some very real challenges given the very broad range of project types and sizes included in that category. To a lesser degree, differences in the labour/materials mix could be expected between small, medium and large building projects.

Walsh and Sawhney favour the BOCC approach and developed this extensively over a number of years in preparation for its introduction as a replacement for the standard projects approach in the round of the ICP. They contend that the component level provides the best balance between accuracy and level of effort required. Meikle (2002, 2004) suggests that this approach is flawed as the pricing of the BOCC lacks context (e.g. scale, location, site conditions, access). It can be argued, however, that the perceived lack of context does not necessarily invalidate the concept, as most of these concerns can be shown to be of relatively little consequence. The fact that the best estimates routinely vary by as much as ±10 per cent when compared to out-turn costs, supports this view as the sort of cost differences that arise through contextual variations are likely to be insignificant within such an estimate band.

Stapel (2002: 5) suggests that 'the principal determinants of price level [in construction] are probably scale, complexity and location rather than the type of work'. Meikle (2002: 2) is quite definite about it. A two-stage study completed in Australia in 1999 (Page Kirkland 1999; Langston and de Valence 1999) supports the view that the type of project has little impact on cost differentials. Based on that research Langston and Best (2000) limited their study to a single building type (high-rise commercial offices) as this was considered to be the most 'generic' building type common to all the countries in their study.

It could be argued that even with the use of detailed BQs the issue of scale may not be addressed. Meikle (2002) shows that the projects currently priced in the Eurostat/OECD programme do not properly represent the typical mix of projects (with regard to scale) usually built. He demonstrates, for instance, that the hypothetical projects priced in the UK are generally unrepresentative of the size range of projects actually constructed. Furthermore it is doubtful that an estimator, producing an estimate for a 'phantom project', would apply a level of care that would include pricing differently for projects of varying scale. There is also no incentive to price as low as possible in order to win the job, and the estimators can be sure that their companies will not have to build to their estimated cost.

Location (geographically speaking) can be addressed as it is now, by asking estimators to give national average prices, or by having estimates produced in several locations within a country. This could be done regardless of whether it is a basket of goods, a basket of components or a set of standard projects that is being priced. As mentioned earlier, some move in this direction was incorporated into the BOCC pilot being run under the ICP. Location (within projects, i.e. ground floor, 10th floor, 50th floor) has some impact on prices but it is common practice for many levels of multistorey projects to be measured and priced together, particularly in countries such as Australia where there has been a definite move towards 'concise' BQs. Hoisting and scaffolding costs will affect unit rates for work at elevation but given that labour and materials generally make up the greater proportion of unit rates, and if prices gathered are estimates of national averages, price distortions due to the inclusion or exclusion of within-project location in pricing exercises would be unlikely to vary beyond the normal limits of estimating accuracy. If overheads are spread within prices then fixed crane and hoist charges are likely to be embedded in unit rates anyway.

Stapel's third determinant, complexity, is more difficult to accommodate but as it is 'average' prices that are generally sought, the effects of complexity of construction on some projects can arguably be discounted. Once again it is unlikely that estimates will vary beyond normally accepted limits of estimating accuracy.

If context is indeed a problem with the BOCC method then it is likely to be even more of a concern in a BOG approach. While scale may be addressed by asking for prices for differing quantities of the same item (e.g. 100 m^3, 10,000 m^3, 100,000 m^3 of excavation in rock), location and complexity would appear to be impossible to deal without providing very detailed contextual information with every item in the basket. Such information would be very hard to convey accurately and the outcomes would be no more or less reliable than those gained using other methods. More importantly, collecting more than one set of estimates from each country would do much to eliminate, or least ameliorate, the effects of contextual differences.

WEIGHTING THE BASKET

Whatever the methods chosen (whether a basket of goods, components or projects) as part of the aggregation process the various components are weighted to reflect the share of expenditure that each constituent of the standard commodity (set of projects, BOG, etc.) represents in total construction costs typical of each location. This is a similar process to that used in Consumer Price Index (CPI) calculations where the expenditure shares of the various goods and services included in the basket are calculated from extensive surveys of household expenditure. Weights must be ascertained from the lowest level applicable depending on the type of study; for a BOG or factor cost approach, weights for individual items are needed, down to the level of individual materials and categories of labour. At the project level the weights relate to building type in the determination of sectoral PPPs, and finally, at a national level, weights for the three main classes of construction (listed above) are used.

In the pricing of BQs in the standard products approach weights for material, labour and so on are implicit in the pricing as whole projects are priced and the pricing of each item reflects the relative weight of that item. The BOG and BOCC approaches, however, involve the pricing of only selected parts of an infinite number of hypothetical projects and these parts must be weighted to reflect the relative contribution of each item or component to the total cost. The question is how should these weights be derived? At the national level most countries publish percentages of residential, non-residential and civil engineering construction, but at the level of factor inputs or construction components weights have to be determined. In the BOCC method currently being used by the World Bank, sets of related components are treated as a 'system' and weights are calculated for systems such as substructure, superstructure, and exterior shell/building envelope (Walsh and Sawhney 2005). In a BOG or input factor approach individual materials and labour types are weighted. In both the BOCC and BOG weights for each location are necessary as proportions of cost attributable to the various constituents of each basket are likely to differ between countries, particularly in respect of developing countries versus developed countries, and in respect of labour-to-plant (capital) ratios. Dubner and McKenzie (2002) suggest that groups of countries could be identified that employ broadly similar construction methods and weights could be calculated for a representative country in each group, thus reducing the effort needed in establishing weights. However, once weights are established they are unlikely to change significantly in the short or even medium term so the weighting exercise would be largely a one-off exercise that would not need to be repeated often.

In a proposed BOG method Davis Langdon Consultancy (DLC 2003) used input–output tables to determine input weights. National accounts generally include figures that represent purchases of materials by the construction industry from other sectors and these provide a value weighting of inputs to the construction industry. Priced items in the BOG were assigned to various product groups in the input–output tables and the average contribution to the basket determined. The labour:materials split was assumed to

Table 7.1 Quantity weightings for the basket of goods

Item	*Unit*	*Survey price (GBP)*	*Price (€)*[1]	*ONS*[2] *product group*	*% of €600,000*	*Value (€)*	*Derived quantity*
Common bricks	each	0.20	0.32	53	4.59	27,519	86,525
Clay plain roof tiles	each	0.24	0.38	51	1.48	8,858	23,209
Chipboard sheet flooring	m²	2.88	4.58	31	1.60	9,590	2,094
Clay floor tiles	each	0.37	0.59	51	1.48	8,858	15,055
Vinyl floor tiles	m²	5.00	7.95	48	6.65	39,876	5,015
etc.							
					100	*600,000*	
Unskilled	hours	8.00	12.72	12.00%	30.00	120	120,000
Semi-skilled	hours	11.00	17.49	12.00%	30.00	120	120,000
Skilled	hours	14.00	22.26	12.00%	30.00	120	120,000
Site manager	hours	18.00	28.62	4.00%	10.00	40	40,000
					100	*400,000*	
		Total value of basket:				*1,000,000*	

Source: DLC (2003).

Notes
[1]Exchange rate: 1 € = 0.62883 GBP. [2]Office of National Statistics.

be 40:60 with no separation of plant costs or profit and overheads. The Davis Langdon report notes, however, that plant typically represents less than 5 per cent of total cost and as the inclusion of the missing factors would reduce both the materials and labour contributions proportionally the overall effect of ignoring these factors is probably insignificant.

Using the weights established from the tables, quantities for each of the 35 items in the BOG were derived that, when priced and summed, equated to 60 per cent of a UK standard basket worth €1,000,000. Labour weights for the four categories of labour that were priced were used similarly to complete the million euro basket. Table 7.1 shows a small section of the BOG.

It is interesting to note that UK survey prices were converted to euros using a standard exchange rate – there is a potential anomaly here in that prices are being converted using exchange rates as part of a process that is intended to produce PPPs that will eliminate the need to use exchange rates. In this instance, given that most of the countries in the survey are in the euro zone, most prices were obtained in euros and required no conversion. The UK prices, however, were converted using a rate of 0.62883 (GBP to EUR) – over the 5 years preceding the study (1998–2002) monthly average exchange rates ranged from a low of 0.5877 to a high of 0.7094, with the mean of the yearly averages being 0.6392. This is only 1.65 per cent higher than the exchange rate used and therefore is not of great significance; however, if this method were used to compare countries with quite different, more volatile exchange rates, then the reliability of this method would be questionable.

PRICING THE BASKET

Pricing varies according to the method. For standard project BQs, individual items of work are priced and rates normally include all materials, labour and contractors' margins (general overheads and profit); plant may be included, although major plant will often be priced into project overheads (preliminaries). As whole projects are priced, then however individual items are priced the final total should include all factors and reflect a realistic estimate of the price that a client would actually pay. Labour/capital mix is reflected in the prices, as are productivity differences.

In a BOCC, each component is priced in a similar fashion to that of the BQ items; however, care is needed to ensure that prices are consistent in respect of inclusion of factors such as margins and plant. For example, when pricing a reinforced concrete component such as a pad footing, input costs for concrete may include typical allowances for plant (e.g. concrete pump) or these costs may be included in project overheads and would therefore not be included in BOCC pricing.

AN ALTERNATIVE APPROACH – BUILDING BLOCS

An alternative method based on a factor cost or BOG approach has been developed that uses a basket of labour and materials as the standard commodity but has several unique characteristics that will alleviate or even eliminate some of the problems associated with the basic BOG approach (Best 2007). It is has been nicknamed the 'building blocs' approach, with 'bloc' derived from '<u>b</u>asket of <u>l</u>ocally <u>o</u>btained <u>c</u>ommodities'. The basket is similar to Meikle's but both the selection and weighting of the materials components are derived from analyses of priced BQs of completed representative projects of various building types. Cost-significant items are identified from the priced BQs and their contributions to the total project cost are calculated. Labour content is deducted from BQ prices based on the typical labour/materials split for the type of building and country involved – where these are not available indicative proportions can be ascertained by building up rates for selected BQ items using published price- and labour-constant data from each location. While a demanding exercise initially this would only need to be done once and repeated at very infrequent intervals as labour/materials splits are unlikely to vary greatly from year to year (as noted previously). In this way not only are the most cost significant items identified, thus ensuring that prices gathered are those that contribute most to building cost, but the relative weighting of each major material input can be determined.

Labour costs require a different approach as it is not possible for proportions of labour of different classes to be directly determined from the priced BQs. However, estimating data usually includes 'tradesman' hours and 'labourer' hours and these could be used to estimate proportions of skilled and unskilled labour input into various BQ items. Whether site management costs are included will depend on whether such costs are normally included in BQ rates or priced in overheads. Site supervision costs are generally small in relation to total labour costs and depending on the relativity of skilled labour rates and supervision rates it may be that the division into skilled and unskilled labour is sufficient to reflect the labour costs included in BQ rates.

The outcome is a weighted basket of the most cost-significant materials and two or three categories of labour. The composition of the basket will be representative of a particular building type (e.g. high-rise offices, medium-rise apartments, five-star hotels). Analysis of sample projects from each location will determine if there are significant differences in either the composition of the basket and/or the weights of the various constituents of the basket. If so, then some adjustments may be necessary to ensure that comparability and representativeness are maintained as much as possible.

The building bloc, once established, is then priced in each location. Pricing may be on a national basis, using national average prices, or on a city-specific basis using local prices – this would allow more robust comparisons between specific locations and eliminate the often large regional variations in cost such as those described by Lynton plc in their 1993 study in which regional variations in the United States we shown to be in the order of ±20 per cent. Building costs (perhaps the average cost/m^2) in local currency would then be divided by the local cost of the building bloc to derive a bloc equivalent (similar to the hamburger equivalent described previously). Comparing bloc equivalents between countries will show the relative cost of constructing a building of a particular type in each location for which a bloc price is calculated and for which there are typical project costs available. These can be aggregated in the usual ways to produce PPPs for various categories of buildings (residential, etc.) or composite CPPPs for each country.

WILL BUILDING BLOCS WORK?

As with any method the building bloc approach has advantages and disadvantages, but on balance it appears that it improves on previous versions of the BOG approach by addressing several areas of concern associated with earlier models. The robustness of the method is substantially improved by the use of real projects to identify cost significant items and to assign weights to the items that are included in the basket. The input/output approach, while appearing to be conceptually sound, has the limitation that it is difficult to produce anything other than two country comparisons and therefore is of restricted value in the formulation of national indices and the components of the basket of goods used in the Eurostat trial, while based on the knowledge of experienced experts, had no clear basis for their inclusion in terms of their significance in the overall cost of construction. Indeed a quick analysis of the Eurostat basket shows that only 20 per cent of the material items relate to engineering services elements yet cost analyses of most types of non-residential buildings (and this also may include high rise apartments) show that in modern buildings 50 per cent or more of the cost is in the services. While the Eurostat basket may be more representative across the three categories of construction, given the low cost impact of services in civil engineering construction for instance, it does suggest that different baskets may be necessary for the three categories and even that separate CPPPs are required for the three categories. These could be used for comparisons at the level of particular building types or categories yet still be aggregated into overall CPPPs and contribute to GDP PPPs at a national level.

Problems that need to be resolved include the incorporation of contractors' margins in pricing to produce costs more representative of out-turn prices paid by clients, and the establishment of labour ratios that are representative of the various building types and categories. Additionally, to identify various representative baskets and weight them appropriately will entail a good deal of analysis of completed projects; however, these exercises should only need to be done from time to time, and the relative ease of pricing, given the extent and nature of the baskets, would make more frequent pricing at multiple locations an economically viable exercise and provide a much better range of input prices.

CONCLUSION

Comparing construction costs between countries remains a difficult but perhaps not unsolvable problem. While there are many concerns that need to be addressed in relation to finding methods that are sufficiently detailed that they allow valid comparisons yet are cost-effective, ongoing work and further testing of various models will hopefully lead, incrementally, to the production of more reliable indicators of comparative cost. How successful the BOCC is in the ICP will be of great interest and no doubt provide further insights into how these mechanisms can be further refined. Similarly, further investigation of the BOG approach, and its derivative, the building bloc, will provide a useful comparator for the BOCC. One problem, of course, cannot be solved and that is the problem that we have no 'correct' answer to compare results to, so the search will continue for a method that at least enjoys some level of consensus amongst the researchers who are interested in this particular construction economics problem.

NOTES

1 The terms 'cost' and 'price' here are used interchangeably – while some studies focus on price and others on the costs the distinction is not significant in this context.
2 In the sense of being traded between locations, which implies some sort of portability.
3 German for 'roast meat'.
4 The reference to potatoes is odd as the index is based on only the hamburger – without fries.
5 That is, separation of residential, non-residential and engineering construction.
6 The use of input/output tables is specific to the DLC/Meikle BOG method and not generally characteristic of the BOG approach.

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8 Innovation in construction

A case study of the Australian context

Karen Manley and Stephen Kajewski

INTRODUCTION

The dominant economic paradigm currently guiding industry policy-making in Australia and much of the rest of the world is the neoclassical approach. Although neoclassical theories acknowledge that growth is driven by innovation, such innovation is exogenous to their standard models and hence often not explored. Instead the focus is on the allocation of scarce resources, where innovation is perceived as an external shock to the system. Indeed, analysis of innovation is largely undertaken by other disciplines, such as evolutionary economics and institutional economics.

As more has become known about innovation processes, linear models, based on research and development or market demand, have been replaced by more complex interactive models which emphasise the existence of feedback loops between the actors and activities involved in the commercialisation of ideas (Manley 2003a). Currently dominant among these approaches is the national or sectoral innovation system model (Breschi and Malerba 2000; Nelson 1993), which is based on the notion of increasingly open innovation systems (Chesbrough *et al.* 2008).

This chapter reports on the 'BRITE Survey' funded by the Cooperative Research Centre for Construction Innovation which investigated the open sectoral innovation system operating in the Australian construction industry. The BRITE Survey was undertaken in 2004 and it is the largest construction innovation survey ever conducted in Australia. The results reported here give an indication of how construction innovation processes operate, as an example that should be of interest to international audiences interested in construction economics.

The questionnaire was based on a broad range of indicators recommended in the OECD's Community Innovation Survey guidelines (OECD/Eurostat 2005). Although the ABS has recently begun to undertake regular innovation surveys that include the construction industry (2006), they employ a very narrow definition of the industry and only collect very basic data compared to that provided by the BRITE Survey, which is presented in this chapter.

The term 'innovation' is defined here as a new or significantly improved technology or organisational practice, based broadly on OECD definitions

(OECD/Eurostat 2005). Innovation may be technological or organisational in nature and it may be new to the world, or just new to the industry or the business concerned. The definition thus includes the simple adoption of existing technological and organisational advancements.

The survey collected information about respondents' perceptions of innovation determinants in the industry, comprising various aspects of business strategy and business environment. It builds on a pilot innovation survey undertaken by PricewaterhouseCoopers (PwC) for the Australian Construction Industry Forum on behalf of the Australian Commonwealth Department of Industry Tourism and Resources, in 2001 (PwC 2002).

The survey responds to an identified need within the Australian construction industry to have accurate and timely innovation data upon which to base effective management strategies and public policies (Focus Group 2004).

CONCEPTUAL FRAMEWORK

The literature indicates that a broad-based approach to interpretation of construction industry boundaries is essential to understanding economic dynamics in project-based contexts and improving industry growth (Gann and Salter 1998). Because production in the industry is project-based, employing participants from a number of traditionally defined industries, an understanding of industrial linkages and networks is essential to interpreting the nature of innovation processes. Figure 8.1 shows the broad range of participants involved in the industry. This framework provided input to the structuring of the survey sample, ensuring that the views of all the key industry participants were represented.

Figure 8.2 shows the two key macro-drivers of innovation at firm level. The diagram highlights two key types of innovation, four key strategy types and four key elements of the business environment. Business strategies and business environment are the two major influences on firm-level innovation activity (Seaden *et al*. 2003). These two macro-drivers can be thought of as the internal and external influences, respectively, on an organisation's innovation performance.

The relationships between the macro-drivers and innovation outcomes are shown in all cases as two-way flows, indicating the impact of strategies and environment on innovation, and the influence of innovation, in turn, on these factors. Although the latter dynamics are important, this study focused largely on the determinants of innovation.

METHODS

The research questions driving the study were:

- What are the determinants of construction innovation in Australia?
- What is the impact of such innovation?

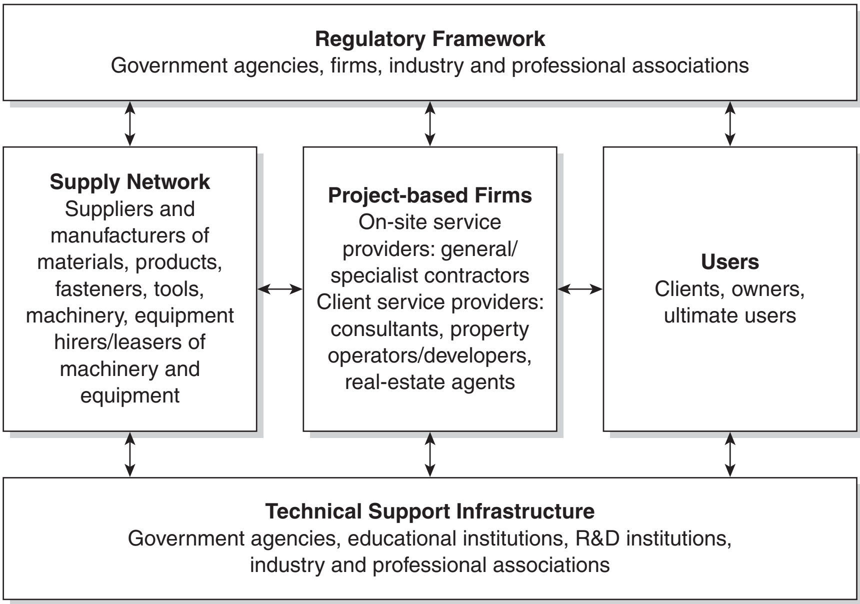

Figure 8.1 Participants and potential relationships in the building and construction industry.

Source: Based on Gann and Salter 1998.

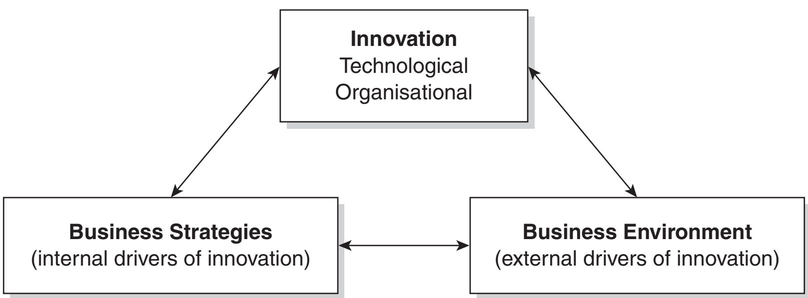

Figure 8.2 Overview of firm-level innovation determinants.

The answers to these questions are provided here. It was decided that the best approach to investigating the research questions was through a large-scale survey. The questionnaire was organised into three sections: innovation activity; business practices and strategies; and industry-wide issues.

While most of the questions required ticking appropriate responses, the survey also collected perceptual data through one open-ended question, which asked about the respondent's ideas to improve the industry's international performance. Quantitative results were derived for this question by manually coding repetitive themes and reporting the frequency with which they occurred. In most cases, multiple codes per respondent were allotted.

A pilot survey was undertaken, covering six respondents from across the sub-sectors to be represented. Following this, some adjustment was made to the key innovation performance questions, mainly to provide examples that were more appropriate to the industry.

The study population was defined as key organisations in the Australian construction industry. The sampling unit was therefore at organisational level. To make the survey manageable, the study focused on the commercial building and civil engineering sectors (excluding residential building). Further, the study was confined to NSW, Victoria and Queensland, and the industry was defined broadly to include main contractors, trade contractors, consultants, suppliers and clients. 'Suppliers' covered manufacturers. 'Consultants' were roughly 50 per cent engineers, 25 per cent architects and 25 per cent quantity surveyors. 'Key organisations' were defined as those appearing on the pre-qualification lists of government road and building agencies in the three states, together with members of eight selected industry associations. The suppliers and associations chosen for surveying were identified by government agencies working with the researchers, as those that made the most significant contribution to construction projects.

In all, 1,317 surveys were distributed to the survey population of 3,476 businesses and 383 useable responses were received, giving a sampling rate of 38 per cent and a response rate of nearly 30 per cent. This is a very good result for the construction industry, given that rates of 15–20 per cent are considered reasonable, and that results of a recent Singaporean construction industry study were published in a well-respected journal with a useable response rate of only 4.5 per cent (Ling 2003: 642).

The survey was distributed through the post, rather than electronically via email or the internet, to avoid any bias introduced by lack of access to email or the internet. The surveys were sent to the contact person on the government agency pre-qualification lists and the industry association memberships lists. These people were mainly managers. Table 8.1 shows the survey response rates by sector and the sampling methods employed.

OVERVIEW OF CONSTRUCTION INNOVATION IN AUSTRALIA

Types of innovation undertaken – technological and organisational

The survey investigated the industry's involvement in two main types of innovation – technological and organisational. Technological innovation was reviewed via examination of a key input variable – research and development (R&D). The survey data shows that one-quarter of the Australian construction industry

Table 8.1 Key survey data

Industry sector	*Firms sent survey forms*	*Completed survey forms returned*	*Response rate*	*Population size, by number of firms*	*Population definition*	*Percent population sampled*	*Sampling method*
All sectors	1,317	383	29%	3,476	–	38%	–
Main contractors: non-residential building and civil	300	93	31%	1,122	Pre-qualified firms	32%	Random
Consultants: non-residential building and civil	409	130	32%	1,549	Pre-qualified firms/ association members	26%	Random
Trade contractors: electrical, communication, air conditioning, mechanical	236	74	31%	346	Major association members	68%	Census
Suppliers: glass, plaster, asphalt, steel	328	63	19%	415	Association members/'yellow pages'	79%	Various
Public-sector clients: non-residential building and civil	44	23	52%	44	Agency managers	100%	Census

invests in R&D, and that these businesses are also significantly more likely than others to think the industry is internationally competitive (ChiSq = 18.11, df = 4). However, significance testing showed no relationship between investment in R&D and profitability. It may be that R&D results in other benefits, such as expanding markets, reducing negative environmental impacts and reducing energy consumption. It is also the case that R&D is only an input to innovation outcomes, with the latter relying on a range of business practices and environmental factors discussed later in this chapter.

Overall, 53 per cent of respondents did not know if they were entitled to claim the Australian Government's tax concession for R&D investment, while 32 per cent knew they weren't entitled to receive the concession, and only 15 per cent knew they were entitled. The high degree of uncertainty may indicate the need for better policies aimed at increasing the industry's awareness and understanding of the scheme. Alternatively, the data may suggest that the benefits offered by the scheme do not justify the compliance costs, or that construction innovation fails to meet the qualification criteria. Further research is needed in this area.

Although one-quarter of the industry *invests* in R&D, the rate of *performance* of R&D within the industry is very much lower. Recent data shows that the following performers were registered with the ABS:

- 173 engineering consultants;
- 19 trade contractors (with electrical contractors accounting for 90 per cent of these, having more than doubled their performance over the past two years);
- 18 main contractors;
- 14 surveyors;
- six architects (ABS 2004a).[1]

Data restrictions make calculation of a rate of performance difficult; however, for the main and trade contractor sectors (in building and non-building construction) in 2000-2001 there were 65 businesses that performed R&D, constituting 0.1 per cent of businesses in those sectors (ABS 2004a, b).[2]

The industry's innovation activity relies heavily on the performance of R&D by organisations that formally reside in other sectors, such as CSIRO and Australian universities. Nevertheless, this structure does not explain the low level of interest in the R&D tax concession scheme, as eligibility is based on the *funding* of R&D.

In addition to reviewing technological innovation via R&D activity, the BRITE Survey also focused on organisational innovation, given its increasing importance to economic growth in the construction industry (Hardie *et al.* 2005). The survey asked which was more important to respondents – technological innovation or organisational innovation. The results showed that these two key types of innovation were equally important, with 50 per cent of respondents to the question supporting each category. This reinforces

Table 8.2 Adoption rates for advanced practices, by percentage respondents, Australian construction industry, 2004

Practice	*Respondents (%)*
Computerised systems for estimating, inventory control, modelling, asset analysis, project management, etc.	74
Computer networks (LAN or WAN)	68
Digital photography	68
Web site	64
Quality certification (e.g. ISO 9000)	59
Design and construct contracts	52
Written strategic plan	48
Staff training budget	47
Partnering on projects, or other relationship forms of contract	41
Long-term collaborative arrangements with other businesses	40
Documentation of technological/organisational improvements developed by your business	34
Managing contractor	31
3-D CAD	31
Alliance contracts	30
Written evaluation of new ideas in order to develop options for your business	26
Risk-sharing/performance-incentive contracts	24
Design/build/fund/operate (DBFO) contracts or public–private partnerships (PPPs)	18
On-line remote construction management	16
Intelligent systems	15

Note
The list was based on one employed by Statistics Canada, and on the results of an industry focus group exercise.

an increasingly common view in the literature that the historical emphasis on technological innovation as the key driver of growth needs to be broadened to acknowledge the growing importance of organisational innovation (Gann and Salter 2000; Drejer 2004).

As a means of exploring organisational innovation in detail, and following Statistics Canada (Anderson and Schaan 2001; Seaden *et al.* 2001), the BRITE Survey asked respondents if they had adopted advanced practices from a list supplied, with results shown in Table 8.2.

Only 30 per cent of the 19 advanced practices are used by more than 50 per cent of the industry. Computer-related practices were the most intensively adopted. There are relatively low rates of adoption for practices that can be considered particularly important to innovation outcomes. For example, on-going collaborations (40 per cent) are an important method of improving relationships in the industry (given a history of adversarial relationships) (Bresnen and Marshall 2001). They are also a key means of carrying-forward project learnings and redressing problems associated with discontinuity of learning in the project-to-project production environment that characterises the construction industry (Miozzo and Dewick 2004).

Second, 3-D CAD (31 per cent) can provide significant business efficiency gains, and recent research suggests that even greater industry-wide benefits will result once 3-D CAD becomes the expected standard (Mitropoulos and Tatum 2000).

Third, alliance contracts (30 per cent) provide extensive improvements in project performance, particularly on large/complex projects (Walker *et al.* 2000). Indeed, the first road project alliance in the world was undertaken in Brisbane, Australia in 2001 and the first building project alliance in the world was undertaken in Canberra, Australia in 2000 (Manley 2003b; Walker *et al.* 2000). Partnering (41 per cent) is another key means of improving project performance through better relationships and is more suitable than alliancing for smaller/more straightforward projects. Although these uptake rates, 30 per cent and 41 per cent, are quite low compared to other listed practices, alliances and partnering are relatively new procurement approaches, and they are also only suitable to selected projects, so the adoption rates observed are probably quite robust.

Finally, 34 per cent of respondents document their technological and organisational improvements, while 26 per cent undertake written evaluation of new ideas in order to develop options for their business. These are relatively low proportions given that the innovation literature stresses the importance of formal evaluation for innovation outcomes and business growth (Barrett *et al.* 2001).

Business strategies

The survey asked about the importance to the respondent's business of four types of strategies covering human resources, technology, marketing and knowledge. These strategies are considered in the literature to be the drivers of construction innovation (Anderson and Schaan 2001). The proportion of businesses nominating each of 23 individual sub-strategies as 'highly important' is shown in Table 8.3.

The results show that knowledge and human resource strategies are of key importance to the industry. This is a positive result, as these strategies can be considered to provide more substantive competitive advantage than marketing strategies. The low importance attached to 'transferring project learnings into continuous business processes' is probably of concern, given research findings indicating that knowledge losses between projects are a major cause of inefficiency in the industry (Dubois and Gadde 2002).

Table 8.3 Business strategies, by percentage of respondents finding them highly important to business success, Australian construction industry, 2004

Strategy type	*Business strategy*	*Respondents (%)*
Marketing	Building relationships with existing clients	85.1
Human resource	Actively encouraging your employees to seek out improvements and share ideas	80.4
Technological	Enhancing your business's technical capabilities	76.0
Marketing	Attracting new clients	74.7
Human resource	Providing or supporting training programs for your employees	69.7
Human resource	Recruiting experienced employees	68.7
Knowledge	We have robust relationships with key organisations in the industry	65.0
Technology	Introducing new technologies	62.1
Marketing	Delivering products/services which reduce your clients' costs	60.6
Marketing	Providing a broader range of services to your clients	56.4
Human resource	Use of multi-skilled teams	52.7
Knowledge	Participating in the development of industry standards and practices	48.0
Marketing	Increasing your market share	46.2
Knowledge	Protecting your business's intellectual property	44.6
Human resource	Recruiting new graduates	44.1
Knowledge	We actively monitor advances in related industries that might be applicable to our business	42.8
Knowledge	When we make changes, we measure how well the changes have worked	39.9
Human resource	Participating in apprenticeship programs	38.6
Knowledge	We actively monitor international best practice in our field	35.8
Knowledge	We have a formal system for transferring project learnings into our continuous business processes	31.9
Human resource	We have a formal system to encourage staff to share ideas	30.5
Human resource	We reward staff for maintaining networking linkages with strategically useful industry participants	22.2

The second-highest-ranking strategy 'actively encouraging your employees to seek out improvements and share ideas' was employed by 308 respondents; however, only one-third of these had a formal system in place to back it up ('a formal system to encourage staff to share ideas'). This is

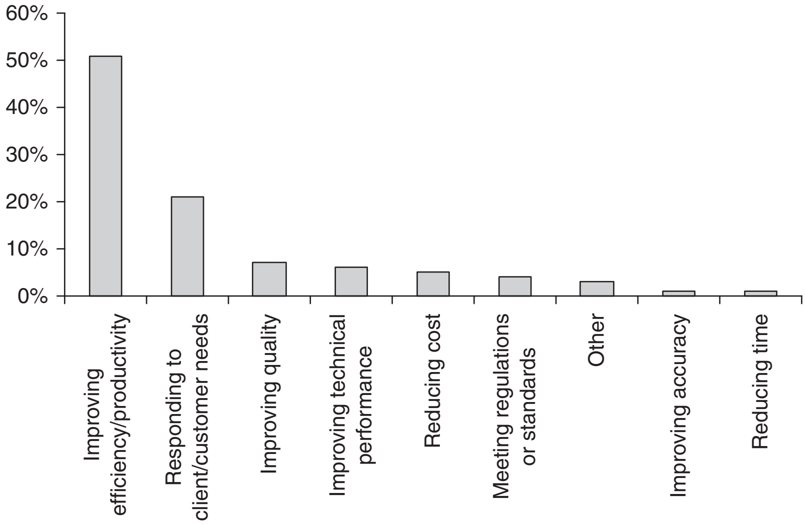

Figure 8.3 Key reason for undertaking innovation, by percentage respondents, Australian construction industry, 2004.

an important finding; many businesses pay lip service to the importance of knowledge diffusion; however, improved business performance relies on having formal robust policies in place (Love *et al.* 2004).

Innovation drivers

The survey also asked about the main reason for undertaking innovation. It was found that the desire for efficiency/productivity improvements drives just over half of all innovation undertaken by the industry; this and 'customer needs' are the two key motivators nominated by respondents, as shown in Figure 8.3.

Technical performance and quality are more important drivers of innovation in the industry than cost. It may be that the increasing attention paid by Australian public-sector clients to value-driven tender selection is behind these results.

Sources of innovation ideas

Another view of innovation drivers is provided by considering sources of innovation ideas, as shown in Table 8.4. This ranking reflects that which emerged in recent economy-wide EU surveys, where internal sources similarly dominated. Clients and suppliers were ranked more highly in the EU surveys (European Commission 2004: 24).

Table 8.4 Key sources of innovation ideas, by percentage of respondents, Australian construction industry, 2004

Rank	*Source*	*Respondents (%)*
1	In-house staff	68
2	Professional or trade associations	45
3	Conferences/workshops	39
4	Previous projects	38
5	Clients or customers	35
6	Journals/magazines	33
7	Suppliers	29
8	Technical support providers	29
9	Competitors	22
10	Consultants	21
11	Overseas sources	20
12	Research institutions	10
13	Trade contractors	10
14	Main contractors	7

The table shows that 'In-house staff' are a key source of innovation ideas for more than half the industry, highlighting the dangers of out-sourcing and underlining the importance for organisations of maintaining strong internal skill-sets and attracting creative employees. The high profile of 'trade associations' highlights the value of their contribution to the industry, especially for small and medium-sized businesses. 'Previous projects' rank fourth, drawing attention to the need for organisations to have effective knowledge transfer mechanisms between projects.

One in five respondents monitor 'overseas sources' of ideas, which would play an important role in the industry becoming more internationally competitive. 'Research institutions' are a relatively unimportant source of innovation ideas. This may be because such institutions play a more important role in other stages of the innovation process, such as *development* of ideas. Or it may indicate that such institutions need to make their research more relevant to industry, and/or they may need to invest more effort in diffusing the results of their research.

On average, respondents nominated only four key sources of ideas. It may be that broader surveillance would improve innovation performance in the industry; however, that may be difficult given time and cost obstacles discussed later.

Finally, a correlation analysis between the number of key sources consulted by an organisation and the number of advanced practices they

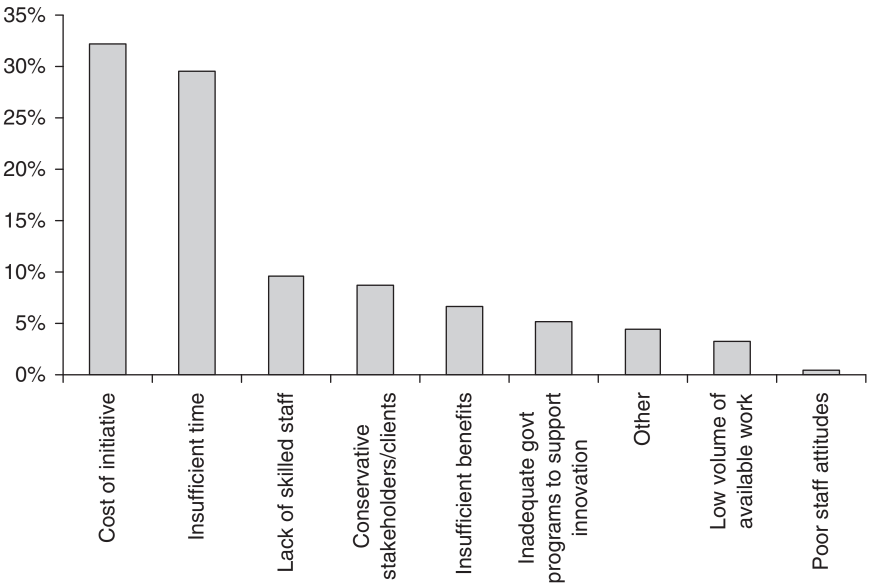

Figure 8.4 Key obstacle to innovating, by percentage respondents, Australian construction industry, 2004.

adopted resulted in a significant positive relationship (Pearson correlation coefficient 0.237). Hence it would appear that if a business wanted to increase its successful adoption of advanced practices (a measure of organisational innovation), a useful strategy may well be to expand the sources of ideas about innovation they consult.

Innovation obstacles

The survey also looked at the factors that hamper innovation in the industry. Figure 8.4 shows that cost and time clearly stand out as two dominant innovation obstacles. These findings are likely to be driven by the relatively poor profitability levels in the industry, compared to the industry internationally (PwC 2002: 49).

'Cost' and 'time' accounted for 58 per cent of the obstacles nominated by respondents, pointing to the need to prioritise current efforts aimed at improving industry profitability. Compared to overall results, consultants are more likely to be obstructed by 'cost', main contractors by 'conservative stakeholders/clients', trade contractors by 'time' and suppliers by 'other' key obstacles (ChiSq = 69.38, df = 32). Analysis of supplier text responses showed little consistency, except three respondents who indicated that their businesses were too small to manage innovation activities.

Table 8.5 Industry group, by percentage of respondents perceiving them to encourage and block innovation, Australian construction industry, 2004

Encouragers	%	*Blockers*	%
Large/repeat clients	59	Government regulators	47
Architects	55	Insurers	42
Engineers	51	Funders	28
Manufacturers	46	Organisations that set industry standards	28
Building designers	44	One-off clients	25
Main contractors	43	Quantity surveyors	23
Developers	38	Letting agents	22
Project managers	38	Developers	19
One-off clients	27	Project managers	19
Trade contractors	27	Main contractors	18
Other suppliers	26	Trade contractors	18
Organisations that set industry standards	26	Engineers	17
Quantity surveyors	19	Large/repeat clients	15
Funders	15	Building designers	12
Government regulators	11	Architects	10
Letting agents	7	Manufacturers	7
Insurers	5	Other suppliers	5

Industry groups encouraging or blocking innovation

Analysis of innovation drivers and obstacles is expanded by considering the role different groups in the industry play in either encouraging or blocking innovation. Results are shown in Table 8.5. The two charts show consistent findings; groups that feature as high-level encouragers of innovation also feature as low-level blockers, as would be expected. The most obvious and consistent findings between the two charts are that the key encouragers of innovation are large/repeat clients, architects and manufacturers, while the main blockers are perceived to be government regulators, insurers and funders. These findings are consistent with anecdotal evidence, and dominant views in the literature. Indeed, the PwC (2002: 46) survey also found that clients, suppliers and consultants were the leading innovation drivers within the industry.

Table 8.6 Percentage of respondents believing the industry is sufficiently innovative to cope with international competition, Australian construction industry, 2004

Response	*Percentage*
Yes	52
No	21
Don't know	27

Table 8.7 Respondents' suggestions for improving the international competitiveness of the Australian construction industry, 2004

Suggestion	*Respondents (%)*
More education and demonstration projects	19
Increase government assistance	13
Increase project-based recognition, rewards, incentives	11
Less conservative attitudes	11
Improve client contribution to good processes and performance	10
Improve relationships and cooperation	6
More whole-of-life approach	5
Remove lowest cost tendering	5
More help from unions	4
Improve contractual/legal arrangements	4
Reduce regulation/intervention	4
More large projects	4
Increase competition	4

Knowledge of international competition

Given the Australian industry's increasing exposure to international competition, the survey asked about respondents' views of the industry's global standing, with results shown in Table 8.6.

Most construction firms think the Australian industry is sufficiently innovative to cope with international competition. The findings of the PWC survey (2002: 46) on international innovation suggest this is a misconception. Most (69) of the 80 respondents who thought the Australian industry was not sufficiently innovative gave their opinion of what could be done to improve the situation. Text analysis resulted in 111 ideas being identified, falling into the categories shown in Table 8.7.

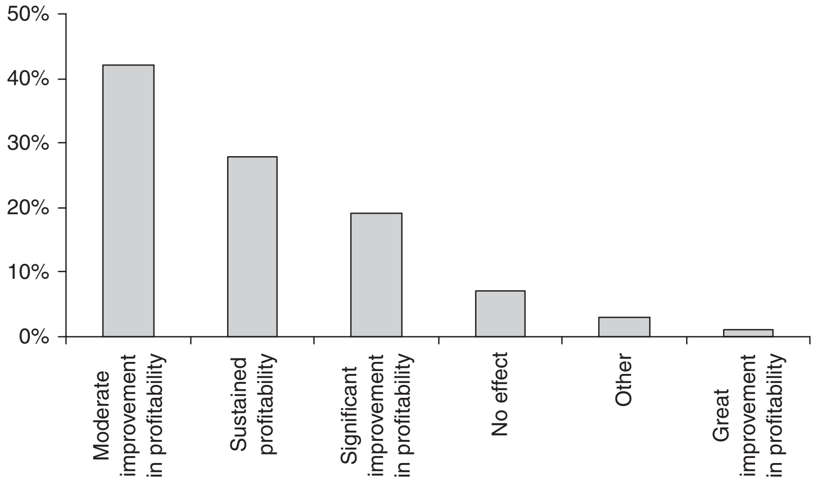

Figure 8.5 Profitability impact of most successful innovation in the past 3 years, by percentage respondents, Australian construction industry, 2004.

The need for better education, demonstration and government assistance tops the list of priorities. The finding concerning government assistance relates to the earlier finding that the R&D tax concession scheme may not meet the needs of the industry.

Innovation impact

The survey asked about respondents' most successful innovation over the past three years and found that for 93 per cent of the sample, this innovation had a positive impact on profitability, while for 7 per cent there was no impact on profitability (it may be that there were other benefits that were not captured by the survey). No respondents indicated a negative impact on profitability. Figure 8.5 shows the results.

The most common impact was a moderate improvement in profitability, experienced by nearly half of the respondents to this question. Ten respondents nominated the 'other' response and all of these comments related to benefits, other than improved profitability, flowing from the innovation. Given that this question related to the organisation's most successful innovation over the past three years, it can be seen that, in terms of profitability at least, the impact of a single innovation is relatively modest, with only one-in-five respondents recording a 'significant or great improvement in profitability'.

Significance testing found a positive relationship between profitability and the average number of advanced practices adopted by an organisation

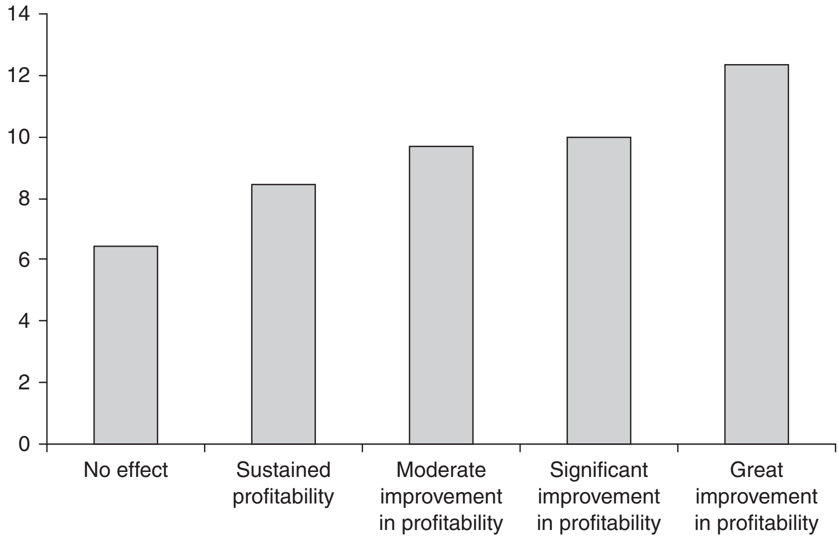

Figure 8.6 Average number of advanced practices adopted, by innovation profitability impact, Australian construction industry, 2004.

(Kendall's tau_b correlation coefficient 0.143). Figure 8.6 shows descriptive results.

The average number of advanced practices increased as profitability impact increased. This suggests that businesses adopting a greater range of advanced practices may generate greater profits.

CONCLUSIONS

The current business environment globally is one in which open innovation systems drive economic growth (Chesbrough *et al.* 2008). The BRITE Survey has shed some light on the extent to which the Australian construction industry is engaged in interpersonal, interdiscipline, interfirm, interindustry and international knowledge sharing. Such activity is a key element of open innovation systems. Focusing attention of these indicators suggests that the Australian construction industry is well placed to maximise its growth potential in the context of the national and international knowledge economy. Table 8.8 summarises the key points in this regard.

This chapter has presented a descriptive overview of innovation within the Australian context, providing an example of the way in which innovation process can operate in the construction industry.

Table 8.8 Selected results, Australian Construction Industry Innovation Survey, 2004

Knowledge sharing mode	*Evidence of Australian construction industry engagement*
Interpersonal	Nearly one-quarter of firms in the industry reward their staff for maintaining networking linkages with strategically useful industry participants
Interdiscipline	Contractors in the industry acknowledge the lead role played by architects, engineers and manufacturers in encouraging innovation
Interfirm	Sixty-five per cent of firms have robust relationships with other key organisations in the industry
Interindustry	Nearly half of firms actively monitor advances in related industries
International	Thirty-five per cent of firms actively monitor international best practice in their fields

NOTES

1 ANZSIC codes: 4113, 4121, 4232, 4233, 4241, 4245, 7821, 7822, 7823.
2 ANZSIC codes: 41 and 42.

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9 Theory testing in building economics research

An experimental approach

Bee-Lan Oo

INTRODUCTION

There has been much debate about the role of, and the need for a theory in construction management and economics research (e.g. Betts and Wood-Harper 1994; Seymour *et al*. 1997; Koskela and Vrijhoef 2001). Instead of scientific research that involves the use and testing of theories, a lot of research into construction management has been directed towards finding better work practices or providing industry practitioners with decision-making tools (Betts and Lansley 1993; Runeson1997a), and Runeson (1997b) used the term 'in total confusion' to describe construction or building economics research. He went on to point out that there has been no apparent progress in the theoretical framework of building economics.[1] In particular, the theoretical development of tendering theory[2] as outlined by Friedman (1956) and later Gates (1967) which is conventionally referred to as part of building economics, has been slow.

It is now over 50 years since Friedman's paper was published and there is now a voluminous literature on bidding which is probably beyond the reading capacity of anyone just entering the field. Nonetheless, apart from a few notable exceptions (Skitmore 1991; Skitmore and Runeson 2006), little attention has been devoted to testing the general tenability of the key Friedman-based assumptions, namely (i) all bidders can be treated as behaving collectively in an identical (statistical) manner (i.e. the bidder homogeneity assumption); and (ii) individual bidding behaviour does not change over time (i.e. the stationarity assumption).[3] These assumptions, which have been adopted in many papers on construction contract bidding, are crucial in any bidding modelling attempts and if inappropriate, would invalidate the reported results and proposals.

Given that there are so many possible variables affecting contractors' bidding decisions which would need to be considered, and that different factors may have been considered differently by different contractors at the time of bidding, an experimental approach is seen as an effective means towards real theory testing in the context of tendering theory. The basic intent of an experiment is to allow the researcher to control the research situation (or control for all factors that might influence the outcome), so that one or more variables can be manipulated in order to test a hypothesis. Fellows and Liu (2003: 84) define experiment as 'an activity or *process*, a combination of activities, which produces *events*, possible outcomes'. The distinctive difference between a survey and experimental design is that events may be controlled in an experiment in a way that is not possible in a survey. Smith (1994) pointed out that economists conduct experiments to test a theory, or discriminate between theories, to explore the causes of a theory's failure, and to establish empirical regularities as a basis for new theory. What experimental economists do, i.e. real theory testing, is essentially promoting scientific development (the right picture of the science learning process) where substantial progress has been accomplished in conventional economics.

The aim of this chapter is to present a bidding experiment aimed at testing the tenability of Friedman's assumption of bidder homogeneity. While Runeson (1997b) has that a wide-ranging methodological debate is necessary if the discipline is to progress, the purpose here is less ambitious – namely to show that a simple experiment can deliver the death blow to the tendering theory.

This chapter first presents an overview of the application of an experimental approach in building economics research. It demonstrates the practicality of experiments in previous works. The subsequent section describes all events in detailing the designed bidding experiment which involved participants from Hong Kong and Singapore. A discussion on the challenges that the author faced in this experimental research is presented next before the concluding note.

THE EXPERIMENTAL APPROACH TO RESEARCH

Let's look at the experimental studies in the context of construction contract bidding. Using Bowen's (1978) classification framework, previous studies using bidding experiments, variously termed as bidding games or simulations, can be classified into one of three purposes, namely (i) learning (e.g. Harris and McCaffer 1989); (ii) teaching (e.g. Nassar 2003); and (iii) research (e.g. Hackemer 1970; Drew and Skitmore 2006). The 'teaching' and 'learning' game formats are generally the products of specified lessons in the games and are highly dependent on the course of play. The research game is used as an empirical tool for investigating decision-making in a setting that allows for controlled hypothesis testing. For example, Hackemer (1970) examined the effect of variability of estimate, number of competitors and mark-up on bidding strategy by asking five competitors to bid for 200 contracts. The bidding experiment, what the author refers to as 'simulation', produced some 200,000 bids via application of different variability factors of estimate. Dyer *et al*. (1989), on the other hand, compared the naive and experienced bidders in construction contract bidding via a laboratory experimental setting. Most recently, Drew and Skitmore (2006) used a bidding experiment to test the applicability of Vickery's revenue equivalence theorem in construction contract bidding.

Although none of the experimental studies mentioned above made any attempt to test the tendering theory, they do demonstrate the practicality of experimental designs in construction contract bidding research. The bidding experiment for testing the tenability of Friedman's bidder homogeneity assumption presented next, shows that experiments are essential to find misspecifications in a theory and so uncover its edges of validity, setting the stage for a better theory and a better understanding of construction price formation.

BIDDING EXPERIMENT: TESTING THE BIDDER HOMOGENEITY ASSUMPTION

For some background information, the research was based on the premise that there is heterogeneity in the population of contractors. That is, individual contractors change their bidding behaviour when confronted with changes in a given environment. In this case, the focus was on the effect of different (i) market conditions, (ii) number of bidders, (iii) project type, and (iv) project size on individual Hong Kong and Singapore contractors' bid/no-bid and mark-up decisions. It examined the notion of heterogeneity at two levels: at macro-level by comparing contractors operating within different competitive environments or industry settings (i.e. Hong Kong and Singapore); on a micro-level, it is concerned with heterogeneity across contractors operating within the same competitive environment.

Given that there are so many possible factors affecting contractors' bidding decisions – e.g. Shash (1993) identified 55 bid/no-bid factors – only an experimental research design would allow for control over the variables, something that would not have been possible using empirical data. Certainly, it would have been difficult to obtain the necessary data for projects of different sizes and types along with different market conditions and number of competing bidders, especially as many clients do not make such information public. In addition, the design of the bidding experiment permits the following that further justified its application:

1 a direct comparison of contractors' bidding decisions between the two city states;
2 generation of adequate samples that covers the regions of interest of the four project decision environment factors (e.g. bid data sample for number of bidders ranging from 4 to 30);
3 examination of the effect of changing the number of bidders on contractors' bidding decisions, as bid/no-bid and mark-up decisions for several possible number of bidders scenarios are unobtainable in 'real world', where contractors only submit one-off bids when bidding for projects;

4 application of a heterogeneous approach to modeling contractors' bidding decisions without prior assumption of homogeneity, since multiple observations were obtained from each participant in the experiment.[4]

The experimental procedure of the bidding experiment is based on an 'after-only', or as it is also known, a one-shot case study design. It involves an exposure of a group to an intervention followed by a measurement to determine the effect of the exposure. The paradigm of the chosen experimental design using the standard notation system proposed by Campbell and Stanley (1963) is:

$$X \rightarrow O$$

where:

X = an exposure of a group to an experimental variable or event, the effects of which are to be measured;
O = an observation or measurement recorded on an instrument.

In this research there are four experimental or independent variables, the effects of which were measured in terms of two dependent variables as shown in Figure 9.1.

The after-only experimental design is an example of quasi-experimental design that does not qualify as true experimental design in a formal scientific sense. This is because it does not address some potential threats to the validity of an experiment (Creswell 2002). The results of the after-only design may fail to identify the net effect of an exposure as (i) there is no proper base-line data to compare the observation with; and (ii) some of the changes in dependent variables may be attributed to many other variables or conditions (Kumar 1999). However, the author went on to point out that the adequacy of this design will be enhanced if reasonably accurate base-line data are available before an exposure is introduced. For the bidding experiment, actual past tender reports were used as the base-line data in constructing the experiment instruments in an attempt to overcome the deficiencies in the chosen after-only experimental design. In addition, various steps were

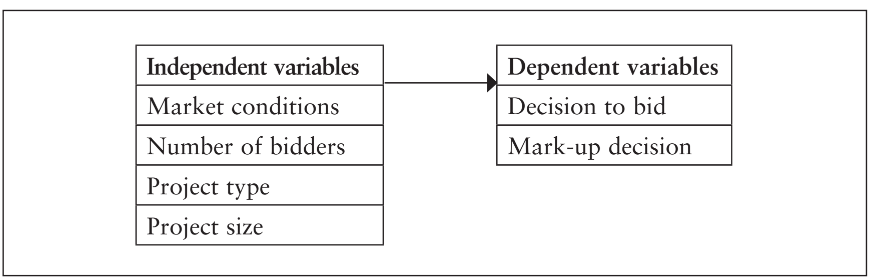

Figure 9.1 The independent and dependent variables of this research.

taken to deal with the potential threats to both the internal and external validities of the bidding experiment as discussed below.

For the 'after-only' experimental design chosen, the laboratory experiment on auction theory by Dyer (1987), which examines the effect of changing the number of bidders on seller's revenue, was chosen as the starting point for the bidding experiment. This experiment was similar in aim to the intended experiment as it applied a hypothetical setting for examining the effects of changing the number of bidders by asking the participants to bid in scenarios of three and six bidders. The overall aim of this experiment is to extend Dyer's experiment by including other bidding variables of interest. Instead of the laboratory setting used by Dyer, the designed experiment used a field setting where the experimental intervention was implemented in a real-life environment. This was due mainly to the impracticality of carrying out laboratory experiments that involved construction firm executives from Hong Kong and Singapore. The ultimate goal was to establish a commercial construction contract bidding setting which the participants are familiar with, thus allowing their experience to manifest itself efficiently.

The bidding experiment involves participants bidding for twenty hypothetical projects. The use of hypothetical projects removes the need to identify matching projects from Hong Kong and Singapore. Project information from past tender reports by the local procurement agencies was used to give a broad but carefully worded description of the hypothetical projects. Participants were required to draw upon their previous experience in making bid/no-bid and mark-up decisions. The following sections examine the various aspects of the designed bidding experiment in turn, namely:

- manipulation of the independent variables;
- the instruments;
- the experimental procedures;
- the repeated-measures design;
- controlling the extraneous variables;
- overcoming the threats to the validity of the experiment; and
- the experiment's limitations.

Manipulation of the independent variables

The manipulations of the four independent variables in terms of values or levels which they assumed were based on the literature and previous empirical findings as described below.

1 *Market conditions*. The bidding experiment was arranged in two rounds according to two extreme market conditions scenarios, i.e. (i) boom times with low need for work, and (ii) recession times with high need for work. This setting is closest in spirit to the work by de Neufville *et al*. (1977) in what they refer to as 'good' and 'bad' years where the prevailing market

conditions are seen as the proxy variable for the contractors' need for work. That is, contractors would only take on additional work on favourable terms in a boom, whereas they may be willing to take on marginal projects just to stay in business during a recession. It was therefore decided to include the need-for-work factor in the formulation of the market conditions scenarios. Considering that larger projects may extend over one or more phases of the business cycle, and that contractors do anticipate the likely future in their bidding decisions, participants were informed that all hypothetical projects could be completed within the stated boom and recession periods. This was done to obtain a distinctive comparison of results that reflect the extreme ends of the market.

2 *Number of bidders*. For every hypothetical project there were eight estimated numbers of competing bidders, *N*, increasing from 4 to 6, 8, 10, 14, 18, 24 and 30. This enables a close examination of bidding patterns with different numbers of bidders, and reduces the repetitive nature of the experiment since divergence in bidding decisions is expected to be less noticeable if there are too many bidders (Wilson *et al.* 1987). Also, the term 'estimated' was used in the design because contractors are unlikely to have the exact number of competing bidders when submitting a bid. The participants were asked to bid up to the bidding scenarios of *N* bidders that they wish to bid in. It is worth noting that the range – from 4 to 30 – was determined based on the recorded number of bidders per contract for Hong Kong's (Fu 2004) and Singapore's public sector general building projects (Oo and Drew 2005).

3 *Project type*. The twenty hypothetical projects were constructed based on past public sector projects for the period 2002–2004 obtained from the local authorities. The project selection process adhered to two main criteria. First, the projects were of conventional type, i.e. new construction or rehabilitation works that involved buildings of usual design, and did not require any unusual construction technologies. This was done to control the effects of project type on contractors' bidding decisions, since both the project type and complexity are assumed to determine who are competing. Second, the awarded contract values or lowest bid prices of the projects fall into the pre-determined range of project size. Project information of the selected past projects including project duration, project description and awarded contract value or lowest bid price (subjected to adjustments) were used to form a realistic base-line data in constructing the hypothetical projects used in the bidding experiment.

4 *Project size*. The predetermined range of project sizes was based the participants' tendering limits set by the local government agencies for the prospective Hong Kong and Singapore participants. The twenty projects ranged from HK$50m to HK$150m (or S$10m to S$30m based on a conversion rate of S$1 to HK$5) in order to establish a competitive range that included all the prospective Hong Kong and Singapore participants with different tendering limits. Having satisfied the project

selection criteria, the corresponding awarded contract values or lowest bid prices of the selected projects were used to compute the cost estimates for the hypothetical projects with necessary adjustments and updated to a common base date using published tender price indices. These figures were selected to reflect the assumption that the lowest prices were awarded the contracts in both city states.

It should be noted that the cost estimates provided in the experiment instrument are identical for all participants. This was done to form a strong basis for comparison of contractors' mark-up decision. The variability in contractors' cost estimates is outside the scope of the research. To facilitate the participants' decision-making, the cost estimate was (i) expressed in millions of dollars, e.g. 55 million (instead of actual dollars) in the respective local currencies, and (ii) defined in the experiment instrument as an 'unbiased' cost estimate, where it is assumed that the cost estimate is a random variable of the true cost of a building contract derived from drawings and specifications, bills of quantities, and from previous experience of similar contracts (for detailed discussions of these issues see Rothkopf 1980; Flanagan and Norman 1985). Participants were told that the estimate is the construction cost (i.e. contractors' in-house estimate) which includes the project preliminaries and site overheads, but without any adjustments for items such as general overheads, profit, risk margins, competition, finance, etc.

The instruments

The instruments for the bidding experiment consist of a leaflet and two sets of bid response forms. As an alternative of a cover letter, an eye-catching colour-printed leaflet with a brief summary of this experimental research was first sent to the participants in seeking their participation in the experiment. This was done to seize their attention so as to increase the response rate. Certainly, the two-round nature of the bidding experiment represented a significant hurdle in recruiting participants.

Each participant was required to complete two sets of bid response forms, one for each of the different market conditions scenarios. The bid response form consists of two parts, i.e. a single page of written instructions that was presented in the first session, comprising assumptions, definitions and steps required to complete the bid response form, and a second part that listed the twenty hypothetical projects. A pilot study that aimed to test the instruments was carried out before the experiment begins, involving construction management academics and 'experts' in commercial construction contract bidding from Hong Kong and Singapore.

The experimental procedures

The participants were invited via email to participate in the bidding experiment by (i) acting as senior managers of their construction firms, and (ii) bidding for a total of 20 hypothetical projects. These were arranged in two rounds according to two extreme market conditions scenarios. The participants were required to decide (i) which jobs to bid for, and (ii) what mark-up they should apply to the job if they decided to bid.

Apart from the information on the four independent variables, the participants were also given information on project duration, location, client and contract type to facilitate their decision-making. Participants were informed that their ultimate aim was to survive and prosper and that the lowest bidder will win the job. This was done to reflect the lowest price paradigm in awarding contracts in the local construction industries.

In an attempt to establish a strong basis for comparison of the results, a repeated-measures design (see next section for detailed discussion) was adopted in which the same twenty hypothetical projects were used in both rounds of the experiment. However, the sequence of the projects was randomly revised in the second round in order to avoid contamination of responses.

The repeated-measures design

The bidding experiment is a repeated-measures design in which multiple bid/no-bid and mark-up decisions were collected from each participant over the two rounds of the experiment. There are two major classes of repeated-measures designs, i.e. same response to be measured (i) at different points in time, and (ii) under different treatment conditions (Lunneborg 1994). This experiment falls into the second class, since the focus is on the changes in the experimental treatments or interventions in the form of market conditions, number of bidders, and project type and size, rather than on time.

The advantage of a repeated-measures design is that it is more economical (in terms of time) to 'reuse' the same participants as well as treatments (same project list) and forms a strong basis for comparisons. It does have disadvantages as well as (i) participants may become bored or fatigued – *habituated*, and (ii) there may be an *order of presentation bias* caused by participants accumulating experience when making the same response repeatedly (Lunneborg 1994). Double measures were adopted to deal with these issues by (i) scheduling a 3-week washout period between the two rounds of the experiment whenever possible, and (ii) using a counterbalanced design wherein half the participants were exposed first to the boom scenario (treatment A) and then to recession (treatment B). The other half received treatment B before treatment A.

Controlling the extraneous variables

Apart from the information of the four independent variables, the participants were also given information on cost estimate, project duration, location, client and contract type to facilitate their decision-making. Given that it is impractical to not include any extraneous variables in the experiment, a *constancy of conditions* was established by controlling these extraneous variables (Venkatesan and Holloway 1971). The basic intent of this procedure is to ensure that all the participants were exposed to situations that were exactly alike except for the differing conditions of the independent variables.

Overcoming the threats to the validity of the experiment

Experiments are judged by two measures: (i) internal validity, which indicates whether the independent variable(s) was the sole cause of changes in the dependent variable(s); (ii) external validity, which indicates the extent to which the results of the experiment are applicable in a real-world situation, and whether the results can be generalised to the population it is meant to represent (Campbell and Stanley 1963). With respect to the designed bidding experiment of repeated-measures design, the various measures designed to overcome the identified threats to both the internal and external validities of the bidding experiment are presented in Tables 9.1 and 9.2, respectively.

The experiment's limitations

Setting up a bidding experiment which is an exact replica of the commercial construction industry is extremely difficult, if not impossible. Given that there are so many possible factors affecting bidding decisions, the focus has therefore been on those key factors which comprise market conditions, number of bidders, and project type and size. Other factors in the experiment including project duration, location, client and contract type have been held constant in establishing a setting that the participants are familiar with, thus allowing their experience to manifest itself effectively.

The experiment, however, does not consider the direct effect of bidding decisions on future events, since the twenty hypothetical projects were released at once. No feedback information was given to the subjects at the end of each round of the experiment as the two rounds of experiment are treated as independent study, based on different market conditions scenarios. It is felt that inclusion of twenty projects is necessary to generate a reasonable dataset and to reflect that contractors are selective in their bidding decisions as bid enquiries are received continuously. Also, the participants tend to be more risk-seeking in an experimental setting, although it is believed that industry practitioners who are willing to spend time on non-rewarding academic studies (in this case two rounds of experiments) will respond genuinely and many stated explicitly that they would do so. It is worth noting that another laboratory experiment by Dyer *et al.* (1989) which involved experienced business executives from the construction industry did provide reasonable results. This is further evidenced in their follow-up study using interviews and past bid data (Dyer and Kagel 1996).

Table 9.1 Adopted measures to overcome the threats to the internal validity of the bidding experiment

Threats to internal validity	*Definition*	*Adopted measures*
History effect	A specific event in the external environment occurring between first and second measurements that is beyond the control of experimenter	A short interval was allowed between the repeated measurements, i.e. only a 3-week interval was scheduled between the first and second rounds of the bidding experiment
Maturation effect	An effect caused by changes in experimental participants over time; a function of time rather than response to a specific event	As above
Testing effect	An effect that occurred if identical instrument is used more than once	The sequence of the twenty hypothetical projects was randomly revised in the second round of the experiment to avoid contamination of responses
Instrumentation effect	An effect caused by a change in the wording, or other changes in procedures to measure the dependent variable	A pilot test on the instruments used for the bidding experiment was carried out prior to data collection
Selection effect	A sample bias or sample selection error	The selection of participants for the bidding experiment was based on the tendering limits set by the local government agencies
Mortality effect	Sample attrition that occurs when participants drop out during the experiment for any number of reasons (e.g. time, interest and money)	All the prospective contractors were contacted, since it is very likely that some participants will drop out after first round of the experiment. This was done to increase the number of complete response sets from the two rounds of the experiment

OUTCOME OF THE EXPERIMENTAL RESEARCH

In testing the tenability of bidder homogeneity assumption, the datasets obtained from the designed bidding experiment were used to test eight hypotheses formulated in this research. The results show not only that there is significant heterogeneity between the Hong Kong and Singapore contractors in terms of both their preferences (intercepts) and responses (slopes) to the bidding variables (i.e. market conditions, number of bidders, project type

Table 9.2 Adopted measures to overcome the threats to the external validity of the bidding experiment

Threats to external validity	*Definition*	*Adopted measures*
Interaction of selection and treatment	Inability to generalise beyond the groups in the experiment	The feasible measure to overcome this particular threat is to repeat the experiment with different samples, e.g. Singapore contractors of different tendering limits. If, however, the replication with this group of contractor gives rise to different results, it does not mean that the experimental procedure is flawed. Rather, it enables the experimenter to specify the limits of generalisation and the groups of contractors to whom the results *do* and *do not* apply
Interaction of setting and treatment	Inability to generalise from the setting where the experiment occurred to another setting	Similar to the above, replication is the possible strategy to draw the limits of generalisation by conducting the experiment in a different context, say, for private sector contracting along with different settings for the four independent variables
Interaction of history and treatment	Inability to generalise findings to past and future situations	Likewise, replication is the possible strategy to draw the limits of generalisation by conducting the experiment in different periods of time

and project size) that affect their bid/no-bid and mark-up decisions, but also that the individual Hong Kong and Singapore contractors have different degrees of sensitivity towards the bidding variables (which is reflected in the varying individual-specific intercepts and slopes). Thus, the eight hypotheses are all justified, providing strong evidence on the existence of heterogeneity across contractors.[5]

The major contribution of this research is an empirical demonstration of the notion of heterogeneity across contractors in the context of construction contract bidding. The bidder homogeneity assumption is shown to be untenable for the samples involved. In particular, this research has demonstrated the need to account for heterogeneity across bidders in any further bidding model attempts. Future work on bidding models should concentrate on the development of 'individualised' models with parameter estimates for individual bidders. This leads to a research agenda in applying a heterogeneous approach to modelling contractors' bidding behaviour in construction contract bidding research.

Resistance to the experimental approach

It is not surprising that researchers have held, to some extent, the view that the experimental approach is impractical in building economics research (as in construction management). This may explain why so much research into construction management and economics have been performed using other research methods, especially surveys and case studies. Empirical data is normally derived from survey questionnaires or from in-depth interpretative interviews in these research projects. However, it does not imply that there is no role for conventional scientific research methods, since they are sometimes more appropriate.

Let's discuss the two common issues raised by other researchers when the bidding experiment was presented to them, namely: (i) the validity of results, and (ii) the effect of monetary rewards in experimental studies. The following questions were typical of their concerns: 'Why don't you use real past bid records?', 'How do you make sure that the participants will respond genuinely in the experiment?', 'How are you going to validate the experimental results?' and 'Do you think the participants will respond differently if there is any monetary reward?'

For the first issue, it seems that our research community is still judging a research project 'on results, and results alone. Research methods or philosophies do not really seem to matter' (Runeson 1997a: 300). It has now more than ten years since he made this comment in a debate on the role of theory in construction management research. This situation may also suggest that there has been very little progress in the methodological component of construction management and economics research, in the sense of using what is appropriate from related, well-established disciplines. It is worth noting that experiments have been remarkably successful in terms of extending, among many other things, the theoretical framework for auction theory in economics. Kagel and Levin (2002) have devoted a whole volume to the experimental research in auction theory and is used successfully in a wide range of social science theorising.

As for the designed bidding experiment, sample selections and analytical methods are important in order to give credibility to the results. The majority of the participants (around 90 per cent) in the bidding experiment are senior management personnel, including director, managing director, estimating and contracts manager, who have experience in bidding exercises. The Hong Kong and Singapore participants have an average of 21 (std dev. = 7.19) and 20 (std dev. = 6.92) years of experience in the industry, respectively and about 70 per cent of them are involved in 80 to 100 per cent of their firms' bidding decisions. I believe that they have engaged in the experiment seriously since they asked relevant questions after reading the instructions and they were willing to participate in both rounds of the experiment. If they had not been serious and had believed all other participants to be serious, there would have been no point in them spending time and effort on the experiment.

For the analytical methods, heterogeneous approaches to statistical modelling were applied to the experimental datasets where the possible correlation and heterogeneity biases[6] have been taken into consideration. The relevant procedures for assessing the resultant models' (four of them) goodness-of-fit have shown that there is no serious violation of any of the relevant statistical assumptions. In addition to the model-checking exercises, the final step for the result validation, perhaps the most convincing step to the majority of readers, involved the application of the resultant models to real past projects. The results show that the resultant models have performed satisfactorily in predicting Hong Kong and Singapore contractors' bid/no-bid and mark-up decisions given that they were developed based on four bidding variables only. It is clear then that the datasets obtained from the designed bidding experiment are consistent for theory-testing purposes.

Turning to monetary rewards in experimental studies, this may lead to the questions: 'how much we should pay?', 'what is a sufficiently high reward?' and 'how small is a too small award?'. Interestingly, Gneezy and Rustuchini (2000) found that offering money does not always produce an improvement. In their experiment, subjects who were offered monetary incentives performed more poorly than those who were offered no compensation. In this case, they asked the experiment subjects to answer a set of questions and promised a payment for each correct answer. However, they have also provided evidence that higher amounts yielded a better performance in their experiments. Several possible interpretations of the results were discussed in their paper, but the important note for an experimentalist to think about is that 'either you pay enough or you don't pay at all'.

In the bidding experiment it is clear that the determination of the 'right' amount of monetary rewards is likely to be difficult and subtle, since all the targeted participants are senior management personnel in their firms and earn 'decent' incomes. For instance, a small monetary reward may be considered insulting where the participants might be concerned about looking 'cheap' for making the effort of participating to collect such small amount. Similarly, a sufficiently high amount may be perceived as too small when we consider other relevant factors like reputation is at stake. Hence, it was decided not to offer any monetary reward to the Hong Kong and Singapore participants in the bidding experiment. Without a doubt, the result validation exercises have demonstrated that they have responded genuinely in the experiment. Instead of monetary awards the participants were offered a copy of the research findings for their participation.

CONCLUSION

This chapter has concentrated on the application of an experimental approach to testing the bidder homogeneity assumption in tendering theory, i.e. that all bidders can be treated as behaving collectively in an identical (statistical) manner. The bidding experiment described has illustrated the importance of, and the need for, experiments if the building economics research is to progress. If we look at what experimental economists do, and the results they achieve in terms of progress in conventional economics, we get the right picture of science learning. That is to say, we should start treating building economics as a science. The essential ingredients for scientific research are, in my opinion, the use of theories, the selection of samples (or experiment subjects), the testing of theories using empirical and/or experimental data, and finally the selection of analytical methods.

The outcome of this experimental research has been that the crucial bidder homogeneity assumption in tendering theory is shown to be untenable in terms of both individual bidders' bid/no-bid and mark-up behaviour. Similarly, Runeson and Skitmore (1999) have shown that the tendering theory fails because it is unable to take into account changes in market conditions, heterogeneity across individual bidders' behaviour and the firms' capacity levels. Hence, future work on tendering should be driven by, or contribute to, the development of a suitable theoretical framework or evaluation of alternative theories. A good starting point would be to examine the suitability of neo-classical microeconomic theory which is claimed to offer a useful means of analysis for construction price formation in a recent work by Skitmore *et al.* (2006). Certainly, experiments are essential in this research area as a means to establish empirical regularities as a basis for a new theory, similar to what laboratory experimental economists and social scientists do as a matter of course.

There are also possibilities of using experiments in other construction management and economics research areas, especially with regard to behavioural studies. Its practicability has been demonstrated in a limited number of papers. For example, Lingard and Rowlison (1998) used experiments in their behavioural-based study on construction safety management. Han *et al.* (2005), on the other hand, studied contractors' risk attitudes in selection of international construction projects using an experimental setting. It is time to look beyond what have become conventional research methods and use what is appropriate from related, well-established disciplines. Here, the conclusion is that an experimental approach has paved the way for real theory testing in construction management and economics research.

NOTES

1 Other than tendering theory, which is now one of the most frequently researched areas of building economics, it also includes various techniques for cost control, quantity surveying, estimating, design evaluations, feasibility studies, investment evaluations and cost engineering.

2 For detailed discussion on tendering theory, see Runeson and Skitmore (1999).

3 The assumptions of homogeneity and stationarity are important within the tendering theory because they solve the problem of empirical estimation of individual-specific parameters as, if each bidder is assumed to bid from the same probability

distribution, all bids made by all bidders contribute to the empirical estimation of parameters will increase the amount of data made available this way, thus allowing the temporal invariance assumption (fixed parameters) to be relaxed at least to a yearly time span (see Skitmore *et al.* 2001). However, it could be expected – indeed very likely – that individual bidders' behaviour is dependent on many individual firm-specific characteristics (e.g. the firm's relative efficiency in terms of management skills), including some that are unobservable by their competitors. This suggests that construction firms are fundamentally heterogeneous, making the bidder homogeneity assumption highly unlikely. In other words, there is heterogeneity in the population of contractors. This heterogeneity puts contractors at varying predispositions for bidding decisions, with varying degrees of preference or sensitivity placed on factors affecting their bidding decisions, in achieving their own performance aim and objectives. The experimental research reported here was based on the premise that there is heterogeneity in the population of contractors. Testing the stationarity assumption is, however, beyond the scope of this research.

4 The measurement of the heterogeneity is only possible if a given sample of construction firms is followed over time, and thus gives multiple observations on each firm, see Hsiao (2003). The resultant datasets are known as panel datasets in statistical texts. The key advantage of a panel dataset is that it allows a researcher to capture within-individual pattern of change (i.e. heterogeneity) over experimental interventions that cannot be addressed using cross-sectional datasets (see Fitzmaurice *et al.* 2004).

5 For the full research report, see Oo (2007).

6 Issues involved in utilising panel datasets that require special consideration in the analyses are: (i) correlation bias – multiple observations from the same individual (bidding for twenty hypothetical projects for two rounds) will typically exhibit positive correlation, and this correlation invalidates the crucial assumption of independence, the cornerstone of many standard statistical techniques; (ii) heterogeneity bias – for a panel dataset, if important factors peculiar to a given individual are left out, the typical assumption that the effects of explanatory variables are identical for all individuals at all times may be not a realistic one. An individual's pattern of response is likely to depend on many characteristics of that individual, including some that are unobserved. Hsiao (2003) highlights that ignoring the individual or time-specific effects that exist could lead to parameter heterogeneity in the model specification. Also, ignoring such heterogeneity could lead to inconsistent or meaningless estimates of interesting parameters. In other words, there is natural heterogeneity across individuals in their responses over different experimental conditions (or over time) and this heterogeneity must be accounted for in the analyses.

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10 Market types and construction markets

Gerard de Valence

INTRODUCTION

The type of market an industry operates in is known as its structure, and in microeconomics there are four types of market. The type of market found in the construction industry is a point of debate among researchers and analysts and this chapter reviews that debate. The aim of this chapter is to establish the relevance of different market types to the construction industry. This is important because of the relationship between market types and the competitive behaviour of firms in the industry.

The literature on market structure issues associated with the construction industry will be reviewed. The following topics are covered. First, the different types of markets and their related forms of competition found in economics are identified and their characteristics discussed. Second, the relevance of market structure to the construction industry is then established. The different views on the application of market structure models to the construction industry are discussed. Third, there is an analysis of two topics that emerge from the review as central to the debate over market structure in the construction industry. These topics are the delineation of construction markets and the definition of construction industry output.

The chapter analyses one of the characteristics of the building and construction industry that is difficult to quantify in a meaningful way – how competitive markets operate in the industry. The difficulties arise from the characteristics of the industry on one hand and data limitations on the other. This makes a discussion about what constitutes markets and market sectors in building and construction important, because how markets are defined leads to conclusions about the intensity and type of competition.

The intensity of competition in an industry is the outcome of its structure, and four types of market structure are identified in the following section. Economic analysis of an industry begins with a study of its market structure, and in industry economics the definition of the relevant 'market' is the determining factor when analysing the nature of competition and structural characteristics of an industry (Scherer and Ross 1990).

The building and construction industry is typically seen as a fragmented, very competitive industry (e.g. Marossezky *et al*. 1997; O'Brien 1997).

Cooke (1996: 138) describes the industry as 'dominated by a large number of small firms' and 'geographically fragmented'. An explanation was given in the 1988 UK report *Faster Building for Commerce*: 'the level of fragmentation was a direct result of the sophistication and complexity of technology used in commercial buildings, the vagaries and variability of demand and the consequent increasing trend towards specialisation, subcontracting and self-employment' (Male 2003: 135).

Ten years after *Faster Building For Commerce* the Egan Report (1998) emphasised integrated project processes and partnering the supply chain to overcome the effects of fragmentation in construction.

MARKET TYPES AND MARKET STRUCTURE[1]

In many construction or building economics texts the starting point for discussion of markets is the neoclassical model of perfect competition. For example, Warren (1993), Cooke (1996), Hillebrandt (2000), Runeson (2000), Gruneberg and Ive (2000), and Ive and Gruneberg (2000) all have chapters on markets in construction and all begin with the characteristics of perfect competition. In Warren and Cooke there is no linking of construction industry characteristics to these market types, and an emphasis on perfect competition. The characteristics of a perfectly competitive industry are many small firms with no control over price, producing the same product under conditions of perfect information and no barriers to entry (see Table 10.1). The other industry model found in neoclassical economics is the monopoly, where a single firm is the only producer.

Because many industries do not have these characteristics and fall between the extreme cases of perfect competition and monopoly the alternative models of monopolistic competition and oligopoly were developed. The 'monopolistic competition revolution' of the 1930s developed theories of imperfect competition based on the work of Chamberlin (1933) and Robinson (1933). Under monopolistic competition there are many small firms with limited control over price, producing differentiated products supported by brand names and marketing with some (often important) barriers to entry. Cooke (1996), Hillebrandt (2000), Runeson (2000), and Gruneberg and Ive (2000) all discuss monopolistic competition in construction markets.

A second monopolistic competition revolution occurred in the 1980s after Dixit and Stiglitz (1977) developed a formalised model of imperfect competition incorporating product diversity and consumer choice. The Dixit–Stiglitz model has been applied in international trade, growth theory and economic geography, and led to renewed interest in issues associated with economies of scale, market power, information and uncertainty (Brakman and Heijdra (2004: 2–3), their book reviews the impact of Dixit–Stiglitz in detail).

The fourth market type is oligopoly. The key characteristics of an oligopoly are a few large (but not necessarily the same size) firms and the significant barriers to entry first identified by Bain (1956), discussed in detail in Chapter 6. The modern theory and definition of oligopolistic markets was developed in the 1950s (e.g. Modigliani 1958) 'as a result of two processes of economic change: the process of concentration (the market share of the largest four, six or eight firms) and the process of differentiation' (Sylos-Labini 1987: 701). Industries that became concentrated oligopolies produce homogeneous product (steel, cement, basic chemicals, electricity), while differentiated oligopolies are found in consumer goods markets. Sylos-Labini describes industries that are concentrated but have differentiated products as mixed oligopoly, such as computers, automobiles, banking and insurance. Sylos-Labini's review found that barriers to entry can substitute the 'competitive mechanism' for distributing benefits of technical progress (falling prices, stable nominal incomes) by the 'oligopolistic mechanism' (stable prices, increasing nominal incomes). Income in this case includes both wages and salaries and profits, and both can become above-normal depending on industry price rigidity and levels of competition (ibid.: 704).

Thus economics has a framework of four models of market structure, each one having a set of distinctive characteristics. Table 10.1 shows the relationship between the four models of market structures and the characteristics of each type. The extent of control over prices is determined by the intensity of competition in a market, which is determined by the number of firms and type of product. The degree of monopoly power exercised by the largest firms in an industry is the concentration ratio, the degree to which an industry is dominated by the largest firms. A monopoly has one producer, therefore the concentration ratio is 100 per cent, while under perfect competition there are many firms, none of which has any market power, and the concentration ratio is zero.

INDUSTRY, MARKET AND FIRM

Another approach to market structure is to base the distinction on product homogeneity (sameness) or heterogeneity (differentiation). Using this approach, monopoly, homogeneous oligopoly and perfect competition are similar, with homogeneous products, and differentiated oligopoly and monopolistic competition are similar, with differentiated products (Scherer and Ross 1990: 17). Scherer and Ross also develop and define two different ideas of competition in economics, one emphasizing the conduct of sellers and buyers and the other emphasizing market structure. On the conduct side, competition depends on resources moving from industries where returns are low to those with comparatively high returns. This requires the absence of barriers to resource transfers between industries. A different, structural concept of competition sees a market as competitive when the number of firms selling a homogeneous

Table 10.1 Market structures and characteristics

Characteristics	*Perfect competition*	*Monopolistic competition*	*Oligopoly*	*Monopoly*
Number of firms in market	Very large	Many	Few	One
Product	Identical, standardised	Differentiated	Identical or differentiated	Unique, no close substitutes
Barriers to entry	None	Few	Significant	Very high
Firm's control over price	None	Limited	Constrained	Considerable, often regulated
Non-price competition	None	Emphasis on brand names, trademarks	Through product differentiation	Use of PR and advertising
Concentration ratio	0	Low	High	100
Information and mobility	Full customer information and mobility	Limited customer information and mobility	Restricted customer information and mobility	No effective choice or alternative
Examples	Agriculture, dry cleaning, commodities	Household and electrical goods	Automobiles, chocolate bars, aircraft	Water, gas and electricity utilities, railways

Note
Developments in regulation and deregulation of monopolistic industries with large network effects, such as utilities, communications and railways, have challenged the idea of these monopolies as unavoidable (see Braeutigam 1989 on introduction of competition into markets where a natural monopoly exists).

commodity is so large, and each individual firm's share of the market is so small, that no individual firm can influence price by varying the quantity of output (ibid.: 16).

The unit of analysis used by Scherer and Ross is the industry, not the market or the firm. This avoids the major problem found when trying to apply market models to particular industries. In the one-product perfect-competition market model the relationship between firms, the industry and markets is relatively straightforward. Firms belonging to the same industry produce a single identical product, which they all sell in the same market. In this framework the industry and the market are identical because each has the same group of firms as producers. However, this identity does not exist where firms are large and produce a range of products, many of which are not close substitutes, and sell in more than one market. In this case industry and market are not equivalent (Devine *et al.* 1985: 27).

> The basic difficulty is to distinguish between products that, although differentiated, belong to the same market and other products that, because they are more differentiated, belong to other markets. The distinction is essentially one of degree and is concerned with the extent of substitutability between products.
>
> (Ibid.: 47)

If industry and market are not equivalent, is the industry, market or firm the appropriate level for analysis? This is particularly relevant to construction because of the diversity of views on precise definitions of the boundaries between industry and market. Further, which is the appropriate market type to apply to construction? To address these questions the key characteristics of construction markets, industry output and arguments for product homogeneity are discussed in turn below.

RUNESON ON CONSTRUCTION AS PERFECT COMPETITION

Is there an argument to be made that the building and construction industry is an example of a perfectly competitive industry? Fleming (1993: 190–193), for example, argues that the different forms of contractor selection reflect different forms of competition.[2] It seems obvious that, because construction uses the tendering system as the basis for price determination, a competitive tender that uses price as the winning factor must represent perfect competition. In fact, this is not the main argument found in the literature.

Runeson (2000: 138–139) examines the structure of the industry and the level of competition based on the idea that market structure determines conduct, which in turn determines performance. Three operational measures of competition are used. The first is number of firms in the industry, based on the ABS Construction Industry Survey of 1996–97, and finds the typical firm small with little expenditure on capital. Second is the concentration ratio, and the share of the largest building firms is found to be 'not sufficient to convey the impression of much market power'. Third is profit levels, with a rate of profit of 4.3 per cent of turnover, below most other industries, and a high proportion of business failures indicating a very competitive industry.

In summing up previous research on competition in markets for building the conclusion was that firm behaviour is the determining factor:

> the large number of firms in typical markets, the ease of entry and exit, the perception of the participants of the market as being very

> competitive, the speed of adjustment of prices in response to changes in demand, and the low rate of profit all seem to indicate that whatever the actual situation really is, firms behave as if they were operating in a very competitive market where price is determined by the competition. That is all that is required for the markets to be defined as perfectly competitive.
>
> (Runeson 2000: 142)

Runeson suggests that there are three characteristics of the building industry (or the market for building management services) that need to be examined to apply a model of perfect competition. These are uniqueness of projects, competitive tendering where prices are determined before actual costs are known, and the large size of individual projects in relation to the capacity of the firm (ibid.: 145–149).

After analysing the factors that affect price determination in the market for buildings, Runeson concludes that the

> most appropriate model is that of perfect competition. In most cases there is a low level of profit and the perception of a very competitive market, and as long as the participants perceive the market as competitive, they will act as if it is.
>
> (Ibid.: 170)

This is a strong argument, based on the behaviour of contractors. A different view based on the role of clients and their choice of procurement method and contractor selection is found in Hillebrandt.

HILLEBRANDT ON CONSTRUCTION INDUSTRY MARKETS

The three editions of Hillebrandt's *Economic Theory and the Construction Industry* are major works in the still-emerging field of construction economics.[3] On the key issues of definition of the industry, delineation of markets and form of competition there were some differences in emphasis between the second and third editions.

Hillebrandt (2000) considers the relationship between construction firms and markets in some detail. For Hillebrandt:

> The construction industry is an industry whose product is the services necessary to produce durable buildings and works. [*and*] In spite of the diversity of the construction industry, in the nature of its product, in the types of organisations and in the process by which production is organised, it is nevertheless one industry. For certain purposes, it is convenient to regard it as a number of sub-industries and it certainly embraces a great range of different markets.
>
> (Ibid.: 4)

In the previous edition this was explained at slightly greater length:

> It is the contracting part of the industry which undertakes to organise, move and assemble the various materials and component parts so that they form a composite whole of a building or other work. The product which the contracting industry is providing is basically the service of moving earth and material, of assembling and managing the whole process. To the extent that the service given and management supplied are similar through various building types, the industry can be regarded as one industry. The service and management will, however, vary according to the technical process involved, and to this extent there is not one industry but many sub-industries which may be regarded as coming under the umbrella of the main industry concept.
>
> (Hillebrandt 1985: 24)

There are many possible sub-industries. These sub-industries can be the trades used in collections of industry statistics or by specialisation in type of work. However, when considering the degree of competition, what is important is the market where firms operate. Chapter 2 of Hillebrandt (2000) starts with a discussion on 'the meaning of market as opposed to industry'. A market brings buyers and sellers together to determine the price of commodities which are more or less close substitutes for each other, and:

> In contracting it means the whole mechanism of the selection of contractor and the fixing of the price at which he will provide his services he has to offer may be provided. The sellers in any particular market in construction are the group of firms whose services to provide various products are more or less substitutes for each other in terms of the type of expertise required.
>
> (Ibid.: 10)

The key characteristics of construction industry markets are the type of product, and size and complexity of the contracts, because as these increase the number of firms capable of undertaking the contract diminishes. This leads to a definition of markets in the construction industry:

> Markets in the construction industry should therefore be defined in terms of the total demand for a particular identifiable service which is not a close substitute for other services outside this market. Relevant parameters include degree of complexity and size, geographical area and type of contractual arrangement. The total number of firms interested in work of this defined type are referred to as being 'in a particular market'.
>
> (Ibid.: 11)

This analysis is one of the most thorough of those attempting to cover these issues. Whether this is a satisfactory solution to the question of market type is debatable, because when applied to construction the determining factor turns out to be not the number of firms interested but client selection processes.

When Hillebrandt (2000) considers the relationship between construction demand and market structure, she links the system used to select contractors to a specific type of market. In Chapter 12 the four basic market types are outlined (as done in Table 10.1 above), and then Chapter 13 considers 'to which broad types construction industry markets belong', including the extent to which the characteristics of a perfectly competitive market apply to the construction industry. Chapter 13 covers nine important topics associated with market type and structure, summarised in a brief form as:

1 *Homogeneity of product:* the service offered by contractors can be differentiated by quality, extent or specialisation, but at the tendering stage the product becomes homogeneous and price becomes the determining factor, therefore 'the market on this criterion is near to perfect competition' (ibid.: 147).
2 *Number of firms:* for simple small-to-medium projects there are many firms that could do the work, but where there are contractor registration schemes, selective tenders, local markets or non-traditional procurement methods (such as build–own–operate–transfer (BOOT), private finance initiative (PFI), partnering and prime contracting) the number of firms and thus competition is reduced; importantly, 'the new arrangements are likely to change substantially the operation of the market for large projects' (ibid.: 151).
3 *Ease of entry and contestable markets*: Hillebrandt argues that there are no barriers to entry for small firms, and no significant barriers for the large contractors that are 'working in a considerable number of markets simultaneously, and if they suspect that in work of the appropriate size the profits are abnormally high in a particular specialism, they are likely to buy in expertise in management and enter the market', therefore competitive intensity is maintained by 'freedom of entry and relative ease of entry from a separate but similar market' (ibid.: 151); however, for large projects at the top end of the market pre-qualification and non-traditional procurement systems will limit access for new firms and 'it may be that there are no firms capable of entering the market who are not already functioning in it' (ibid.: 152).
4 *Perfect knowledge:* 'the whole system of price determination in construction … ensures that perfect knowledge … does not exist' and when contractor's make bids they 'guess' the ruling market price, so 'on the criterion of perfect knowledge, perfect competition certainly does not exist in construction' (ibid.: 153).
5 *Assessment of the extent of competition:* the argument is that for different procurement paths and stages in the selection process there is

a different type of market; the table showing Hillebrandt's scheme for the 'type of market, each way of selecting a contractor and of price determination' (ibid.: 153) in contracting is reproduced as Table 10.2 here.

6 *Level of profit:* 'there is no evidence that large firms in the construction industry are making exceptional profits' (ibid.: 156).
7 *Influence of the client*: because projects are separately let, Hillebrandt suggests 'for a given project the client is the monopsonist', so sophisticated, large and regular clients can substantially determine the degree of competition, but if they are small and unsophisticated they don't have the knowledge to use this market power (ibid.: 157).
8 *Demand curve facing the contracting firm*: this leads into an extended discussion on average and marginal revenue curves based on the effects of the types of markets shown in Table 10.2 and the range of tender prices on a contract (ibid.: 149–152).
9 *Non-resaleable product and single project market*: the service that a contractor sells becomes embodied in a building, and the client cannot resell these services because they have been used up, and the contractor will get as high a price as possible in each 'price-determining situation', the temporary market created by the tender or negotiation for a contract (ibid.: 160).

Hillebrandt takes the contractor as the basic business unit in the construction industry, and the typology developed in Table 10.2 uses the procurement method as the key distinguishing factor between different market types found in construction. In contrast to Runeson, Hillebrandt does not see perfect competition as the typical market type, but as specific to certain stages of the selection process under certain conditions.

The Hillebrandt concept of construction markets is clearly an adaptation of microeconomics to accommodate the characteristics of a project-based industry. The linking of contractor selection and procurement methods to the form of competition through the type of selection/type of market matrix is an important insight, because clients have increasingly used their position to push agendas of reform and improved performance onto the industry (see Gyles' recommendations in RCBI 1992; Latham report 1994 and the Egan Report 1998).

THE IVE AND GRUNEBERG MODEL

Ive and Gruneberg address the distinction between firms, industry and markets. Adjustment of the conventional (neoclassical) model of the market, based on a homogeneous product with no transaction costs and perfect competition, to account for aspects of market behaviour in construction occupies Chapters 4–6 of Ive and Gruneberg's *The Economics of the Modern Construction Sector* (2000). They suggest that:

Table 10.2 Hillebrandt's assessment of type of market in contracting

Type of selection	*Stage of selection*	*Number of firms*	*Product differentiation*	*Type of market*
I. Many firms in the market:				
Open tendering	Tender	Many	None	Approaching perfect competition
Selective tendering	Pre-tender	Many	Substantial	Monopolistic competition
	Tender	Few	None	Partial oligopoly without product differentiation
Two-stage tendering	Pre-tender	Many	Substantial	Monopolistic competition
	Tender	Few	None	Partial oligopoly without product differentiation
	Negotiation	One	n.a.	Limited monopoly
Negotiation	Pre-selection	Many	Substantial	Monopolistic competition
	Post-selection	One	n.a.	Limited monopoly
II. Few firms in the market:				
Open tendering	Tender	Few	None	Oligopoly without product differentiation
Selective tendering	Pre-tender	Few	Substantial	Oligopoly with product differentiation
	Tender	Few	None	Oligopoly without product differentiation
Two-stage tendering	Pre-tender	Few	Substantial	Oligopoly with product differentiation
	Tender	Few	None	Oligopoly without product differentiation
	Negotiation	One	n.a.	Limited monopoly
Negotiation	Pre-selection	Few	Substantial	Oligopoly with product differentiation
	Post-selection	One	n.a.	Limited monopoly

Source: Hillebrandt (2000: 154). Interestingly, this table is the same as in the Second Edition of *Economic Theory and the Construction Industry* (1985: 147).

Note

Partial oligopoly is where firm behaviour is influenced by expectations of other firm's behaviour, but the firms does not have a large share of the market, as in a full oligopoly. Limited monopoly is where the ability of the client to remove a contractor is limited.

> In practice, it is not possible to define the construction industry to make it synonymous with the execution of all construction activity. The basic way any industry is defined is as a set of firms. The population of firms in the economy is divided into industries on the principle of potential competition. Firms are put in the same industry if they produce outputs which are similar or reasonably close substitutes for one another, or if they use similar technology and materials, and are therefore in competition in markets to buy these inputs. If these two criteria conflict, it is the similarity of inputs that is the more important criterion used to define an industry, whereas similarity of outputs is used to define a market.
>
> (Ibid.: 7)

This view differs from both Runeson and Hillebrandt above. Where the previous authors see the service of construction management as a homogeneous product offered by contractors, Ive and Gruneberg suggest that on both the output and input sides there are significant differences between different parts of the building and construction industry:

> The construction sector certainly comprises several industries and several markets. Its constituent industries comprise sets of firms engaged in each stage of the process of production of the built environment. Thus the firms of each stage compete directly (actually or potentially) with one another, and thus constitute an industry. The firms of other stages in the process stand not as competitors but as suppliers or buyers from that industry.
>
> (Ibid.: 7–8)

They then go on to

> develop the view that it makes sense to regard construction as fundamentally split into just three sub-industries ... main contracting of all kinds, subcontracting, and speculative building. Each of these has certain fundamental and distinctive business characteristics that make the differences between them outweigh the differences within them.
>
> (Ibid.: 13)

As well as their contrary view of construction industry and markets, Ive and Gruneberg have a different view on industry output and a different answer to the question: Can the standard concept of a homogeneous product be applied to construction? In a companion volume to Ive and Gruneberg,[4] Gruneberg and Ive suggest that 'In construction, product markets can be seen as sets of projects, clients and producers' (2000: 106). Also, there are no 'clear product markets' or 'a tendency towards homogeneity within product markets or a single product market unit price' (ibid.: 107). Runeson's answer to this is that the industry is the market for building management services, not for products called buildings. Hillebrandt has a similar view. The Gruneberg and Ive model is therefore distinctive, in that it sees construction industry output as a product rather than a service.

This point is picked up in the next chapter where the question of what the construction industry actually provides to clients is addressed.

OTHER VIEWS

Cooke (1996: 138) states: ‘There is strong evidence to suggest that there are examples of both oligopolistic and monopolistic competition’, but does not, however, go on to provide any data or supporting arguments for this claim. The evidence provided in the following section in his book was based on the UK *Housing and Construction Statistics* between 1983 and 1993 (DoE 1994). Cooke found the proportion of firms with up to seven employees rose from 89.3 per cent, employing 31.1 per cent of the workforce, to 94.3 per cent employing 40 per cent of the workforce, while firms employing more than 80 people remained at less than 1 per cent of the total with the share of employment falling from 36.9 per cent to 32 per cent of the workforce. In 1992–93 the small firms did 28.4 per cent of the work and the large firms 43.1 per cent (Cooke 1996: 140).

Ofori (1990) recognises that there are many heterogeneous small firms in the construction industry, and discusses (and provides data for) Singapore, the United States, Canada and Western Europe. However, the conclusion is:

> whereas the construction industry has a pyramid structure, the distribution of its workload takes the form of an inverted pyramid. In other words, the industry is relatively concentrated. The small firms are generally uncommitted, transient, undercapitalised, have poor access to credit, operate within limited geographical areas, and seldom apply modern management tools.
>
> (Ibid.: 77)

Ofori arrived at a definition of the construction industry as: ‘persons, enterprises and agencies … involved in physical construction; and those providing planning, design, supervisory and managerial services relating to construction’ (ibid.: 24). This definition means the construction industry ‘assembles what other sectors of the economy produce: Therefore, it appears to be a service industry’ (ibid.: 25). Six features of construction are identified that have the characteristics of services industries (ibid.: 25–26):

1 Its products cannot be resold on completion by those involved in their design and erection.
2 The industry provides managerial skills to convert materials and components into a building or works and this expertise cannot be resold once committed or used.

3 Products cannot be transported or stored.
4 Labour-intensive and no standardised products, so it does not have economies of scale.
5 The service offered differs between clients.
6 Only managerial and technical skills can be exported.

Ofori (1990: Ch. 4) details the five characteristics of construction goods as unique, indivisible and expensive, immobile, subject to external influences (such as cultural and economic), and susceptible to the actions of government. Given these characteristics, the markets for construction items 'possess very few of the features of perfect competition (ibid.: 110).

Using construction activity data

Another approach to construction sub-markets is to use the statistical divisions used by national agencies to provide data on building and construction activity. Although there are differences between countries, all agencies broadly follow the Standard Industrial Classification (SIC) based on the UN *System of National Accounts* (SNA 1993).

The SIC used by the ABS has four levels: divisions (the broadest level); subdivisions; groups; and classes (the finest level). At the divisional level the main purpose is to provide a broad picture of the economy. Industries are called a division, and there are 17 divisions. The subdivision, group and class levels provide increasingly detailed data. Each subdivision has a two-digit code and each group a three-digit code. Each class is represented by a four-digit code.

To use the data from the Australian Bureau of Statistics (ABS) as an example, statistical data on the construction industry is broken into the engineering construction, non-residential, and residential building sectors, and the data is provided for each of the eight states and territories. For each of these sectors, data is given by a number of sub-sectors. Residential building is divided into detached and non-detached dwellings, plus alterations and additions. Within the non-residential building sector, there is ABS data on twelve different building types, divided into offices, retail, factories, health, and so on (ABS *Building Activity*). For engineering construction there are highways, ports, power, oil and gas, and other categories (ABS *Engineering Construction*).

Because demand for different types of construction good is influenced by different variables, Ofori divides construction into four categories: housing; commercial and industrial buildings; social type construction; and repair and maintenance (1990: 111). These categories also represent data available on construction activity in Singapore.

Briscoe (1988) and Shutt (1995) base their approach on the data available, and thus both discuss the categories used by the DoE when publishing UK activity data. Shutt defines sectors of the industry by type of work, and uses the structure of the data available on the UK industry as the basis of his approach to markets and products. Shutt initially breaks the industry into building works and civil engineering works, and then explains that it is necessary to further break down these categories 'in order to analyse more accurately current trends in construction activity' (1995: 91). Using the DoE classification system there are the two major groupings of new work and repair and maintenance (R&M). New work comprises public and private housing, industrial and commercial work, and other new public work. R&M is divided into public and private housing and public and private other work. This approach is also followed by Briscoe (1988: 114–135).

CONSTRUCTION MARKETS

Complex, overlapping patterns of substitutability have been an issue in industrial economics since Chamberlin (1933) first developed his definition of an industry as a product market limited by substitution, with industries identified by their product. If industries are broken into separate sub-industries in order to address this problem, the choice can be between any number of different groups of products. The products may be close or distant substitutes, and may be products of firms on other technological trajectories using different production techniques.

There are three broad areas covered in the following discussion. First is the Hillebrandt typology of contracting markets. Second is the question of whether construction contractors specialise in production of particular works. Third is the three-industry framework of Ive and Gruneberg.

Contracting markets

Is the approach taken by Hillebrandt, with the distinction between the types and stages of different selection systems, appropriate? Fleming (1993) also bases his analysis of competition on contractor selection methods. The central role played by contractor selection and procurement methods is one of the distinguishing features of the construction industry, and one of the determining factors in project performance. The focus of the influential Latham Report (1994), for example, was procurement and the contractor–client relationship.

The issue here seems to be whether the use of procurement systems as a means of defining markets is the best approach. If two projects for a similar building, a high-rise office building or a high-rise apartment building for example, are completed under widely different contractual systems, say cost plus and project management, are these really two different markets in any recognised sense? This seems intrinsically unlikely if markets and products, or the services provided, are to be the basis of the method of analysis.

A further complication is that here is no agreement on what the construction industry produces. As the literature reviewed above shows, some believe that the industry provides services (management, coordination, finance); others believe the industry delivers products (buildings and structures). The former group argues that the main task of the industry is one of coordinating site processes, while the latter are more concerned with the physical production of buildings and works.

On building and construction as a product there are two views. On one hand is the data-driven approach of Shutt or Briscoe, where the markets that constitute the building and construction industry are characterised by a wide range of different products (as in buildings and works), and these products are represented by the data available from statistical agencies. Ofori broadly follows this path with his division of construction into four industries.

On the other hand, Gruneberg and Ive (2000) argue that construction product markets are not delineated and products are not homogeneous. As discussed above, their model divides the industry into three distinct sectors based on the characteristics of the output (product) of 'main contracting of all kinds, subcontracting, and speculative building'.

Further, Gruneberg and Ive (2000: 91–92) suggest that the application of 'the conventional concept of product differentiation' leads 'some construction economists' to 'describe the product of the construction firm not as the building but as a construction service'. They argue against the 'output as a service' view because:

> The rules of selective competitive tendering on price contain an assumption that all tenderers are equivalent or undifferentiated in terms of the quality of the service they are offering. Differentiation under this market arrangement is … into approved and non-approved, or tender listed and non-listed, firms.
>
> (Ibid.: 2)

The alternative to the product approach is argued by Runeson and Hillebrandt. Their solution to the product homogeneity problem is to define it away, by making the industry's output a service, the management of construction, rather than a product (buildings and structures). Ofori also argues for construction as a service industry. The importance of 'management' in construction is clearly apparent, because the industry uses subcontractors to do the majority of work onsite.

Runeson (2000) argued that the role of builders and contractors is to organise the production process, thus providing a service, while the delivery of the product (a building or structure) is the responsibility of the subcontractors who carry out the work. He suggests:

> the argument that since builders build buildings that are different in size, design location and time, they are marketing different products, can be very effectively countered by the argument that builders do not

> sell buildings. They sell the management services required for: the procurement of the necessary resources – labour, materials and equipment, the mobilisation of the resources on the building site, the management of the resources to complete the work, and the demobilisation of the resources when the work is completed.
>
> (Ibid.: 143)

By restricting the analysis to the level of main contractors, as Ofori, Runeson and Hillebrandt do, it is a logical step to argue that the role of contractors is to provide management services for clients.

Specialisation

Applying the idea of sub-markets to the building and construction industry raises a range of issues. The first is the general lack of specialisation of firms in the construction industry in terms of their product. Ive and Gruneberg (2000: 12) argue that 'it is mostly not the case that the larger firms are specialised' in either building or civil engineering, but have separate divisions operating in sub-markets.

Generally, there are few firms that work across all three of the engineering construction, non-residential, and residential building sectors. Typically firms work in either the residential or the non-residential sectors, with some of the largest firms in both the engineering and non-residential building sectors. High-rise residential is similar to office and hotel buildings in materials and methods, and many contractors do both commercial and residential towers.

However, some firms specialize in building particular types of buildings or works. In Australia, Grocon specialises in high-rise office and residential buildings and Westfield specialises in shopping centres, and only a few of the largest firms such as Leighton Holdings and Baulderstone Hornibrook do both civil engineering and building work. Bovis Lend Lease, Multiplex and Leighton Contractors are examples of Australian firms (operating internationally) that provide construction management or project management services with a focus on managing processes, but the range of services and expertise offered by these contractors varies widely.

Some firms cross these market boundaries, some stay within them. However, more commonly a building contractor will apply management skills to a range of building types, and not limit themselves to specific submarkets (Hillebrandt 2000: 26). Therefore, for the construction industry specific sub-markets are difficult to identify because firms can be highly specialized in one area, or they can be highly generalized and put up a wide range of buildings and structures.

The conclusion seems to be that specialisation is not an issue in the construction industry when considering the boundaries of industry and market.

The lack of economies of scale in construction (Fleming 1993 and Runeson 2000) and the generalised nature of contractors' application of their management skills means that the role of specialisation found in manufacturing industries (see, e.g. Sutton 1991) are not significant. However, this begs the question of whether the contractor level is the only level of analysis appropriate for the construction industry, or should the various subcontractors be considered in their own right?

Subcontractors as an industry

Would following Ive and Gruneberg (2000) in dividing the industry into three be appropriate? Is the product market approach used in their analysis preferable to the 'homogeneous service' approach of Runeson and Hillebrandt? Finally, how are the subcontractor markets to be distinguished?

What, however, is the role of subcontractors and what do they produce? Ive and Gruneberg are the only ones to address the role of subcontractors in construction, and to give them recognition as a distinct sector with characteristics of resource use and output that make it different from main contractors. This is clearly an issue that should be addressed, but has not been a feature of the construction economics literature to date.

CONCLUSION

The purpose of this chapter was to assess market structure issues associated with the construction industry. The chapter therefore covered issues associated with the types of markets construction firms operate in and the characteristics of construction output.

From this analysis, it appears that the appropriate model of construction industry markets will depend on three variables: the definition of the industry's product and output; the existence or not of sub-markets within construction; and the sector of the industry that is to be analysed. As the review of previous literature in this chapter has shown, there is no agreement on these variables.

On the definition of construction output there are two views. On the one hand is the majority view that it is management of the production process, and therefore a service. On the other hand, some writers see output as the production of buildings and structures, physical products with certain characteristics that differentiate construction from manufacturing or other industries. Between these two competing views, one that the industry provides a service and the other that it produces a range of buildings and structures, there is no single knockdown argument that can conclusively settle the debate. There is merit in both views.

This makes the theoretical structure given to different types of markets, based on the idea of clear product markets, problematic when applied to construction. In theory, where industrial economics specifies product and market characteristics in order to identify the form of market structure, the requirement is typically for either identical products, or for clearly identifiable markets for those products. The Chamberlinian definition of the industry as a product market does not easily fit the construction industry.

Similarly, there are two views of the appropriate level that the market is defined at. The majority discuss competition in the context of the contractor–client relationship and make the tendering and procurement process the central feature of competition, and argue that the behaviour associated with tendering and winning projects is the determining characteristic.

Gruneberg and Ive differ from the majority view on both these points. First, on the definition of the industry's output their view is that it is a product. Second, on the existence or not of sub-markets within construction, they argue that subcontractor markets exist in a separate and distinct way from contractor markets. This is a distinctive view not found in any of the other research on construction markets.

Thus, for the construction industry the definition of the market is particularly opaque, as the issues raised in the discussion above highlight. Are all buildings and structures to be regarded as a single product, or are bridges, shopping malls and apartment blocks distinct and different markets? Does it make sense to suggest that different types of buildings are substitutes for each other? Do contractors offer a homogeneous product/service to clients?

In the end, it is probable that the answers to these questions are indeterminate, because of the range of issues addressed in the discussion. This is not unusual in the industrial organisation/industry economics field, and is why many cases involving transactions between firms bought under competition law are decided on a rule of reason basis rather than a *per se* legal basis. However, this does not mean the issues should not be considered when analysing aspects of the construction industry. Therefore the approach that is suggested is that, when the analysis involves markets or products, the specific form that is subscribed to should be identified.

NOTES

1 This section and the one below on perfect competition are repeated from Chapter 6.

2 Fleming is the only author discussed here to raise the issue of collusive tendering where selective tendering is used (1993: 192).

3 See Ofori (1990) for the view that construction economics has not yet developed to the point where it could be recognised as a distinct part of general economics.

4 Ive and Gruneberg, *The Economics of the Modern Construction Sector* and Gruneberg and Ive, *The Economics of the Modern Construction Firm* were published together in 2000. The latter's analysis of market structure and barriers to entry is in the next chapter.

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11 The methodology of building economics research

Göran Runeson

INTRODUCTION

Academic research into building economics is comparatively new, if by academic research we mean the kind of research we have in well-established academic disciplines. It seems that a new discipline, like building economics, goes through a set of stages before it reaches scientific maturity. Initially, there is no research and the writing is prescriptive. When the research begins, it's essentially descriptive. This stage is followed by a stage of explanatory or analytical research where the aim is to build and test theories. The final step is the problem-solving stage where the theories and analytical techniques developed in the previous stage are used for forecasting and predictions or to solve practical problems.

Where, then, is building economics research now? The most descriptive answer is probably: 'in total confusion'. The confusion starts with the variety of opinions about what is covered by the concept 'building' economics. To some it is a science, a branch of conventional economics, distinct only in the way it is focused on various aspects of the built environment. To others, it is a set of techniques for estimating, valuing and evaluating the output of the construction industry.[1] Most of us probably fit in somewhere between these two extreme views – just as conventional economics incorporates also a number of techniques such as Discounted Cash Flow analysis or the construction of index numbers, so can building economics when based on conventional economic theory – but it's my feeling that over the last 20–25 years there has been a quite considerable move towards seeing building economics primarily as derived from and being a part of general economics.

With building economics just entering the stage of analytical research, there is confusion also about both the meaning and the role of research in the discipline. The development of analytical techniques, particularly statistics, has been impressive, but there has been no corresponding progress in the evolution of an underlying theoretical framework. It is my opinion that at least part of the reason for the lack of progress has been the use of poorly defined, inconsistent and often conflicting methodologies.[2] It is interesting to draw parallels between building economics where research has been fairly, if not totally sterile, and conventional economics where substantial progress has been accompanied with an almost continuous and often vigorous methodological debate.[3]

The aim of this chapter is to show that the methodology we select for building economics research matters. I'll do that by illustrating some of the methodological issues involved in formulating and testing theories. I'll expose my biases when doing that, because I'll use the similarities between conventional and building economics and draw on the methodological debate in conventional economics.

In places, to illustrate what may happen if we don't consider methodological issues, I'll make references to the theory of tendering as outlined by Gates (1967) or Park and Chapin (1992).[4] It is a good demonstration of what may happen in a state of methodological confusion, such as that currently found in building economics. Finally, I'll touch on some recent developments sometimes referred to as qualitative research.

The emphasis is not on the empirical implications of testing theories but rather on the methodological, extending the idea of testing theories beyond their predictive and explanatory abilities into an evaluation of the structure of the theories for a more comprehensive understanding. The theory of tendering is especially interesting in this context, as it is one of the few, if not the only, example of a theory developed specifically by and for the construction industry. It is a theory of how prices are determined for building and construction projects, but it is radically different from the more conventional pricing models developed in neoclassical micro-economic or auction theories.

Especially over the last 25 years the interest in methodology has increased substantially in science in general and in conventional economics in particular. When I was an undergraduate student, it would have been difficult to put together a reading list for a full semester course on economic methodology, but as early as 1989, Redman's bibliography of economic methodology contained more than 2000 works, while Backhouse (1994) and Caldwell (1993) listed four new major journals dealing exclusively with economic methodology issues and another five which frequently publish articles on economic methodology. The internet has helped expand this even more with specialised publications like *The Qualitative Report*, now in its tenth year and devoted entirely to qualitative research, and publishers like Sage have added to the offerings. As a result, the range of philosophies and methodological propositions is greater and the common ground less than ever before. A comprehensive review of recent developments in methodology must therefore be outside the scope of this study.[5]

Rather, I'll concentrate on mainstream methodologies for formulating and testing economic theories. This means essentially what we can refer to as a sophisticated falsificationism of the kind advocated by, among others, Blaug (1992) and the objections to Blaug as articulated by Caldwell (1991, 1994), Putnam (1974/1991, 1978) and others, and we will come back to this after a small digression to look at what has happened in building economics, in terms of discussions on methodology.

The answer is: not very much. While the methodology of conventional economics has been examined and re-examined over the last 40 or so years, there has been no corresponding separate study of building economics.[6] However, building economics as a derivative of conventional economics, shares most of its characteristics and most of the debate in economics has also been relevant for building economics. While the apparent simplicity of the structure of tendering theory should make tendering theory, as developed by Gates, comparatively simple to evaluate, it has, in addition to all the characteristics it shares with conventional economics a number of its own, very special problems as discussed later.

FALSIFICATION AND MOTIVATIONAL ASSUMPTIONS

The best-known philosopher of science in the twentieth century is, no doubt, Karl Popper, and one of the best known of his contributions to the philosophy of science is the demarcation criteria between science and metaphysics. According to Popper, 'a statement has the status of belonging to the empirical sciences if and only if it is falsifiable' (Popper 1983b: xix). This statement is behind one of the major methodological issues in economics. The issue is well illustrated in a small anecdote told by Caldwell. Talking to Blaug, he asks him to explain the difference in their positions on methodology, and Blaug answers 'We both think falsification is hard to put into effect in economics. You say we should abandon it and I say we should try harder' (Caldwell 1994: 138).

This sums up, not only the major differences between the positions of Blaug and Caldwell, two of the leading methodologists in economics, but much of the contemporary methodological debate in economics. The problem with economic theory – and also tendering theory – is that it is difficult, if not impossible, to test the theory in such a way that it can be falsified. The first problem is that the central core assumption in both cases is a motivational assumption: to maximise profit. An additional problem is the so called Duhem–Quine thesis (discussed below), and each of the two, as we will see later, would in practice make it virtually impossible to attempt any conclusive falsification of either theory. The extensive use of the *ceteris paribus* condition[7] in conventional neo-classical micro-economics can have the same effect as the Duhem–Quine thesis, in terms of making falsification difficult. Tendering theory, on the other hand, is a probabilistic theory. This means that in principle, there is no outcome that would conclusively contradict the theory, hence there is no way in which it could be falsified in the way Popper suggests.

The problem with having a motivation as the generative assumption is that there can be no unconditional causality. This has been discussed by, among others, Hausman, (1985, 1989), Klant (1984: 184–186), de Marchi (1988: 12–13) and Redman (1991: 119). One way of illustrating the problem of a hypothesis based on a motivation is presented by Rosenberg (1994:

224). His argument is that motivations are not classes of natural phenomena like ‘gene’ or ‘electrical charge’. They are not sets of items that behave in exactly the same way and share exactly the same, manageable, small sets of causes and effects.

Rather, motivations require individual interpretations of the consequences of specific behaviour. We have to stop and think about the effects of what we do. This, of course is particularly evident in the case of imperfect competition in micro-economic theory, where as a result the models are non-deterministic, unless the behaviour is specified.[8] The debates about rational expectations or the consistency between short-term and long-term profit maximisation are other examples of issues where a specific motivation may lead to different behaviour, depending on how we interpret the consequences of our different ways of behaviour. This means that there is not necessarily a unique relationship between our motivation and our behaviour and therefore, people cannot be brought together in unconditional causal generalisations that enable us to predict and control individual human actions. Because there is no ‘right’ response, motivational assumptions cannot be falsified.[9]

This means that because of the characteristics of our motivational variables, we cannot expect to improve our motivational explanations beyond their current level simply by attempting falsification. As the assumptions cannot be improved, neither can our system of propositions about markets, consumption and production. Accordingly, there can be no progress in the way natural sciences progress through empirical testing and attempted falsifications.

As an illustration to one of the problems that result from our inability to falsify social science theories, Rosenberg (1994: 225) draws the parallel between economic theory and Euclidean geometry – the science of space. Euclidean geometry, like economics, is a totally deductive system based on a set of ideal assumptions, and it also has only a limited or regional truth, but, unlike economics, there is an underlying theory – the general theory of relativity – that defines and delineates the region where it applies and how it must be modified outside this region. Without a corresponding general theory that sets out the regions where the hypothesis of profit maximisation is true, economic theories will neither become more accurate nor provide a better understanding about the regions where they are true.

The problem with falsification, and all of what that brings with it in terms of theoretical developments, is not confined to conventional economic theory. It applies equally well to tendering theory. Like conventional economics, tendering theory uses profit maximisation as a generative hypothesis.

An alternative to Popper’s uncompromising attitude to falsification is provided by Lakatos (1970, 1971, 1977). Lakatos saw a system of theories, like economics, as a research programme that could be built around a metaphysical hard core – in this case a non-deterministic causality – but protected from testing by belts of subservient or derivative theorems. To get to the centre, where the theory could be falsified, the protective belts would all have to be removed by falsification, just like peeling off the layers of an onion. A successful research programme, according to Lakatos (1970), is not one that withstands falsification, because falsification is really not an issue. Rather, it is a theory that offers corroboration and the best way of doing that is to be progressive, by generating new theories that can provide new insight into a range of new problems. An inadequate theory, on the other hand, is a degenerative programme – a research programme that provides no new insight or development.

While degeneration does not necessarily imply anomalies of the kind required for falsification, and is not necessarily irreversible, a reversal would normally require fundamental changes to the theoretical framework (Riggs 1992).

Progressive and degenerative theories can only be recognised in hindsight by the ability of theories to corroborate novel facts, but tendering theory must now, after 40 years, be considered as a degenerative theory, not having contributed any new insight into price determination in the construction industry. Neo-classical micro-economics, on the other hand, has provided such insight in terms of explaining changes in price level and profits over the business cycle, capacity adjustments in response to changes in activity, systematic variation in competitiveness of tenders, and so on.

The difference here between Popper and Lakatos doesn't necessarily make Lakatos a 'softer' option, but it certainly opens up a different method of evaluating theories and places him much more in line with actual practice in economics, a field dominated by attempts to explain a wide range of economic phenomena on the basis of a very small number of behavioural assumptions. Lakatos has also had a much greater influence on economics than has Popper with his more uncompromising attitude. The issues where Lakatos (1970, 1971, 1977) differs from Popper (1959, 1972, 1983a) are exactly the issues where there are substantial differences between what Popper postulates and what most social scientists actually do (Hands 1993a: 68).

In terms of Lakatos' criteria, tendering theory fails miserably in that it is, and always has been, totally sterile, while conventional economic theory is made to look very good.

THEORY TESTING

The kind of theoretical system we have in conventional economics is called positivist or post-positivist. In any positivist or post-positivist scientific research, we have a theory that consists of a set of assumptions (hypotheses, statements, axioms). Normally, the assumptions are of two kinds: (i) generative statements from which we may derive the hypothesis itself and (ii) auxiliary statements that are used in conjunction with the hypothesis in order to logically deduce theorems or predictions (Melitz 1965: 42–43).

For the testing to be conclusive, the theory should be applicable to the aspect of the real world that is tested; the relevant variables must be specified so that they may be accurately observed and quantified and must represent the reality that is tested. The theorems will convert a set of observations into predictions and, provided that no *ceteris paribus* condition has been violated, these predictions may be compared to an actual event.

In conventional economics, we have the generative assumptions of profit maximisation and utility maximisation. Together with a well-specified set of auxiliary assumptions, such as the specification of the conditions for perfect competition, *ceteris paribus*, these assumptions produce the prediction of an equilibrium where price, marginal revenue, marginal cost and average total costs are all equal (AR = MR = MC = ATC). The logic has been well established and the auxiliary assumptions are well defined and enumerated in the literature, and the proposition that there is any ground for rejection on these counts can safely be rejected.

In tendering theory we also have a profit-maximising generative assumption, but the auxiliary assumptions are mostly implicit, and the definition of profit maximisation, the operational concept that is actually written into the theory, is logically flawed as there is a huge difference between maximising the net return to the productive resources of the firm, which maximises profit, and the maximised expected value of each tender as proposed in the theory.

Figure 11.1 outlines the processes involved in theory testing. The processes we have just listed are represented by ovals. With one exception, any of them may introduce a deviation between a prediction and the outcome without being considered a falsification. The only source of such a deviation that would automatically cause rejection of a hypothetico-deductive theory, such as the conventional or building economics, is if the logical reasoning is invalid – although even this has been questioned in the context of the Duhem–Quine thesis[10] (Betchel 1988), as we will see below. First, however, we will look at the realism of the assumption. This is a very important issue, because of the relationship between the assumptions and the applicability of a model. Without realism in the assumptions, it is impossible to determine the applicability – the domain – of the model.

THE REALISM OF ASSUMPTIONS

One of the issues in a methodological examination of a theory is the realism of assumptions. Most introductory texts in the social sciences start by explaining that some abstractions are necessary in all theorising, to remove any non-essential features of the agents, events or forces, and to focus on the essential aspects. Without abstractions, the reality is too complex to observe. The logical conclusion of this is that it is the purpose of the theory that determines the aspects of reality to be observed and therefore the degree of realism needed of the assumptions.

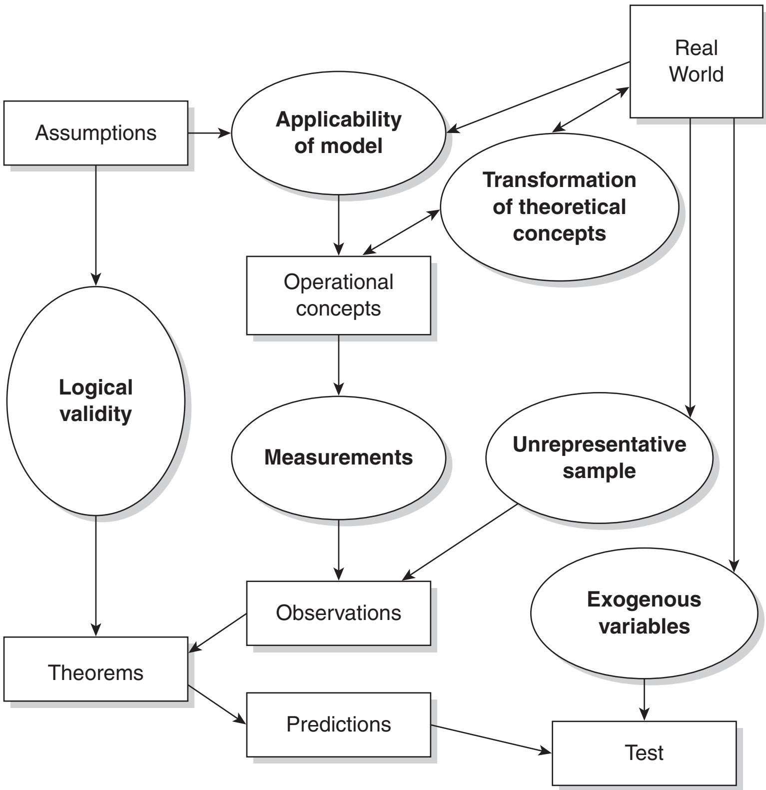

Figure 11.1 A diagrammatic representation of theory testing. The ovals represent processes that have the potential to cause distortions of the predictions.

Source: Adapted from Runeson (1983).

While the extreme instrumentalism of Friedman (1953), that totally rejects the need for any form of realism of assumptions, would now be rejected by most economists, whether conventional or building economists, there is little agreement about how much realism that is required of theoretical assumptions. Machlup sees this as a totally pragmatic issue. He argues, in his 'Principle of the relativity of the relevance' (1952), that the purpose of economics is not to explain the behaviour of a business firm, but to account for the behaviour of market entities or of the economic system as a whole (1967). This means that concepts like that of the firm need only be mental constructs that exist in the theorist's mind, but not in reality. While this may sound convincing, it is far from the final word on the issue.

An alternative proposition, attributable to Friedman (1953), is that assumptions may be regarded as '*as if*' statements, i.e. that certain events take place *as if* the assumptions were true. This means that we don't need to assume that the assumptions are true, but also, more importantly, that a theory does not aim to answer 'why' something happens, but only 'how it may be possible'. In contrast, van Fraassen suggests that 'Science aims to give us, in its theories, a literally true story of what the world is like, and acceptance of a scientific theory involves the belief that it is true' (1980: 8). Not only need the predictions be true, but every part of the theory itself. As a generalisation, the stronger our view that science should explain, rather than, or in addition to predict, the stronger our demand for realism in the assumptions.

While it may be possible to construct arguments why both Machlup's and van Fraassen's positions may be accepted, and the 'as if' assumptions may be valid in the sense that they appear to be useful in certain circumstances (especially in some branches of physics) the middle-ground for conventional economics and building economics as well as for most other social sciences, would appear to be closest to van Fraassen.

As Melitz (1965) points out in his polemic with Machlup, a conditional statement, by itself, gives no observable implications whatever and cannot be accepted in isolation from other statements. For instance, if I make the statement 'if *A* is true, then *B* is true' I don't say anything about the state of the world unless we know that *A* is true. The combined assertion of 'if *A* is true, then *B* is true' and '*A* is true' implies, however, *B* and all implications that *B* may have (also Putnam 1974/1991). To be able to state this argument, we need to be able to say with absolute certainty if *A* is really true. This means that there is a logical requirement that all assumptions are true. Accepting this requirement has the added advantage that it identifies uniquely the domain of the theory, as the area where all assumptions are true. A theory without this specification, is in practice untestable because any refutation can be countered by the argument that the theory has been incorrectly applied.[11]

This also provides us, as Nooteboom (1986: 199) argues, with a middle ground for testing, between the instrumentalism of Friedman and the *a priorism* of van Fraassen. It is in the form of a methodology that combines 'indirect' empirical tests of the logical implications of a theory with direct theoretical and/or empirical tests of the auxiliary assumptions.

This kind of testing is presumably what Popper refers to when he re-entered the debate on the 'science' in social sciences almost 50 years after his original demarcation statement[12] by saying that '*as long as a metaphysical theory can be rationally criticised*, I should be inclined to take seriously its implicit claim to be considered, tentatively, as true' (1982: 199, emphasis added). He continues that:

> Any critical discussion of it will consist, in the main, in considering how well it solves its problems; how much better it does so than various competing theories; whether it does not create greater difficulties than those which it sets out to dispel; whether the solution is

> simple; how fruitful it is in suggesting new problems and solutions; and whether we cannot, perhaps, refute it by empirical tests.
>
> (Ibid.: 200)

Furthermore, '*the so called method of science consists in this kind of criticism*. Scientific theories are distinguished from myths merely in being criticisable, and in being open to modifications in the light of criticism' (1983b: 7 emphasis added).

While Popper's change of heart absolves both conventional economics and tendering theory from the demand that it should be falsifiable in principle, it offers no real relief to tendering theory. It is quite clear that the lack of realism in the assumptions of tendering theory constitute a problem with applicability, and therefore with testing. This is especially so as it doesn't recognise changes in demand and therefore assumes away changes in the behaviour of the tenderers as market conditions change. Neither the explicit nor the implicit assumptions represent any form of known conventional market for builders (Runeson 1996). Conventional economics, on the other hand, has a more appropriate set of assumptions, in line with actual markets, which have withstood repeated tests.

CORRESPONDENCE RULES

How variables are measured is crucial for any form of testing. Hypothetico-deductive models require that a theory can be related to the real world through transformations or correspondence rules that translate the concepts in the theory into observational concepts – concepts in the real world that can be observed and measured. A theory depends for its truth or falsity on how it reflects the world that is external to the theory. Similarly, inductive theorising requires that the observational variables can be transformed into unique theoretical concepts. This need for correspondence, which is an additional argument in favour of realism in assumptions, is essential for any verification or falsification.

The Duhem–Quine thesis suggests that for theories where the correspondence rules are not part of the theory itself, the fundamental concepts of either verifying or falsifying a scientific hypotheses on the basis of testing cannot be argued (Bechtel 1988). This is because operational variables cannot be taken as theoretically given specifications that are absolute and unmodifiable. Rather the operational variables must be seen as subject to revision as testing generates new or negative evidence. Whenever a theoretical prediction is threatened by an empirical result that is based on operational definitions of theoretical terms – that is, in practice, every time it is threatened – one strategy to protect the theory is to immunise it by rejecting the operational definitions.

Bechtel's interpretation of the Duhem–Quine thesis goes much further than to suggest modifications of operational concepts that provide the 'wrong' answers, and argues that in some circumstances 'in deciding where to modify our theoretical structure in the face of negative evidence, we may choose to modify the propositions of logic and mathematics as well as those more generally thought of as part of empirical science' (1988: 43).

Accepting the full implications of the Duhem–Quine thesis would take us about as far as we can get towards complete scientific anarchy. However, even in a less extreme form, the thesis explains, or at least provides a reason for, the long survival of tendering theory. This is the curious definition of accuracy of tenders used by writers on tendering theory. Accuracy of tenders and therefore the probability density functions of tenders are defined, not in terms of the relation of the tender to the actual cost of providing the service – as one would expect – but in terms of its conformity to other tenders. This, in turn has made it possible to ignore the systematic changes in the price level and profitability over the business cycle, that empirical tests have established (Andrews and Brunner 1975, Chan *et al.* 1996, McCaffer *et al.* 1983, Runeson 1988). With a more appropriate operational definition of accuracy in tendering, it would have been evident that the assumption of fixed probability density functions is not applicable to any market affected by the changes in the degree of competition, which is one of the defining aspects of most construction markets.[13]

EXOGENOUS VARIABLES AND UNREPRESENTATIVE SAMPLES

Exogenous variables and unrepresentative samples will obviously contribute to false outcomes. These are results that justify our tendency to prefer to blame the researcher rather than the theory whenever we get a wrong answer. Whenever the specifications of a model are incomplete it is possible to suffer from these outcomes even when there is no obvious problem. There is, however, no cause to reject a theory because of these problems, unless they affect the applicability of the theory, which, of course, is a possibility.

CORROBORATION AND VERIFICATION

While there are exceptions, the prevailing view would be that the motivational assumption and the Duhem–Quine thesis in both neo-classical microeconomics and tendering theory preclude falsification, and make direct testing all but impossible in principle. However, some indirect corroboration and verification is still possible. Putnam (1974/1991) has suggested, that a theory may be corroborated by investigating the validity of its auxiliary statements. He refers to this as 'Schema II', where Schema I is the attempted falsification of a theory that Popper suggested, and Schema III is when the theory but not the facts are known:

Theory + ?????? auxiliary statements = Fact to be explained

Here, the problem is not to derive a prediction but to find the auxiliary statements which best explain the known facts. While this does not constitute an attempt to falsify the theory, and for obvious reasons cannot verify the theory, it may indicate different degrees of corroboration, depending on the extent to which the auxiliary assumptions are identified. It is interesting to use this test to compare our two theories. For a number of known characteristics of construction markets, such as the pattern of relative competitiveness demonstrated in the 'cusum' curve[14] (McCaffer and Harris 1989), the systematic change in profitability over economic cycles (Chan *et al.* 1996) or the differences between input and output price indices, the appropriate auxiliary statements are close to those of the neo-classical micro-economic price theory but have no correspondence to statements in tendering theory.

Popper (1959), in discussing the implication of a theory passing repeated testing, maintained that this didn't mean that the theory was increasingly likely to be true. Popper could argue this because he saw the testing and the use of a theory as different functions where only the testing was the proper job of a scientist.

By rejecting the separation of testing and application of a theory as different functions with only the testing belonging to the realm of science, Putnam also rejects Popper's contention that a failure to falsify a theory does not reduce the number of potential alternative theories to explain a phenomenon. For Putnam (see also Suppe 1977) it means that corroboration leads to acceptance of a theory, *since this is the theory that the scientist will apply*.

> We judge the correctness of our ideas by applying them and seeing if they succeed; in general and in the long run, correct ideas lead to success, and ideas lead to failure where and in so far as they are incorrect. Failure to see the importance of practice leads directly to failure to see the importance of success.
>
> (Putnam 1991: 134)

However, Putnam goes one step further in his disagreement with Popper:

> If 'this law is highly corroborated', 'this law is scientifically accepted', and the like locutions merely meant 'this law has withstood severe tests' – and there were no suggestion at all that a law which has to withstood severe tests is likely to withstand further tests, such as the tests involved in application or attempted application, then Popper would be right [*in rejecting induction*]; but then science would be a wholly unimportant activity. It would be practically unimportant, because scientists would never tell us that any law or theory is safe to rely upon for practical purposes; and it would be unimportant for the purpose of understanding . . ..
>
> (Ibid.: 122)

Putnam's use of induction, while methodologically very different from the logical empiricism of Lakatos that we have discussed earlier in this chapter, complements Lakatos' concepts of progressive and degenerative theories.

Corroboration through adduction, like Putnam's verification, is an inductivist approach. In the hypothetical statement 'if *A* is true, then *B* is true; *A* is true, therefore *B* is true', we must *affirm the antecedent* in order to conclude that *B* is true, i.e. that *A* is true. If the premises in the hypothetical statement were to read 'if *A* is true, then *B* is true, *B* is true'; it does not follow that *A* is true. To assume that *A* is true would be to *affirm the consequent*, and the conclusion that *A* is true would not follow with logical necessity.[15]

Adduction changes the emphasis: 'B is unexpectedly observed. If A was true, B would be true. Hence it is a likelihood that A is true' (Hoover 1994: 301, following Peirce). This is clearly not a logical deduction, as it is logically invalid, but rather a form of inference. It is also a form of empirical testing of a theory as it indicates the extent to which observations fit a theory.

This concept of testing has been formalised by van Fraassen. He suggests that while we cannot know for certain, we may reasonably believe that a model is empirically adequate when all the appearances fit the empirical substructure of the models (van Fraassen 1991). By extension, a model is empirically inadequate without this fit.

Conventional economics is strongly corroborated by all the methods we have explored under this heading and although that doesn't conclusively demonstrate that it is true, it is in stark contrast to tendering theory, which performs very badly on all criteria, in a way that strongly indicates that it is not true.

THE DEVELOPMENT OF TENDERING THEORY

What is possibly the most interesting aspect of tendering theory is that its development does not appear at any stage to have been the result of a deliberate choice, collectively or individually, between competing theories of economics. Rather, tendering theory seems to have developed in total isolation from conventional economic theory, essentially among academics in professional schools of quantity surveying, building and construction management, and civil engineering, as if there had been no existing alternative theory. It is now the unquestioned centrepiece in the discipline of building economics – for those that see the discipline of building economics as consisting primarily of various techniques for cost control, quantity surveying, estimating, design evaluations, feasibility studies, investment evaluations and cost engineering. It is an essential component for a separate discipline that exists, totally divorced from conventional economics.

Even now, despite some 40 years of parallel theoretical developments, in particular in the areas of auction theory, tendering theory and investment evaluations, there is virtually no evidence of contact between the practitioners in the two branches of economics, the conventional, fully developed, mature science of economics and the new building economics, whether based on conventional economics or built around tendering theory and various techniques.

Kuhn (1970) provides what appears to be at least a partial answer to this isolationism in his discussion of the characteristics of a mature science. His concept of a mature science was of a community of scientists who collectively shared a paradigm and a set of research interests. This means that economists and building economists, with their different research interests, publications and general community, have never interacted despite an overlapping subject matter. Rather, they act as 'members of different scientific communities [*and*] live in different worlds' (1977: 309). Since observations and 'facts' are not independent but determined by the interpretation of the paradigm, there are no neutral empirical observations by which scientific theories can be judged, hence no necessary reason for concordance between developments in different scientific communities.

This view of science, as a set of separate communities, which has been further developed by Barnes (1977, 1982), Bloor (1976, 1983), Shapin (1982), Coats (1984) and Mäki (1992, 1993) introduces an irrevocable social element into science and makes it possible to analyse the process by which scientific communities and scientific knowledge is created and how scientific ideas are communicated.

The perspective provided by the sociology of science can lead in many directions, and some of the motivational aspects for the progress and direction of science are put very forcefully by Bloor:

> [T]he social factors concerned may be ones which derive from the narrowly conceived interests or traditions or routines of the professional community . . .. Much that goes on in science can be plausibly seen as a result of the desires to maintain or increase the importance, status and scope of the methods and techniques which are the special property of a group.
>
> (1984: 80)

Mäki expands on the same motive, but stressing the economic aspects of the sociology of science: '[S]cience is . . . analogous to a capitalist market economy in which agents are maximising producers who competitively and greedily pursue their self-interest' (1992: 79), a perspective shared by Latour and Wolgar (1986) and Roth and Barrett (1990).

Given this economic view of scientific activity, together with traditions, professional interests, techniques and status, it is easy to see how tendering theory developed. From the traditional economist's point of view, building is an untidy and complex industry that is difficult to penetrate, best left alone at a time when industrial studies generally carry a low status. From the building professions' point of view, there was no formal training in economics which could have resulted in membership in, or access to, the economic community, but rather a traditional set of techniques that could be developed within tendering theory in such a way that the profession would be enhanced.[16] Once the foundations of tendering theory had been established in the vacuum created by the disinterest of conventional economics, different avenues for publications and peer review ensured that there would be no overlap.

This process of separate developments was no doubt simplified by the lack of an obvious micro-economic foundation for macro-economics up until the 1970s, as mainstream macro-economics is accepted and embraced, at least partially, also by building economists. Had neo-classical micro-economics been an essential foundation for Keynesian macro-economics, there would have been an obvious conflict between the two theoretical systems, and tendering theory would have been rejected or transformed in such a way that it could be integrated into the predominant theoretical system.

RECENT DEVELOPMENTS

At the beginning of this discussion I suggested that building economics research was in total confusion, and that one of the elements of this confusion has been the lack of a methodological awareness which, among other things, has allowed the development and survival of tendering theory, discussed above. The fact that tendering theory has not passed on any of the methodological criteria discussed here while surviving for 40 years is a strong indication of the problems underlying research in the discipline. Another element, which I haven't discussed so far, is the increasing popularity of so-called qualitative research leading to methodological individualism. While this has essentially happened in construction management research following a paper by Seymour and Rooke in 1995, the close physical and intellectual proximity of construction management to building economics in many academic programmes, especially when the latter is seen as a separate discipline, has meant that the influence has extended also into building economics.

Until now, I have assumed that we should have methodological monism meaning that all scientific theories, whether natural or social, should be tested, rejected or verified in the same way and on the same criteria. It is true that economic phenomena are rarely derived from strict laws of nature, but when we admit non-deterministic causal relations, derived from the choices of individual persons, it is clear that economic phenomena can be tested, within the limits set in this chapter. In fact most of our social explanations depend on assuming such non-deterministic causal relations between social events and processes (*The Cambridge Dictionary of Philosophy* 1995).

While the difference between natural laws in the natural sciences and the interpretation necessary for human social activities has been noted,[17] and the impact of motivational hypotheses on falsification outlined, in the positivism and post-positivism discussed above, our concept of reality – our ontology – and the nature of knowledge – our epistemology – have essentially not varied across the different sciences. All that has been needed has been to add a mechanism in the social sciences, so that a change in one variable can cause a change in another variable.[18]

Qualitative researchers have changed all that. Their paradigms come in several different versions,[19] and in some forms they offer an interesting complement to conventional science. However, in their extreme forms, such as constructivism, and critical theory, the belief in a common ontology and epistemology is rejected. The positivists and post-positivists believe in an ontology, in which there is an objective reality that exists independently of the human mind, and it is the purpose of science to uncover the rules that govern that reality. The constructivists, on the other hand, believe in a relativist reality that is constructed by us, is both socially and contextually specific, and changes over time. This reality exists only in the mind of the person or persons that have constructed it, and there are no general rules that govern this reality (Plack 2005, Krauss 2005). Reality cannot be understood in terms of independent variables as it is either individually constructed or negotiated and agreed upon between members of a social group.

Similarly, in terms of epistemology or the nature of knowledge, positivists and post-positivists believe that knowledge is objective and neutral and exists independently of the 'knower'. Constructivists, on the other hand, believe that knowledge exists only in the mind of the 'knower' and that it consists of interpretations that are context dependent and value loaded. As this kind of knowledge is created by interactions between individuals and accepted by relative consensus, the researcher is the primary research tool for the constructivists, and should be intimately involved rather than being a distant, or neutral observer as in positivist research (Plack 2005). While this represents different research paradigms and different philosophies rather than differences in methodology, such major differences have obvious methodological implications.

The major differences include the rejection of methodological monism, by asserting that social sciences are fundamentally different from the natural sciences, and the acceptance of methodological individualism, which emphasises the individual over the social entity. According to methodological individualism, social entities must be reducible to a set of individuals, social concepts must be reducible to concepts involving only individuals and finally, social regularities must be derivable from regularities of individual behaviour. What that means is that since we can't guarantee that every person will react in exactly the same way, we don't have unconditional causality.[20] Without unconditional causality there can be no theories and no science. We can't even have objective knowledge.

Positivists and post-positivists use experiments and other rigorously defined methods administered by neutral and disinterested researchers to test a priori hypotheses, and validation is seen in the terms we have discussed here. The constructivists, on the other hand, use interactive methods with inductive reasoning in a research design that evolves during the study and the goal is to develop an understanding of the reality that their subjects have constructed. They believe that this construction – multifaceted and complex – cannot be reduced or studied in isolation (Crotto 1998; Kim 2003). Theories and generalisations have no role in this kind of qualitative research (Meyer 1999). As a social construct, a reality cannot be generalised, there can be no prediction, no forecasting and no science as we know it in the context of theories and models, generalisations and forecasting.

This brings up validation, which for constructivist research cannot be the positivist criteria of reliability, applicability and objectivity (Guba and Lincoln 1994). Rather, in a situation where there are assumed to be many realities, there is no way to distinguish between trustworthy and not trustworthy results as there is no way to distinguish between 'good' or 'bad' accounts of these realities (Plack 2005).

Critical theory, like constructivism, is a conglomeration of various 'isms' including Marxism and feminism. They have in common that they aim to challenge the assumptions behind the perceived oppression of their class, gender or race to improve the well-being of the oppressed. The issues include how power dynamics shape social attitudes and in this way direct research. The research of the critical theorist is deliberately biased and the goal is to expose injustices resulting from an uncritical acceptance of a dominant culture as expressed in conventional research. Reality is seen essentially as a historical artefact shaped by social, political, cultural and economic factors and wrongly accepted as objective (Kincheloe and McLaren 2000). The ultimate aim of the research is not to find the truth, but to improve the well-being of the oppressed. Science, in this view, is a resource in a struggle for social dominance, described by Gross and Levitt as 'a parable, an allegory, that inscribes a set of social norms and encodes, however subtly, a mythic structure justifying the dominance of one class, one race, one gender over another' (1994: 46).

As in constructivism, there are no agreed criteria for validation or evaluation of research in critical theory. Like constructivism, critical theory is not sciences in the sense of generating generalisations and forecasts or judged by internal and external validity, reliability and objectivity, as neither are aims of the researcher. Hence, this kind of research, like the constructivism, has little or nothing to offer to a theoretical system for research into building economics.

CONCLUSIONS

This chapter has brought together and discussed a number of methodological issues that are important in both the formulation and testing of theories.

In particular we have looked at the testing and validation of theories under various philosophies. We have also looked at the structure of theories, in particular the need for realism in assumptions and the importance of transparent correspondence rules. The aim is not to formulate a consistent methodology for the discipline, but to illustrate the importance of, and the need for, a wide-ranging methodological debate if the discipline of building economics is to progress. We have seen the danger of not applying methodological criteria to our work in the development and survival of tendering theory, despite its failure to pass any methodological tests.

We have also looked at the philosophical and methodological implications of so-called qualitative research in the forms of constructivism and critical theory. They are different from quantitative research, not primarily in the way variables are defined and data measured, but in the fundamental views of what is reality and how we extend knowledge. In contrast to positivism and post-positivism, they are based on an ontology that assumes that reality is a social construct, that there are no rules governing the reality and that all knowledge exists only in the mind of the 'knower' dependent on context and time. This means that we can have no science in the form of theories and forecasting. This kind of research is the scientific equivalent of playing Trivial Pursuit with the exception only that we do not even have an accepted method of judging the winners.

In conventional economics significant scientific progress has been accompanied by a vigorous methodological debate. I think it is more than just a coincidence that in building economics, there has been little or no methodological debate at the same time as the science has remained virtually totally sterile. One aspect of this debate should be to look outside the narrow confines of our own discipline and use whatever is appropriate from related, well-established disciplines.

NOTES

1 Some also make a distinction between 'construction economics', which is used to denote theories derived from conventional economic theory, and 'building economics', which they use when referring to the set of valuation and pricing techniques. This distinction appears to have no particular merit, and is not made in conventional economics, which also includes a mixture of theories and techniques for various purposes.

2 This may seem a harsh judgement, but as I'm writing this, I'm also reviewing papers for a conference, and it is depressing seeing the waste generated by writers trying to solve problems already solved in conventional economics by attempting to fit them into theoretical frameworks especially designed for the occasion without much regard for logic or internal and external consistency.

3 For a different opinion on the need for a methodological debate, see Stigler (1963: 63), who proposed – unfortunately without testing – the hypothesis 'that methodological discussions have never had a marginal product of scientific progress above zero'. Schumpeter regarded methodology not only as totally sterile but as

a direct obstacle to progress in science (Schneider 1951: 108), while Hawking suggests that methodologists are failed practitioners 'who found it too hard to invent new theories' and so took to writing on the philosophy instead of how other people did it (1994: 35). However, the statements were made at times when the most basic methodological issues were, at least temporarily, resolved within their respective sciences.

4 Essentially, it proposes that a tenderer will maximise the expected value of each tender when selecting mark-up on costs, assuming that the identities of the competitors are known and that their tenders are distributed in known and unchanging probability density functions.

5 This means for instance that some of the fringe movements like the extreme instrumentalism of Milton Friedman (1953) or the sociology of writers like Hands (1993a, b) will not be discussed, although it is not possible to ignore Milton Friedman altogether given the impact that he has had on the methodological discussion. Constructivist philosophies will be outlined only briefly to demonstrate the contrast.

6 There was, in the 1990s a short debate on the merits of qualitative research, following the publication of a paper by Seymour and Rooke (1995), but that ran out of steam within a year or so without anyone taking much notice.

7 *Ceteris paribus* or 'everything else being equal' is a methodological device used to break up a complex situation so that we can examine each of several relationship sequentially, and then aggregate their effects rather than attempt to examine all relationships simultaneously. In many ways, this may have the same impact on testing as has the Duhem–Quine thesis in that it is not possible to defend, absolutely, the proposition that nothing has changed.

8 For instance, the kinked demand curve.

9 According to Popper's criterion, economics, together with many other social sciences, should therefore not be counted as sciences.

10 Also sometimes referred to as the Quine–Duhem thesis.

11 Note, however, Friedman's (1953: 19–36) contention that the valid use of assumptions to specify the domain of a theory can not be interpreted to mean that the assumptions can also be used to determine, uniquely, the domain: '[T]here is no inconsistency in regarding the same firm as if it were a perfect competitor for one problem and a monopolist for another.' However, this extreme instrumentalist view is not widely shared.

12 The statement originally appeared in the German version published in 1934, although it was not translated into English until 1959.

13 It is quite instructive to examine the way Gates first arrived at the probability density function of competitors' bids (1967: 82). Rather than using the ratio (Competitor's Bid)/(Own Cost Estimate), he assumes that the own bids all 'include an allowance for profit equivalent to 5% of the bid price', and calculates the ratio as (Competitor's Bid)/(Own Bid {min} 5%), thereby eliminating, by assumption, the very possibility that the own and the competitors' mark-ups may have changed in response to market conditions or desire to win a contract. Comparing competitors' bids to either the actual cost or cost estimate would have shown if this assumption could be supported, or rather, that it could not be supported.

14 A curve that shows how the average bid changes over a sequence of bids. The cusum curves typically show that a winning tender is preceded by a series of

successively more competitive bids until success, after which a new cycle of high but falling bids starts again.

15 However, while it is logically incorrect to affirm the consequent, it is logically correct to deny the consequent: ‘If *B* is not true, then *A* cannot be true.’ Hence, it is logically possible to falsify but not to verify.

16 Cf. Drake and Hartman (1991) who suggest that building economics originated in quantity surveying, where estimating and tendering are important professional skills.

17 It’s a new idea only in the sense that it has become increasingly popular in the last 10 years or so in the discipline. It is, however, drawing on ideas first expressed in the nineteenth century but traceable even further back in time (see, e.g. Hughes 1980).

18 A mechanism linking the antecedent condition to the consequent.

19 There is a wide range of opinions about what constitutes qualitative research, ranging from the use of non-quantitative data to the constructivism and critical theory discussed here and including grounded theory. The common factor seems to be that the research is not aimed at testing or constructing theories – many of the approaches do not accept the existence of theories in social sciences. Rather, in a very value-loaded terminology used by the proponents of qualitative research, their aim is to generate understanding by seeing the reality through the eyes of their subjects. Grounded theory, which is an exception to the above, in that it acknowledges the importance and existence of theories, is not a theory about research, but a strategy to extend the status of theories to sets of inductively generated research propositions without further validation, so by-passing the normal development of new theories in conventional science.

20 In economic theory, for instance, it is not enough to be able to say that if the price of a good in any market decreases, more will be purchased. We must be able to demonstrate that every individual in the market, without exception, in every possible situation, will be buying more of a good when its price goes down in order to qualify as a valid relationship, according to this view. This means that if I’m worried about my cholesterol level, and therefore don’t buy more butter when the price goes down, I provide a sufficient reason for rejecting all of economic theory.

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