THE DEVELOPMENT OF CONSTRUCTION ECONOMICS SINCE THE 1970s

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Introduction

In the opening paragraph of *Economic Theory and the Construction Industry* Hillebrandt (1974) says construction economics (CE) is "the application of the techniques and expertise of economics to the construction industry", a definition that has been broadly endorsed for nearly five decades. The book was, and is, an important milestone in the development of CE. It was the first time CE had been presented as a distinct form of industry economics, a branch of economics that had a burst of development in the 1940s and 1950s, and it linked an extensive, well-developed body of work on the macroeconomic role of the construction industry with the prevailing economic paradigm of the time, the neo-classical synthesis. The analysis of the demand and supply sides of the construction industry explicitly incorporated four characteristics: the physical nature of the product; the structure of the industry and organisation of the construction processes; the characteristics of demand; and the method of price determination, either by tendering or some form of negotiation. Hillebrandt concludes "In view of these unique characteristics of construction, there is a need for the development of a new theoretical economic analysis, or at least for adaptation of existing theory, to assist in the understanding of the workings of the construction process, the construction industry and the construction firm." (1974: p. 9). This is an assessment of how those challenges were met in the following decades.

The discussion mainly focuses on theoretical developments in CE in the treatment of processes, industry and firms and is divided into three periods, in each period research

contributions to the three broad areas Hillebrandt identified of process, industry and firm are discussed. The first period from 1966 to 1989 is one of emergence and establishment, as topics are investigated and the literature develops. The second period from 1990 to 2007 covers the expansion and development of CE as new approaches such as transaction cost economics and lean construction are applied. The third period from 2008 to 2020 is one of consolidation, which brings the story to the present.

Although a discussion on the nature of a field of inquiry implies some delineation of scope, as in the topics for investigation, the contents of the Elgar *Research Companion to CE Research* (Ofori 2021) and other recent books are in themselves evidence of the scope of CE. The more limited discussion here focuses on development of theoretical understanding of the "workings of the construction process, the construction industry and the construction firm." The conclusion argues that CE is in the process of establishing a distinctive research agenda and that the scope of CE is a strength rather than a weakness, because this reflects the nature of an evolving economy and a construction industry which can be defined in various ways. The openness of CE to ideas from economics has led to important insights into construction firms and markets, and the relationship between the industry and the wider economy.

A note on presentation and handling of sources is required. This is an overview of research, not a compendium, and tells the story with broad brush strokes and some prior knowledge of basic concepts assumed. Nonetheless, there is a great deal of material. The approach followed uses representative publications from each period for the topics discussed, and the citations in those publications should be referred to for more detailed study. Individual papers are cited (Author, date). Most of the works cited are used as a shorthand way of providing links to more extensive research on specific topics. Particularly useful are the relevant review papers and journal special issues that have been used where possible[1]. Some points of interest and supporting material are in the Endnotes.

In 2007 a conference on 25 years of publications in *Construction Management & Economics* provided the opportunity for an assessment of developments in CE research, and identified the areas and topics that had been addressed in the literature. The issues raised in those

reviews of CE form part of the discussion of the third period, along with the availability and quality of relevant data, which has been a significant constraint on empirical research in CE. Nevertheless, the scope of CE has been broad, and an economic perspective has been turned on many aspects of construction and its relationship with other industries, the economy and society. That the boundaries and therefore the profile of CE are indistinct is discussed.

Hillebrandt's book (there were eventually three editions in 1974, 1985, 2000), provided a template for later texts written for students in construction and built environment courses (such as Briscoe 1988, Raftery 1991, Runeson 2000 and Myers 2017). These books, and many others, have approached the adaptation of current economic theory to building and construction in a way that both reflects the industry and remains accessible to students. This context is important. The origins of CE are not in the economics departments of universities, but in courses with diverse students who might take one or two economics subjects, such as Hillebrandt's post-graduate classes. These courses typically sit in schools of the built environment, construction, engineering or project management.

Also in the 1960s, many under-graduate quantity surveying courses in the UK and other countries where the profession is established became building economics courses, where key topics like cost estimating and control, measurement methods and building technology were taught. Accreditation for these courses required an introductory economics subject. As a result, some of the most useful work in CE, including that published in journals, employs fairly basic economic concepts, but requires detailed knowledge of the construction industry and its characteristics. This is a distinguishing feature of CE, one shared with other branches of industry economics like health, transport and urban economics, where industry specific knowledge is combined with economic theory to analyse and understand structure and dynamics under specific conditions. Economic theory, in turn, is based on models of markets, supply and demand and so on.

Models take many different forms (Morgan 2012), depending on discipline, compare physics to sociology, but share the purpose of explaining and the method of testing by prediction (Page 2018). They can be formal (i.e. mathematical) or informal, and are based on evidence

and data. Models of the construction industry, and theories about how and why the industry functions as it does, have progressed through a series of stages of increasing sophistication. The contribution of CE research has been fundamental to that evolution. This chapter focuses on development of models (mainly as mental maps) of firms, industry and processes for two reasons. First, because they are shared with other branches of economics that are focused on specific industries, they are the bridge between them and CE. If CE has developed distinctive models of firms, industry and processes, that argues for a distinctive identity for CE. Second, these models fundamentally underpin researchers' approach to their work, but are not much discussed because their basic outlines are widely known and agreed upon. As the following discussion shows, much of CE research is based on construction statistics and cost data, and is empirical rather than theoretical, but that does not mean such models are not important and are not incorporated into that research. Note that 'construction statistics' is used strictly here, referring only to the data produced by national statistical agencies. Construction data includes other public and private sector sources.

Period 1: Emergence and establishment 1966-1989

The 1960s is taken as the starting point for CE research. On the one hand, prior research into the economics of construction was concerned with the macroeconomic role of the industry, and on the other hand was building economics, called 'project economics' by (Ofori 1992). In the decades leading up to the 1970s, construction had attracted the attention of economists because of its role in investment and macroeconomic importance. When Kuznets (1930) compiled the first set of long-run statistics on US output, from 1869, he found a 15-25 year pattern in construction that came to be known as the Kuznets Cycle, beginning an enduring interest by macroeconomists in the relationship between construction activity and the business cycle (Riggleman 1933, Duca et al. 2010). The business cycle is short-run fluctuations in the rate of economic growth, and construction is the component of investment expenditure that is most sensitive to economic conditions. Thus, in many countries, the level of construction work done is the most volatile sector of the economy as it goes through these periods of expansion and contraction (Barras 2010).

The macroeconomic role of the industry was the subject of Lange and Mills (1976), whose book coined the phrase “the balance wheel of the economy” to describe the counter-cyclical effect of construction, particularly housing, in response to a lowering of interest rates in a recession. This enduring idea is heard today in calls for increased infrastructure expenditure to counter ‘secular stagnation’, as the slowdown in GDP growth rates after the financial crisis that started in 2007 is known (Summers 2016).

Also, during the 1960s a profile of building and construction emerged from economic histories of the industry in the UK (Bowley 1966) , US (Fitch 1973) and Australia (Hutton 1967): the industry had many small firms, typically subcontractors, a small number of medium size firms ,and a small number of large contractors; demand was uncertain and unstable, so firms minimized fixed costs and capital spending; incremental innovation and problem solving were strengths, but new technology spread slowly (Bowley 1960); and productivity grew slowly, if at all (Dacy 1965, Cassimatis 1970). Among the topics addressed by economic histories of construction were building materials and labour costs, prices and price indexes, industry structure and subcontracting, housing policies, training and productivity. As an economics of construction began to emerge, these topics were carried across the divide between history and the present to became part of the research agenda found in CE.

The issues this profile raised were addressed in the earliest research on the organization of construction. Stinchcombe (1959) contrasted bureaucratic and craft systems of work administration: manufacturing has mass production with economies of scale through standardization of tasks, but construction uses standardized products and parts. In craft production work administration and control is given to workers and foremen, but they do not make decisions on product type, design and price, which are made by others, variously referred to as administrators, bureaucrats, clients and employers. Stinchcombe argued bureaucratic administration requires long production runs and predictable work-flow, while uncertainty and variability in work-flow will make subcontracting and the craft system more efficient.

By the 1960s national accounting had developed and more data was becoming available. Attention shifted to the role of construction in long-run economic growth as the relationship between infrastructure investment, capital formation and GDP growth rates was established, becoming a major focus of economic research. In industrialized economies, construction was typically around half of gross capital formation (GCF) and around 10 percent of GDP. However, rapidly industrializing economies in Asia and elsewhere could have construction shares of GDP of 20 or 30 percent, or more. This is a pattern found repeatedly since, for countries to take-off into growth rates above 10 percent a year very high levels of GCF may be required.

Construction's role in economic development was the focus of a report to the United Nations by Turin (1966), on *The Place of Construction in Economic Development*, another founding text in CE[2]. By putting construction at the centre of the analysis of the macroeconomy in development research Turin (1966) and Strassman (1970) provided the foundations for the incorporation of the characteristics of construction into the analysis of construction firms and markets. That project was initially pursued at the Building Economics Research Unit (BERU), established by Turin at University College London in the late 1960s after his appointment as the first Professor in Building in 1966. The BERU began a series of studies on the building process, the functions of its participants, how the industry responds to demand, and the possibilities of 'industrialising' the industry. By the mid-1970s that research had led to a Building Economics and Management MSc, the first edition of Hillebrandt's *Economic Theory and the Construction Industry* and Turin's *Economic Analysis of Construction* (1975)[3]. The treatment of processes, industry and firms in those two books provide a reference point for the first phase of development of CE to the end of the 1980s.

Firms

The textbook neoclassical model of a firm is sparse and lacks detail. Based on cost and demand functions a firm maximizes profit as a 'black box' that mysteriously but efficiently turns inputs into outputs as its contribution to total industry output. Firms are optimisers of scarce resources constrained by technological capacity. In introductory texts this is presented graphically as the set of choices a firm faces to minimize marginal cost and maximize profit based on marginal revenue. Firms here are price takers, they are small relative to the market, do not have market power, and products are homogeneous.

Hillebrandt (1974) used this model in chapters on costs, demand and equilibrium for a firm. However, Hillebrandt ranged widely, with alternative views on the objectives of the firm (growth, revenue, managers' incentives), costs for project-based firms, revenue curves and mark-ups, product differentiation, and the effects of different types of markets included. That discussion incorporated the characteristics of construction, based on Hillebrandt's familiarity with the British industry, and came to two key conclusions. The first was perfect competition due to ease of entry. Even with a limited, selected number of tenderers there is 'effective competition', with the same outcome as perfect competition. The short discussion of imperfect competition (pp. 136-38) is conventional and construction is not mentioned. The second conclusion was that marginal analysis is appropriate for project-based firms. This model of the firm can also be found in Briscoe (1988) who, like Hillebrandt and Cannon (1990), attempted to reconcile neoclassical economics with construction industry characteristics.

At this time, at the end of the 1980s, three books that took significantly different approaches to the industry and the firm appeared. Ball (1988) gives a Marxist analysis of British construction, thus focusing on social relations and the contracting system, and claims "One theoretical avenue which seems of little use in studying the industry is to apply neoclassical economic theories of the firm" (1988, p. 19). The dual role given to firms as producers (of buildings) and merchants (purchasing inputs) foreshadowed the trade credit/cash farming literature to come, with Ball arguing the merchanting role predominates at the expense of wages and productivity.

By contrast, Bon's *Building as an Economic Process* (1989) applied Austrian economics to construction. This branch of economics, a polar opposite to Marxism, is relevant to construction because it emphasises capital and the capital stock, the pivotal role of investment in capital formation, the explicit role of the time taken for investment decisions to be fulfilled, the cyclic nature of economic and building activity, and the possibility of production plans or projects failing. Firms here are vehicles for investment, preparing plans and sourcing the capital required, and the building process is a series of decisions on the use of capital. The book strongly linked construction (supply) to the property market (demand) through capital flows and the need for ongoing repair and maintenance, and Bon suggested

this relationship should be the basis of a research agenda in CE. However, much of that research is now in the atheoretical area of life-cycle costs, and Bon's book remains the only use of Austrian economics in CE.[4] Despite the appeal of the Austrian approach, it had its heyday in the 1980s and has since faded because it is discursive, lacking formal models and empirical methods (Blaug 1992).

In their book Hillebrandt and Cannon (1989) argue it is "inherently difficult to relate the economic structure, behaviour and performance of contracting firms to theoretical models" (1989, p. 6). Their alternative is managerial economics (on firm decision-making) and management theory (on business strategy, organization theory and human resources), explored in seven of the eight other contributions to the book. This illustrates the large grey area between CM and CE, where topics like these are of mutual interest and cannot be considered from an economic viewpoint without reference to industry custom and practice.

Thus, at the end of the 1980s, there were four distinctly different concepts of construction firms, supported by detailed analysis of the industry in Britain, where these researchers worked. These were: Neoclassical firms in competitive contracting markets; Marxist firms acting as producers and merchants; Austrian firms circulating capital between construction and property; and Managerial firms organized for construction.

Industry

One way CE differentiates itself from CM is by emphasising the management of firms rather than projects, although this border is an open one in both directions. A clearer boundary is the analysis by CE of the industry, as the context for firms, which is not found in CM with its focus on projects. In the 1980s, industry analysis followed the structure-conduct-performance framework associated with Bain (1956) and the Harvard School, with the challenges from TCE, empirical industrial organization (IO) studies and game theoretic approaches still developing. As noted above, the analysis of the conduct (management) of construction firms in CE was deeply embedded in an understanding of the structure of the industry, which is completely different from the manufacturing industries studied in IO.

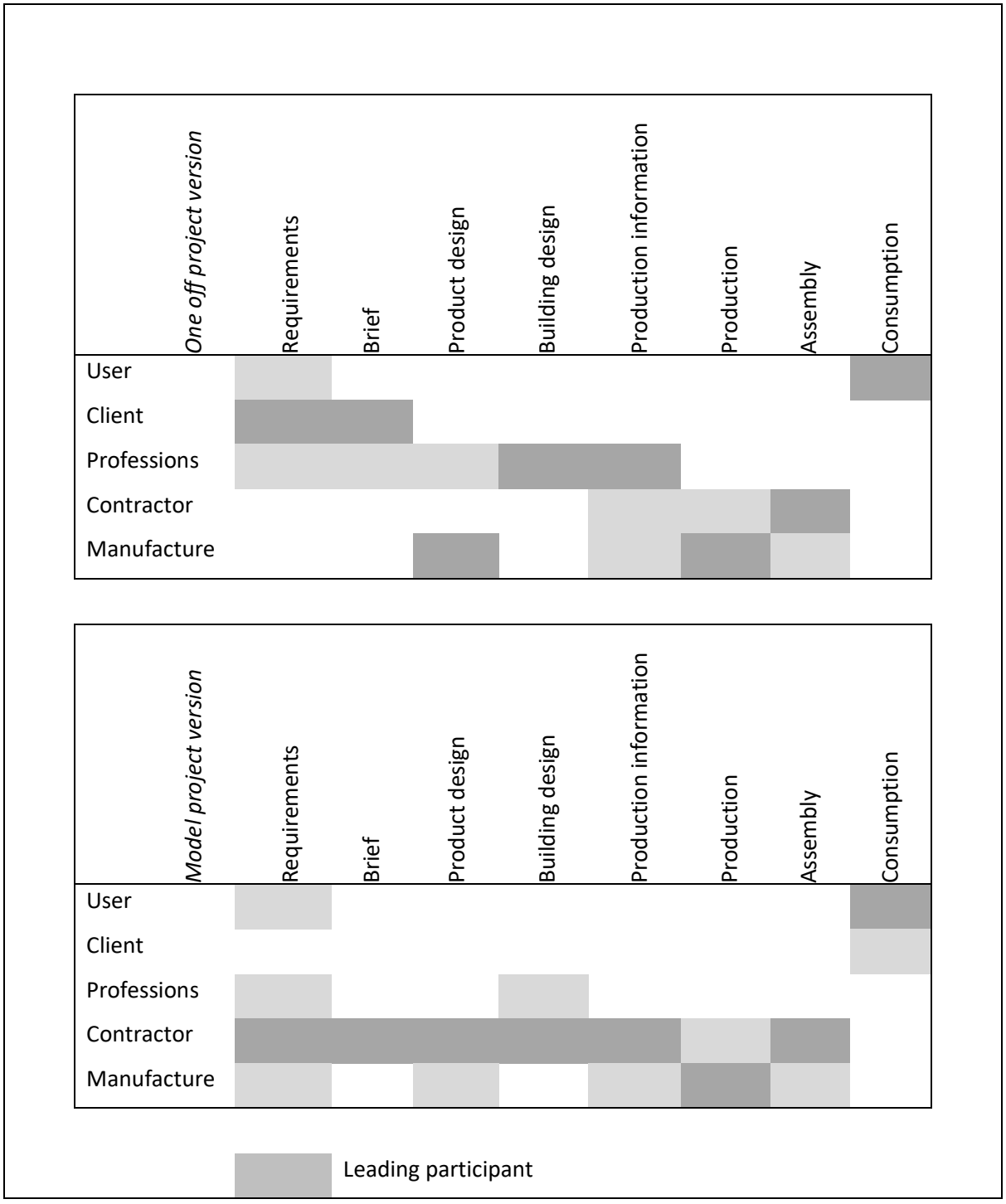
In the 1980s journals started publishing CE research, with *Construction Management & Economics* (CME) establishing itself as the lead journal. CME "was founded in 1982, and the *Journal of the Construction Division of ASCE* was replaced by the *Journal of Construction Engineering and Management* in 1983. These events helped to separate construction economics from urban, property and housing economics, and to facilitate the decision-economics of construction by conjoining construction economics with construction management." (Ive and Chang 2007, p. 1591). CME claimed "construction economics includes: design economics, cost planning, estimating and cost control, the economic functioning of firms within the construction sector, and the relationship of the sector to national and international economies." This agenda also broadly became that of the CIB Working Commission on Building Economics. The first six volumes of CME had papers on tendering and cost estimating, within the project economics stream. The first CE paper on productivity was (Bowelby and Schriver 1988).

A major topic of empirical research in CME and elsewhere in the 1980s was the linkages between construction and other industries, using the input-output tables from national statistical agencies. Initiated by Bon (1984), a series of papers with collaborators compared cross-industry flows in OECD countries, and demonstrated the fundamental role of the industry in capital formation (collected in Bon 2005). These input-output studies on the relationship of construction to other industries confirmed the importance of site work as a driver of output across the economy, but did not provide an industry model. The important finding from these input-output studies was the long-run stability of many of the inter-industry linkages, evidence of the 'technological stability' of construction.

Processes

The foundational paper is another from Turin (1967, 2003[5]). In 'Building as a process' he defined this as "building as an activity concerned with the best possible use of inputs to produce a desired output." (2003, p. 181), and argued traditional building of one-off projects with temporary teams was less efficient than alternatives that better integrated design, manufacturing and assembly.

Figure 1. Turin's industry process maps: One off and Model versions



Source: From Turin (1967, 2003).

The effects of fragmentation/integration have been a theme in many industry reports where, following Turin, the differing roles of users, clients, professions, contractors and manufacturers under different contractual arrangements and the importance of information

flows, or lack of them, is the basis of the discussion. His process has eight stages and four different versions, two of which are in Figure 1. The different processes were: a traditional one off 'maximum fragmentation' version; a manufacturing orientated 'component version; a 'model' version controlled by the contractor; and a 'process' version that would allocate control of a stage to the appropriate participant. This results in a matrix with horizontal time (stages) and vertical participant axes, and reflected Turin's view that industrialization was necessary to improve industry performance. It became the reference model of the industry used by researchers for the next couple of decades (see Groak 1993), and the influence of this approach can be seen in the reports from the inquiries into the UK industry reviewed in Murray and Langford (2002). As they document, government policies for performance improvement in the UK often focused on contractual relations, an approach widely followed elsewhere.

Although neither the purpose nor intention, Turin's model predicted the evolution of the industry over the following decades, as contractors moved to take a central role in managing the construction process, as a comparison of the traditional fragmented one off version with clients and the professions playing a leading role with his contractor focused model version shows. By the end of the twentieth century large contractors had become dominant in many markets with the increasing size and scope of major projects. With the emergence of global multidisciplinary firms that combine consulting, contracting and design the international industry looks a lot like a combination of Turin's model and process versions, with contractors and the professions sharing responsibility for product design.

Period 2: Development and expansion 1990 – 2007

Processes

Turin's stages model was product based, and appropriate for an industry that was rapidly industrializing with standardization of components and increasing use of prefabricated concrete. By the end of the 1980s, however, the issues facing the industry had changed and the focus had shifted to industry performance and processes. A core issue on the construction statistics side was (and is) the low rate of productivity growth of, more or less,

zero percent a year across the OECD. On the construction project side there was increasing pressure to improve value for clients and users by reducing costs and increasing quality. The process based model of the industry that emerged focused on the functions of participants in construction projects. It extended the CE synthesis from the level of the project to that of the industry, an important step, and broadened the range of participants. It also clearly assigned participants, or actors, to either the demand side or the supply side for construction projects.

In 2003, there was a special issue of *Building Research & Information* (BRI) on Re-valuing construction. The papers looked at how the industry operates and the organization of the building process, production strategies, standardization and supply chain management, and thus provide an opportunity to assess developments since Turin's earlier conception of the building process. Turin (1967) focused on variations in process under different contractual conditions. In 2003 this was no longer the main issue, the focus is on management of a 'value stream' and re-engineering processes to create more value for owners and users. Three of the eight BRI papers were from a lean construction perspective, from leading advocates Koskela, Ballard, Tommelein and others, and three were on off-site manufacturing in different forms, from Winch, Gann, Gibbs and others. Processes were unpicked at a much greater level of detail, and the outline Turin drew had been filled in with ideas from business management such as lean production, business process re-engineering and value management. Construction processes were more industrialized, although this was unevenly spread across both countries and the industry, and many new management techniques had been introduced. Importantly, there was now a conceptualization of industrialized construction as a production process, rather than a series of stages, and of projects as a form of production, bringing together on-site work and off-site fabrication.

The founding text for lean construction was Koskela (1992), who emphasised the importance of a theory of production that reflected construction characteristics that he called the transformation, flow and value generation (TFV) framework. Over the next decade his ideas were taken up and developed by a global group of collaborators, bought together at the annual meetings of the International Group for Lean Construction, which made their research available online. They argued project management attempts to manage

by scheduling, cost and output measures, but lean construction attempts to manage the value created by all the work processes used between project conception and delivery. One of the core ideas in lean construction is a system of production control called The Last Planner, usually a front line supervisor such as a construction foreman or a design leader, and lean also brought together the product design, engineering, fabrication and logistics aspects of construction projects. A pair of book chapters summarised lean construction theory (Koskela et al. 2002) and the Lean Project Delivery System (Ballard et al. 2002), which was a stage model like Turin's. In contrast to Hillebrandt and Cannon's (1989) view of managerial economics as primarily about business strategy, lean argues managerial actions affect the design, operation and improvement of a production system and, for construction, the three major factors are the one-of-a-kind nature of projects, site production and temporary organization, three widely recognised features that are embedded in the construction management research literature.

Koskela's TFV theory of production was an explicit attempt to introduce an alternative to what he called the 'economic view' of production. He edited a special issue of BRI in 2008 on developing theories of the built environment that shows how difficult the terrain traversed by CE can be. His editorial asked: "has this reactive discussion that has taken natural science as a reference point, or a straw man, been somewhat misdirected? Could all the energy used for criticizing or undermining the use of the natural science-oriented world view in research have been more productively used in the proactive establishment of different kinds of sciences more suitable for the tasks at hand?" (2008, p. 215)[6]. The six other papers in the special issue discuss in depth and at length challenges, issues and approaches to the built environment, three of them from a design perspective. However, in contrast to the earlier BRI special issue on Revaluing construction there is no data, and while there is much theorizing and many interesting propositions there are no predictions. Fellows and Liu (2020, p. 586) described this as a debate about "management/economics of construction or management/economics in construction".

Industry

The initial industry model was framed by the development of ISIC in the 1960s and Turin's stages model in the 1970s. This bridged the gap between 'statistical construction' defined by

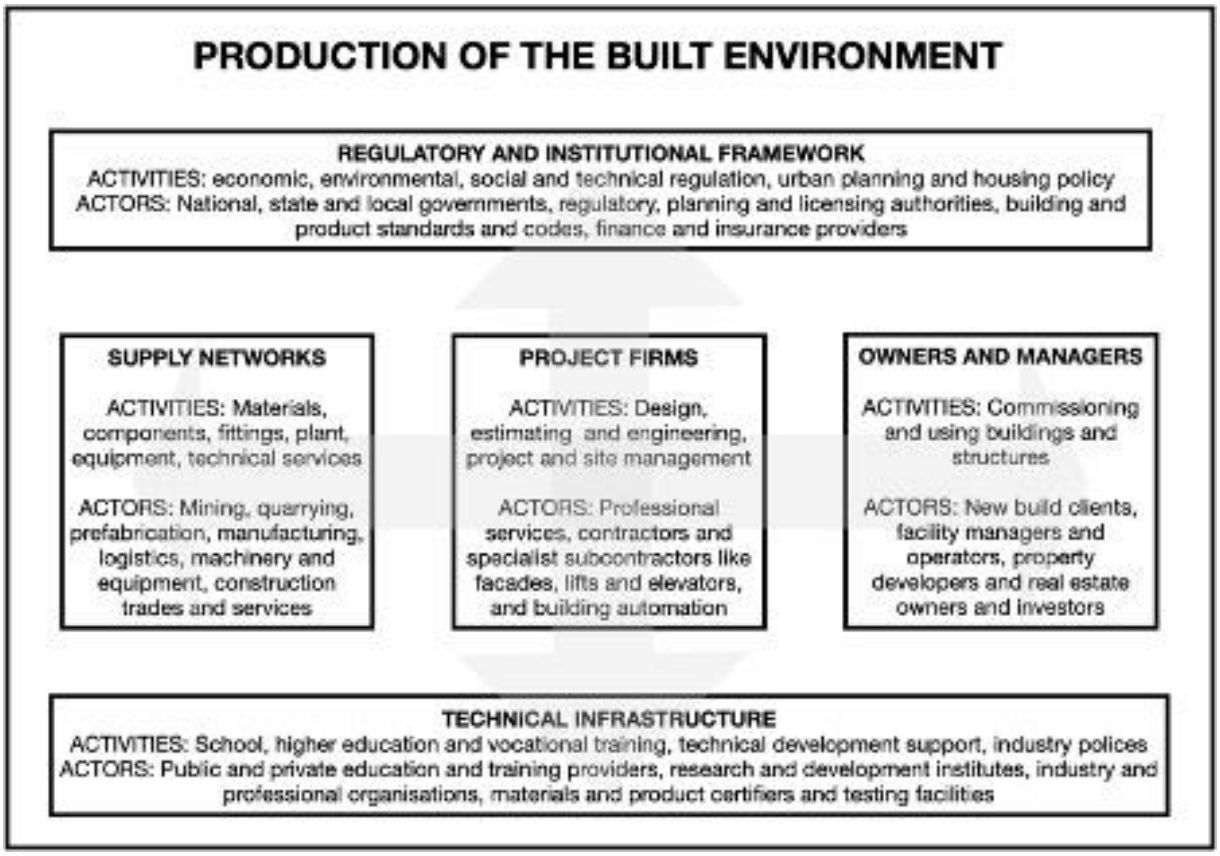
the output of industries with the SIC codes for construction (de Valence 2018), and 'project construction' by recognising inputs from all participants while accepting the SIC categories that defined them. It has been the baseline model of the industry for five decades, and could be described as the CE synthesis, combining economists' work on national accounting with built environment researchers' work on the economic role of the industry. Examples of the widespread use of this model are found whenever participants from outside the construction SIC are included in research into construction processes, such as supply chain research. While this seems intuitive and obvious, the need to do so is a result of the industry boundaries drawn by the definitions in the SIC. The manufacturing industry includes product design within the SIC, but architectural and engineering firms are not included in the Construction SIC. Ive and Gruneberg (2000) called the collection of industries contributing to the production of the built environment the 'broad construction industry'.

Ive and Gruneberg (2000) was a comprehensive analysis of the industry. They started by defining "the construction sector as all production activities contributing to the production of the built environment" (2000, p. 5). As with their book on construction firms this took a heterodox approach. There is discussion on national accounts and financial accounts, measurement of output and business cycles, multiplier effects, social relations of production and ownership of land. They include formal models, examples are labour costs, stocks of capital, a production function and producers' surplus, and there is an analysis of UK construction statistics. Again, the contrast with Hillebrandt (1975) is striking, with the range of topics broadened to include the macroeconomic role of construction, the financing and capital structure of firms, productivity and the role of subcontractors as producers in their own right.

Around the turn of the millennium the first estimates were produced of the total value of production of the built environment. Using value-added and employment data from the Australian and UK national statistics agencies at the industry level, these estimates showed construction directly contributes around half the total value of production of buildings and structures (Ive and Gruneberg 2000, de Valence 2001, Pearce 2003). This strand of research has continued, recently in Gruneberg and Francis (2019) and a special 2019 issue of *Engineering, Construction and Architectural Management* (ECAM) on 'The true value of

construction and the built environment to the economy'. The editorial starts: "There has been a long-standing view that the construction industry as a whole is under-achieving and the industry, in many other countries, is seen as one of the least productive sectors in the economy. A prerequisite for discussion and analysis of the sector's value has to be the production of appropriate information to enable the development of models for the sector." (Ruddock et al. 2019, p. 738). The eight contributions ranged from using the term 'built environment sector' to describe the broad industry, to sustainability and capital stock issues, productivity, and project economics. There is a common theme around assessing the importance of construction and the built environment to social welfare and, highlighting the empirical nature of CE, six of the eight papers are on aspects of measurement of value.

Figure 2. Projects as products



Source: Based on Gann and Salter (2000) and Gann (2001).

A new mapping of participants in the construction industry along these lines was developed by Gann and his colleagues in 1992, shown in Figure 2[7]. Instead of stages, they grouped

participants into supply, site-based and demand categories within an institutional framework. A version of the diagram is in Figure 2, which found its way into many official reports and has been used extensively by researchers since. This was part of the development of the complex product systems approach by Hobday (2000), Gann (2001) and others, which argued construction was a service industry that requires coordination of multidisciplinary teams to organize production, which generally becomes more complex as projects get larger. This is a product-based industry model, with construction projects as the products and contractors (the project-based firms) squarely in the centre.

Firms

Issues with the model of firms with perfect information, constant technology and no market power had created a broad research agenda in economics. Two streams in that agenda appeared in CE papers in the 1990s. The first was on the boundaries of the firm and transaction cost economics (TCE) based on the work of Williamson (1975), who described firms as a 'nexus of contracts'. First applied to construction by Winch (1989), this became an active research stream (see Rashid). Firms in TCE minimize transaction costs by choosing internal production or external supply, the make-buy decision. This added another reason for subcontracting to the flexibility and minimizing fixed cost explanation already established; specialization by subcontractors results in lower cost supply under specific contract conditions. The extension of TCE to construction introduced issues like the hold-up problem on required investment, incentives and contracts, and reframed information asymmetry between participants as a principal-agent problem (see Cerić).

In their book on construction firms Gruneberg and Ive (2000) included a chapter on TCE, and much else. Added to the Hillebrandt and Cannon (1989) model of the firm were contestable markets, industry capacity, productivity, decision-making under uncertainty and models of pricing, cost and investment. Construction firms were differentiated by Gruneberg and Ive by specialization, size and growth rates. Firms manage portfolios of projects in markets that have barriers to entry and can become concentrated. This is a considerably more complex model of construction firms. Their Prologue concludes "The aim of this book is to give a clear understanding of some of the economic issues directly confronting construction firms in their operations and provide the economic basis for planning and decision making."

(2000, p. xvii). However, while they follow Hillebrandt in seeing CE as about management decisions, they also include discussion on capital circuits and the social structure of accumulation, which builds on Ball (1988).

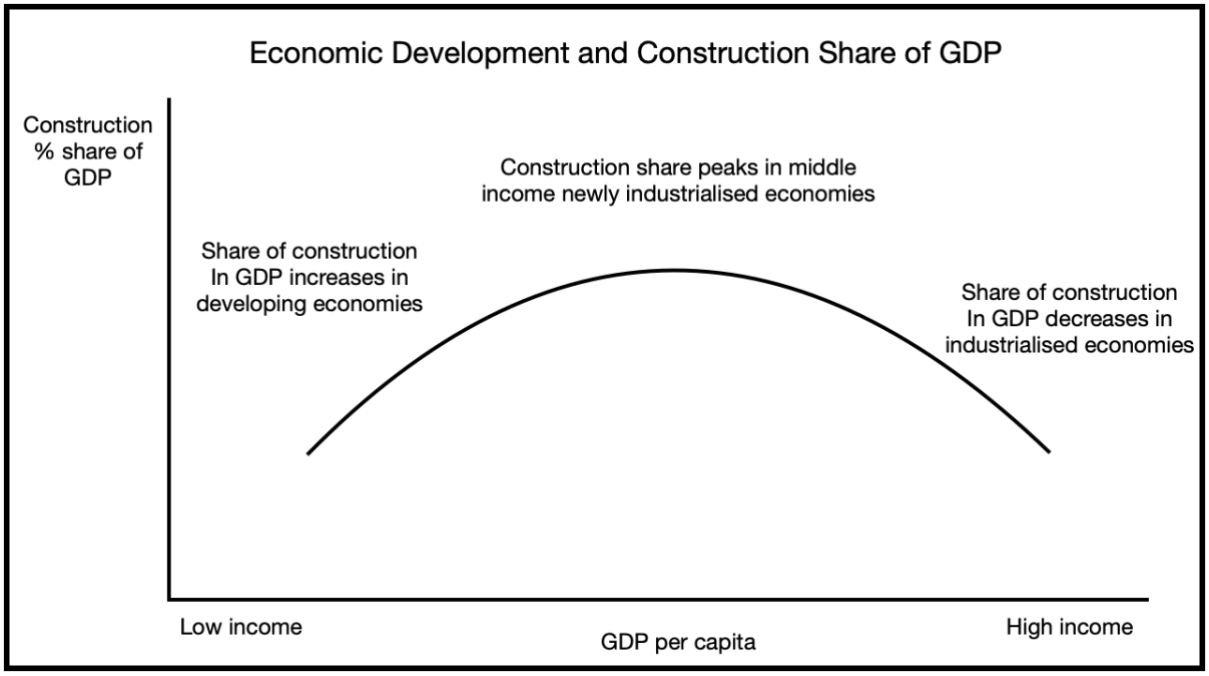
Economic Development and Construction

The relationship between economic development and investment in construction is generally understood to follow an inverted U-shaped curve. In developing countries the level of construction output as a share of GDP rises as the economy grows, reflecting the investment required to generate that growth. Typically, the rate of growth of construction output is higher than the rate of growth of GDP at this stage. As countries become middle income and the stock of built assets accumulates, construction's share of GDP levels out. Construction's share of GDP starts to fall in high income countries as the stock of built assets becomes more productive and repair and maintenance becomes more significant. A high level of capital investment and construction of infrastructure has long been recognised as a characteristic of rapidly industrialising countries, and is clearly related to the stage of economic development of a country (Lopes 2009). This inverted U was first found by Strassman (1970), who called it the 'Middle-Income Country Bulge', but it became known as the 'Bon Curve' much later after Bon (1992) drew it as a simplified, stylised curve.

It was difficult to get data sets for this research. Turin's pioneering work (1966, 1978) used 46 and 78 countries respectively, and the latter found an S-shaped curve for developing countries as the rate of increase of construction's share was rapid at first but levelled out and stabilized over time. Bon (1992) had only six countries is his data set (US, Japan, UK, Finland, Ireland and Italy). Many of the subsequent studies supporting Bon also do not include much data. Most of them are descriptive, typically grouping countries into four categories based on per capita income and then calculating an average of construction's share of GDP in each group. There are many reasons why these average values are likely to be biased, such as non-stationarity of the data, changes in composition of groups over time, omitted variables and outliers. Lewis (2009) notes how variable data is across countries grouped by income levels. Using a data set of 205 countries Choy (2011) found only qualified support for the Bon Curve. Giradi and Mura (2014) tested their 'Construction Development Curve' using 148 countries, finding the curve fits better if economic

development is measured by alternative indicators instead of per-capita GDP, such as life expectancy and a broad Economic Development Index. Population density, demographic growth and credit expansion did not explain cross-country variation in the share of construction in output in their model.

Figure 3. Construction and industrialisation



Source: Based on Strassman (1970), Bon (1992), Lopes (2009).

Progress in CE in Periods 1 and 2

The proposition that building economics was not established as an academic discipline was first made in Bon's *Building as an Economic Process,* where 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 (2001) the future of building economics was seen to lie in fields like corporate real estate and facilities management, topics connected to building use and reuse decisions and building life-cycles. Ofori (1994) argued construction economics had not yet developed to the point where it could be recognised as a distinct part of general economics due to a 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. Myers (2003) saw the future of CE in sustainability to provide both a common purpose and conceptual approach, thus solving the two major problems identified by Bon and Ofori. While sustainability became a large and growing field of study that CE has contributed to, and does provide common purpose, it has not been the basis for a theory because it is based on empirical studies of building/materials/process performance. As noted above, there is a largely one way flow of ideas from theory to empirical research.

The contribution to this debate from Ive and Chang (2007) was in a paper that 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 sub-discipline’. Papers published in *Construction Management and Economics* (CME) between 2000 and 2006 were examined and classed as 'economics of construction', ‘construction management’ or 'building economics'. Ive and Chang found a substantial body of papers categorized as ‘building economics’, because of their lack of reference to recognized economics, and identified a largely one-way traffic in ideas from economics to CE. They were pessimistic about the prospects of CE finding an area where a breakthrough to sub-discipline status could be possible.

> 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, p. 1597).

Ive and Chang concluded that, without a theoretical breakthrough recognised by mainstream economics, the best that CE can aspire to is applying propositions from economics to the understanding of behaviour and explanation of institutions within

construction. This point is important and is revisited below. That conclusion was later supported by a citation analysis of CE and economics journals by Bröchner: “While CME authors often cite articles published in top economics journals, citations in the opposite direction simply do not exist, although the construction industry does figure in mainstream articles, but then with few exceptions only in the periphery of article topics”. (2018, p.179).

So, from one perspective it could be taken CE has in some way failed through lack of external recognition, although this is largely an outcome of its focus on the construction industry. Another perspective is to ask what progress has been made in CE in terms of the scope of topics addressed and development of industry models. In their review, Ive and Change found 63 papers in 10 broad 2-digit JEL classes, of which “36 papers represent pre-established fields within the earlier economics of construction that would be found in a similar analysis of the contents of CME in its first decade (bidding strategy; input-output; building cycles; multinational firms; market structure; firm performance, size and scope; economic development). (Mainly) new fields are: organizational behaviour/transaction costs/property rights; futures pricing/decision making under risk and uncertainty; and innovation (27 papers)”. (Ive and Chang 2007, p. 1595).

The expanding scope of CE can be seen in this broadening of the research agenda, developing from building economics in the 1960s to Ofori’s (1994) widely adopted distinction between construction project economics and construction industry economics. Over the next two decades, as the range of topics in CME and the other journals on economic aspects of construction increased, these became four categories in de Valence (2006) and finally five in de Valence (2011):

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

Period 2 ends in 2007 with the conference to mark 25 years of publication of CME[8]. There were 161 papers across a large and varied range of topics, around a third of which are recognisably CE. This accords with the Pietroforte et al. (2007) paper presented at the conference, which found for 1983-2006 CME papers divided into three perspectives: firms 38%; clients 29%, and industry 33%. A similar analysis of the *Journal of Construction Engineering and Management* showed "overwhelming interest in the operations of construction firms (more than 65% of cases) and significantly less emphasis on project or industry level of analysis, 19% and 15% respectively" (Pietroforte and Stefani 2004, p. 1530). The conference provided the opportunity for Bröchner, Chang, Hughes, Ive, Pietroforte and others, to reflect on the state of CE research based on the journal's papers, and the significant role the journal had played in its development. However, after 2007 a series of books focused CE on issues around the measurement and performance of construction as a distinctive research agenda developed.

Period 3: Consolidation 2008-2020

Issues around the measurement, structure and performance of the building and construction industry, and its relationship with the manufacturing, professional services and materials industries, have become the focus of CE in a series of books published since 2008[9]. The contributions developed topics identified within the scope of CE in Periods 1 and 2, but they ranged widely and again consolidated the boundaries of CE while continuing to introduce ideas from elsewhere in economics. For example, the six books have contributions on the activities of large, international contractors that dominate the global construction industry, a topic that has been, and is, of continuing interest (see Jiang, see Lu). However, the global perspective in these books, while not new, marked another expansion of the topics and issues addressed, to include developments in market analysis, contractor strategies and in particular international cost comparisons and construction data. The following summary of the topics covered in the edited first five books illustrates the scope of CE research and current areas of interest.

The first two books ranged across practical, empirical and theoretical topics. In *Economics for the Modern Built Environment* (Ruddock 2008) seven contributions were on macroeconomic topics such as the economic effects of capital formation and investment, using construction statistics. There were five studies of markets and contractors, with three contributors emphasising the increasing divergence between global firms and local markets and two country case studies. The book brought a great deal of data together, and updated previous work in empirical CE on measuring construction activity and the broad construction industry. *Modern Construction Economics: Theory and application* (de Valence 2011) took an industry economics/industrial organization approach with contributions on market structure and competition, auctions and innovation. There were two on production theory and three others on methodology and experimental methods. Three of the contributions directly attacked the model of perfectly competitive markets with price taking firms, arguing construction markets have significant barriers to entry, and thus can be concentrated and oligopolistic.

Between them the two books covered many of the topics and techniques established in Period 2, and they carried on earlier debates over production theory and methodology. They included global and national research using macroeconomics, research based on industry economics, and case studies with managerial economics. Importantly, they consolidated the expansion of the focus of CE from the SIC construction industry and its activity and management, and made the case for CE being about the economics of the built environment. Bridging the gap between the urban scale of the built environment and new building and construction projects, which will typically only deliver a few percent of the total stock each year, has always been the fundamental challenge for CE; Bröchner's view was "the lack of access to large amounts of data … remains a barrier between highly aggregated urban modelling and smaller case studies." (2008, p. 27). An issue discussed further below.

In *Measuring Construction: Prices, output and productivity*, Best and Meikle (2015) put the focus on data quality and international comparisons of construction costs, raising issues in the collection and use of construction data. As their introduction makes clear "there are standard methods for measurement of physical building work, but the same cannot be said for the characteristics of the construction industry" (p. 1). The twelve contributions covered

measurement of construction work, productivity and prices at the global, national, industry and project levels. Their conclusion was “there is no ‘correct’ answer to any of the questions this book explores … It is perhaps only by applying a variety of techniques to the various problems and comparing the results that we obtain that we will know if we are getting closer to developing an acceptable set of tools and methods.’ (p. 256). It is argued below a multiple models approach is required to tackle the ‘various problems’ with construction data.

In *Accounting for Construction: Frameworks, productivity, cost and performance* (Best and Meikle 2018), the dozen contributions looked at different ways of measuring construction. With chapters on construction statistics, productivity, costs and data, the book both reviewed and extended previous studies. An ‘important thread’ in the book was “the lack of consistency in the way construction industry data is collected and how it is aggregated and/or disaggregated” (p. xiii). This thread became the focus of the next book in the series, *Global Construction Data* (Gruneberg 2019). The ten contributions included three on construction statistics, four used cost data, and the other three covered innovation, architectural services and international contractor’s make-buy decisions. In the title the book made explicit this important agenda in CE research. The reliability and quality of construction statistics is a well-known issue, going back to the 1960s, and the shortcomings of the SNA and SIC have not been overcome in the revisions since then. Those shortcomings were the focus of earlier attention by Cannon (1994) and Briscoe (2006) among others, and are also a major theme in the books edited by Best and Meikle.

The reason for this renewed focus on data quality and reliability is the fundamental role that data is playing in the current topics CE is pursuing. Measuring progress on the UN Sustainable Development Goals (see Opoku), or in moving to a low carbon economy (see Ebohon), are examples where data on how construction contributes to emissions and how production and maintenance of the built environment functions are required. While new data sources will undoubtedly become available, it is important to understand the content and coverage of current data, especially data from national statistical agencies and the international data aggregators like the UN, OECD and IMF (see Meikle).

Because construction statistics are so varied in their quality and extent, identifying what is being measured as 'Construction' is a major task (see Best and Meikle). The supply chain for building and construction projects brings suppliers from many industries together. Construction output, measured as value added, is around half the total output of the broad construction industry. Measurement of the broad construction industry, by adding industry level data together, has been one research topic uniquely pursued by CE (reviewed in de Valence 2019). The broad construction industry is the supply side of a wider economic sector, where it meets demand from private and public sector clients. Bringing the demand and supply side together creates a model of the built environment sector, the collection of industries responsible for the production and maintenance of the stock of buildings and structures (i.e. the human built world). This research is a significant attempt to define and measure construction as an industry at differing scales, from components to buildings, structures and the urban fabric, from projects to firms and to incorporate both the industry and its clients. This is a far more expansive idea of an 'industry' and its processes than possible in the 1960s.

Industry processes have also been subjected to increased interest and measurement. Several different methods for measuring productivity have been proposed. An ECAM special issue in 2019 on *The true value of construction and the built environment to the economy* had contributions on national wealth and investment, productivity and the capital stock, and measuring the built environment sector (Ruddock et al. 2019). Performance measures for projects have been proposed, and how model buildings or types can be used for cost comparisons. How costs and processes vary across countries has been a particular area of research (see Best and Meikle).

After their analysis of 25 years of publications in CME, Ive and Chang (2007) suggested the number of CE papers would support a 'slim quarterly journal'. The content of these edited books and the ECAM special issue, spread over more than a decade since, suggests that might be about right. While these journals are important, overall the proportion of CE papers in them is low compared to the number of project and management orientated papers published. Although an inevitable outcome in built environment journals and construction conference proceedings, as a specialized sub-field this is one reason why CE has struggled to establish an identity alongside the many more CM and PM papers

published. These books addressed that problem by providing a visible collection of CE research from a diverse group of researchers that is clearly differentiated from the management literature, a necessary condition for CE as an academic discipline.
The sixth book was Gruneberg and Francis' *The Economics of Construction* (2019). Gruneberg and Francis provide "a game theory account of the behaviour of firms", the approach typically taken in other branches of industry economics. They discuss aspects of firms' business models, financing, contractual disputes and power relations at greater length than Hillebrandt, clearly building on the research of Periods 1 and 2. Another difference is the use of case studies of the collapse of UK contractor Carillion in 2018, Grenfell Tower, construction for the London Olympics and manufactured housing. These illustrate how the business environment a construction firm faces has become significantly more complex over the decades. Hillebrandt's turnover and profit maximizing firm has evolved into one primarily concerned with growth and survival. While that may be a matter of degree, it is not insignificant. Gruneberg and Francis argue contracting markets compete profits down to the point where firms cannot invest in productivity improvements. In Hillebrandt prices, costs and profits for a project were determined by a conventional marginal analysis, producing an equilibrium result. In Gruneberg and Francis the last two chapters point to an emerging field of research on the economics of construction projects, combining project financial and feasibility studies with procurement strategies. Although they do not develop the link, this field also draws on research applying TCE to construction.

Construction firms operate in an industry Gruneberg and Francis describe as "a highly fragmented project-based industry, with very low profit margins and a high risk of failure for the many firms operating in a very complex supply chain". This is a description Hillebrandt would have agreed with but others would challenge as too simplistic (Laryea and Hughes 2011), and does not take into account the coexistence of an industry with a majority of small firms and the substantial market power of relatively few large multinational corporations in the construction supply chain (see de Valence 2011, McCloughan 2004).

Table 1. Example of developments in construction economics

Chapter	Hillebrandt 1974	Myers 2017	Gruneberg and Francis 2019
1	The nature of construction economics	Introduction to basic concepts	Getting to grips with construction statistics
2	Relation of construction to the economy	Economic systems for economic allocation	Economic theory of markets and construction
3	Basic concepts in economics	The market mechanism	Running a construction firm
4	Demand for housing	The theory of demand	The firm and economies of growth
5	Demand for industrial and commercial building	The theory of supply	Productivity and the construction market
6	Demand for social-type construction	Clients and contractors	The game of construction
7	How Demand is put to the industry	Costs of the construction firm	The underlying causes of conflict in construction
8	The firm and its objectives	Types of market structure in construction	Construction and cyclicality
9	Costs of the construction firm	Markets for green buildings and infrastructure	Projects
10	Market supply curve	Market failure and government intervention	The economics of construction project management
11	Equilibrium in market situations	Environmental economics	
12	Demand curves facing the firm	Managing the macroeconomy	
13	Price determination for a project	The economy and construction: Measurement and manipulation	
14	Conclusions on costs, revenue and equilibrium of the contracting firm	The business case: inflation and expectations	
15		Sustainable construction	

As the first and last of the books that have been discussed, the differences and similarities in the topics and treatment between *Economic Theory and the Construction Industry* and *The Economics of Construction* provide a partial snapshot of where and how CE has been developing. The contents of both those and the fourth edition of Myer's *Construction Economics: A new approach* (2017) are in Table 1. There is much in common, starting with the fundamentals of neoclassical theory on firms and markets, and their analysis of competition, demand, tendering, costs and prices is similar. The books include finance and the sort of managerial economics that Ive and Chang (2007) called 'decision making economics'. However, Gruneberg and Francis take these topics further than Hillebrandt, and introduce different ones like game theory, innovation and productivity. Myers emphasises environmental issues and sustainability. Even without detailed descriptions of the chapter contents, the comparison is an indicator of developments in CE over four decades, and the extent of the range of the current knowledge base in CE.

Table 1 is a partial snapshot because these are three among many contributions to the development of CE, and reflect those researchers' interests. The scope of CE is wider than the topics they cover, primarily because these books are intended to be used as textbooks for CE subjects, and wider than this discussion focused on models and data has allowed. For example, an important area with its own history is bidding theory (see Laryea) and associated research on auctions (Drew 2011). Other important topics not included in these books are TCE, financing/trade credit research using corporate data (Ive and Murray 2015), and industry analysis using input-output tables (Bon 2000). Also, Goh (2008) discusses the range of quantitative methods used in CE, and there may be potential in developing construction econometrics if data reliability issues can be addressed.

Concluding Comments

The review of CE research since 2008 shows the development of a distinctive research agenda focused on two key topics: the data that is used in CE research, which is typically applied and empirical; and the measurement and performance of construction processes, industry and firms. It draws on three traditional areas of economics: industry

economics/industrial organization; development and economic growth; and macroeconomics and public finance. To these are added three industry specific areas: cost estimating and project economics; definition of units of output (components, buildings, value added etc.); and measurement and comparison of costs and output across projects and countries. This combination means CE research generally employs basic economic concepts, but requires detailed knowledge of the industry, technology and institutions.

What does this short history of developments in CE show about its nature? Are there distinctive characteristics of CE research that distinguishes it? Since the 1970s CE research has ranged across productivity and value for money, environmental performance and sustainability, the delivery process and strategies, the financing, viability and competitiveness of construction firms, optimisation of the roles of participants and processes, technological and institutional development, construction statistics and measurement, input-output data and the economic role and structure of the industry. Underpinning that research are models of the industry and its firms and processes, models that have become richer and more refined. From the fragmented perfectly competitive industry of the 1970s, by 2020 the model of the industry is a hierarchical supply chain managed by contractors. Larger firms in two layers of monopolistic competition and oligopoly compete among themselves, above a deep layer of small firms in perfectly competitive markets. The industry maintains key elements of hierarchical governance though contracts between tiers of subcontractors and suppliers, optimizing supply chains through standardization of parts and products. Some firms act variously as contractors, subcontractors, designers or consultants, depending on circumstance.

One reason it is challenging to define the nature and scope of CE is because of the range of issues and topics associated with the production and maintenance of the built environment, which is the economic role of the construction industry in its broader sense. This wide range makes for porous boundaries between CE and related disciplines such as transport, urban and regional economics, housing economics, cost engineering, and in particular construction management. Whether this is a strength or a weakness, an opportunity or threat, has been subject to debate by CE researchers.

This review of CE research has focused on theoretical and empirical development in the three areas identified by Hillebrandt (1974): the construction process, the construction firm, and the construction industry. The development of CE has been divided into three periods. The first from 1966 to 1989 is one of emergence and establishment, as themes and topics are investigated and the literature develops, and the second from 1990 to 2007 covers the expansion of CE as new approaches were applied to construction. In the third period of consolidation from 2008 to 2019 a series of publications are reviewed.

Despite the innovative nature of her work, it would be fair to say that Hillebrandt (1974) did not develop a new theoretical analysis. Although the last part of chapter 13 on price determination is on bidding theory, her book lacks a conclusion with some theoretical principles of CE outlined. Given the difficulties she and Turin had with reconciling the complexity of construction of the built environment with the stylized models of economics, that is not surprising. Nevertheless, while the 'peculiarities of construction firms, processes and markets' have continued to perplex us, our models of firms, processes and industry have developed, becoming more complex and multi-faceted as the range of economic theories applied has expanded. The combining of economic theory and techniques with industry specific knowledge is the first distinctive characteristic of CE research.

The basic tools of economics are models like those for supply and demand, marginal costs, utility, consumer preferences and market structure. The application of those models to an industry is an empirical exercise, based on the characteristics of a specific industry. This has generally seen ideas travel from economics to industry studies and, as Fellows and Liu (2020) note, careful borrowing of theories from relevant disciplines is advantageous. This openness of CE to ideas from mainstream economics has led to important insights into construction firms, processes and the relationship between the industry and the wider economy, and the scope of CE is a strength because it reflects the nature of an evolving economy and a construction industry which can be defined in various ways. The research on defining and measuring construction at many different scales is the second distinctive characteristic of CE, as this is not done elsewhere. The scales range from parts to project to the broad construction industry, which includes all participants in the supply chain on the

supply side, and production and maintenance of the built environment as an economic sector, which also includes the demand side,

There is, however, limited feedback from industry economics to mainstream economics because industry and organizational research has not led to rethinking of the relevant economic models. An example of this is the use of bid-rent curves and the monocentric city model in urban economics, a useful economic model but not one that will affect mainstream economics. Similarly, construction project cost curves and a contractor centric industry model does not change economic principles. So, like other branches of industry economics, CE research works within current economic theory, applying tools and techniques from a wide range of fields in economics, and has not produced results that challenge mainstream economic theory. However, for CE there is a key difference. For many industries data is plentiful, health and transport economists have access to hospital records and traffic volumes for example, and those have become recognised sub-disciplines in economics. The development of discrete choice models to analyse transport decisions led to a Nobel Prize for Daniel McFadden in 2000 for econometrics, and his model of supply (capacity) and demand (distance travelled per person) is widely used.

Some industries provide the data required for detailed economic modelling to researchers, either directly or through regulators. Examples are supermarkets (bar codes), banking (transactions and lending), and airlines (passengers and distance). CE has, by comparison, a more limited set of data available, largely restricted to construction statistics, cost data and corporate financial records, supplemented by surveys of various sorts. Generally, firms involved in construction do not share data because it is, or may be, a source of competitive advantage or is confidential due to commercial and contractual reasons. Government agencies at differing levels hold specific data, which may or may not be available and compatible with other data. Therefore, the third distinguishing feature of CE research is the limited range of data available to work with, and the variable quality of that data. This may be one reason for the uni-directional flow of citations between CE and economics found by Bröchner (2018). On the other hand, the example of the Bon Curve shows that, when CE has a proposition that can be tested with data, crossover from CE to other domains in economics can occur.

It is not that economists aren't interested in construction, and the peculiarities of construction firms, contracting markets and construction projects, with construction used as an example or representative industry and topics such as auctions and contracts also of interest to CE. However, the application of economics to construction by economists was done by those within the built environment, like Hillebrandt, Ball, Ive, Gruneberg and Runeson. In a fourth distinguishing feature of CE, many of the other researchers included here were not economists, but found uses for economic theory, examples are Turin, Bon, Meikle, Winch, Gann and Koskela. The development of CE has been multi-disciplinary and multi-faceted, which is appropriate because a multiple models approach is required to disentangle and analyse the variety of and range of issues associated with the construction industry.

The problem of low visibility in the midst of construction management and project management publications is also a distinctive feature of CE, and was not one encountered in the emergence of other fields in industry economics like health and transport. They emerged from economics departments as their home base before branching out, whereas CE came from construction and built environment departments or schools. This meant much of the potential readership of CE research were not very interested or particularly well-informed on economics, which takes a different approach to core issues like the relationship between data, theory and testing. Over the last decade, as construction management research has become more 'anthropological' (Chan 2019), this divide between CE and construction management, where research is increasingly based on sociology, has widened. CE has succeeded in developing a distinctive research agenda on the economics of production, maintenance, and management of the built environment. It is now developing the tools and techniques needed to investigate those topics under a wide range of conditions in many different countries.

References

Ball, M. (1988). *Rebuilding Construction: Economic change and the British construction industry*, London: Routledge.

Ballard, G., Tommelein, I., Koskela, L. and Howell, G. (2002). Lean construction tools and techniques, in Best, R. and de Valence, G. (eds.). *Building in Value: Design and Construction,* Oxford: Butterworth-Heinemann, 227-255.

Barras, R. 2010. *Building Cycles: Growth and instability*, Chichester: Wiley-Blackwell.

Best, R. and Meikle, J. (eds.) (2019). *Accounting for Construction: Frameworks, productivity, cost and performance,* London: Taylor & Francis.

Best, R, and Meikle, J. (eds.) (2015). *Measuring Construction: Prices, Output and Productivity* Abingdon: Routledge.

Blaug, M. (1992). The Methodology of Economics: Or, How Economists Explain. Cambridge University Press. pp. 45–46.

Bon, R. (2001). The future of building economics: A note, *Construction Management & Economics*, 19, 255-8.

Bon, R. (2000). *Economic Structure and Maturity: Collected papers in input-output modelling and applications*, Aldershot: Ashgate.

Bon, R. (1992). The future of international construction secular patterns of growth and decline, *Habitat International*, 16, 119-28.

Bon, R. (1989). *Building as an Economic Process: An Introduction to Building Economics*, New Jersey, Prentice Hall.

Bowlby, R. and Schriver, W. (1986). Observations on Productivity and Composition of Building Output in the United States, 1972-82. *Construction Management and Economics*, 4(1), 1-18.

Bowley, M. (1966). *The British building industry: Four Studies in Response and Resistance to Change*, Cambridge: Cambridge University Press.

Bowley, M., (1960). *Innovation in Building Materials*, London: Gerald Duckworth.

Briscoe, G. (2006). How useful and reliable are construction statistics? *Building Research & Information*, 34 (3), 220-229.

Briscoe, G. (1988). *The Economics of the Construction Industry*, London: Mitchell.

Bröchner, J. (2018). Construction economics and economics journals, *Construction Management & Economics*, 36:3, 175-180,

Bröchner, J. (2008). Developing construction economics as industry economics. In Ruddock, L. (ed.) *Economics for the Modern Built Environment*, pp. 14-28. London: Taylor and Francis.

Cannon, J. (1994) Lies and Construction Statistics. *Construction Management & Economics*, 12: 4, 307-312.

Cassimatis, P. (1970). *Economics of the Construction Industry*, The Conference Board, Studies in Business Economics No. 111.

Chan, P.W. (2020). Revisiting basics: theoretically-grounded interesting research that addresses challenges that matter. *Construction Management & Economics, 38*(1), 1-10.

Dacy, D.C. (1965). Productivity and price trends in construction since 1947. *RES*, 47(4), 406-414.

de Valence, G. (2019). Comparing construction in national industrial classification systems, in Best, R. and Meikle, J. (eds.) *Accounting for Construction: Frameworks, productivity, cost and performance,* London: Taylor & Francis, pp.31-45.

de Valence, G. 2019. Reframing construction within the Built Environment Sector, *Engineering, Construction and Architectural Management*, 26 (5) 740-745.

de Valence, G. (2011). (ed.*). Modern Construction Economics,* London, Taylor and Francis.

de Valence, G. (2001). Defining an industry: what is the size and scope of the Australian building and construction industry? *The Australian Journal of Construction Economics and Building*, 1, No. 1, 53-65.

de Valence, G. and Meikle, J. (2019). Construction output as Gross Fixed Capital Investment, in Gruneberg, S. (ed.) *Global Construction Data*, London: Taylor & Francis, 18-43.

de Valence, G. and Runeson, G. (2015). Graham Ive and the methodology of building economics, Cons*truction Management & Economics*, 3 (2), 126-133.

Drew, D. (2011). Competing in construction auctions: a theoretical perspective, in de Valence, G. (ed.*). Modern Construction Economics,* London, Taylor and Francis, 63-79.

Duca, J.V., Muellbauer, J., Murphy, A. 2010. Housing markets and the financial crisis of 2007–09: lessons for the future. *Journal of Financial Stability* 6 (4), 203–217.

Eccles, R.G. (1981). The quasifirm in the construction industry, *Journal of Economic Behavior and Organization*, 2, pp. 335-57.

Eccles, R. (1981). Bureaucratic versus Craft Administration: The Relationship of Market Structure to the Construction Firm. *Administrative Science Quarterly, 26*(3), 449-469.

Fellows, R. and Liu, A. (2020) Borrowing theories: contextual and empirical considerations, *Construction Management and Economics*, 38:7, 581-588.

Fitch, J.M. (1973). *American Building: The Historical Forces that Shaped It*, New York: Shocken Books.

Francis, N. (2019). Measuring construction activity in the UK. In Gruneberg, S. (ed.) *Global Construction Data*, London: Taylor & Francis, 3-17.

Girardi, D. and Mura, A. (2014). The Construction-Development Curve: Evidence from a New International Data set, *The IUP Journal of Applied Economics*, Vol. XIII, No.3.

Gann, D. (2001). Putting academic ideas into practice: technological progress and the absorptive capacity of construction organizations. *Construction Management & Economics*, *19*(3), 321-330.

Gann, D. and Salter, A. J. (2000). Innovation in project-based service-enhanced: the construction of complex products and systems, *Research Policy* 29, 955-972.

Goh, B.H. (2008). The state of applications of quantitative analysis techniques to construction economics and management (1983 to 2006). *Construction management and economics*, 26 (5), 485–497.

Groak, S. (1993). *The Idea of Building: Thought and action in the design and production of buildings.* London: Taylor & Francis.

Gruneberg, S. (ed.) (2019). *Global Construction Data*, London: Taylor & Francis.

Gruneberg, S. and Francis, N. (2019). *The Economics of Construction*, London: Agenda Publishing.

Gruneberg, S and Ive, G. (2000). *The Economics of the Modern Construction Firm*, London: Macmillan.

Hillebrandt, P.M. (1974) *Economic Theory and the Construction Industry*, Macmillan, Basingstoke.

Hillebrandt, P.M. and Cannon, J. (1990). *The Modern Construction Firm*. London: Macmillan.

Hillebrandt, P.M. and Cannon, J. (1989) *The Management of Construction Firms: Aspects of theory*. Macmillan, London.

Hobday, M., (2000). The project-based organisation: an ideal form for managing complex products and systems? *Research Policy* 29, 871–893

Hillebrandt, P. (1974). *Economic Theory and the Construction Industry*. Basingstoke: MacMillan.

Hutton, J. (1967). *Building and Construction in Australia*, Melbourne: F.W. Cheshire.

Ive, G.J. and Chang, C-Y. (2007). Have the Economics of Construction got Closer to Becoming a Recognised Sub-discipline of Economics? Can it do so? *Construction Management and Economics 25th Anniversary Conference,* Reading, p. 1585-1605.

Ive, G. and Gruneberg, S. (2000). *The Economics of the Modern Construction Sector*, London: Macmillan.

Ive, G. and Murray, A. (2015). *Trade Credit in the UK Construction Industry: An empirical analysis of construction contractor financial positioning and performance,* Dept. of Business, Innovation and Skills, London.

Koskela, L. (2008) Is a theory of the built environment needed? *Building Research & Information*, 36:3, 211-215.

Koskela, L. (1992). Application of the new production philosophy to construction, Technical Report No. 72, Center for Integrated Facilities Engineering, Dept. of Civil Engineering, Stanford University, Stanford, CA.

Koskela, L., Howell, G., Ballard, G. and Tommelein, I. (2002). The foundations of lean construction, in Best, R. and de Valence, G. (eds.) *Building in Value: Design and Construction,* Oxford: Butterworth-Heinemann, 211-225.

Lange, J.E. and Quinn, D. (eds.) (1979). *The Construction Industry: The Balance Wheel of the Economy.* Lexington, M: Lexington Books, D.C. Heath and Co.

Laryea, S., & Hughes, W. (2011). Risk and price in the bidding process of contractors. *Journal of Construction Engineering and Management*, *137*(4), 248-258.

Lewis, T. (2009). Quantifying the GDP-construction relationship, in Ruddock, L. (ed.) *Economics for the Modern Built Environment*, London: Taylor and Francis, 34-59.

Lopes, J. (2009). Investment in construction and economic growth: a long-term perspective, in Ruddock, L. (ed.) *Economics for the Modern Built Environment*, London: Taylor and Francis, 94-112.

McCloughan, P. (2004). Construction Sector Concentration: Evidence from Britain, *Construction Management & Economics*, 22: 979-90.

Morgan, M. (2012). *The World in the Model: How economists work and think* . Cambridge University Press.

Murray, M. and Langford, D. (2003). *Construction Reports 1944-98*, Oxford: Wiley-Blackwell.

Myers, D. (2017). *Construction Economics: A new approach*, 4th Ed., London: Spon Press.

Myers, D. (2003). The future of construction economics as an academic discipline, *Construction Management & Economics*, 21, 103-106.

Ofori, G. (1994). Establishing construction economics as an academic discipline, *Construction Management & Economics*, 12, 295-306.

Ofori, G. (1990). *The Construction Industry: Aspects of its Economics and Management,* Singapore: Singapore University Press.

Page, S. (2018). *The Model Thinker*. New York: Basic Books.

Pearce, D. (2003) *The Social and Economic Value of Construction*. London: nCRISP.

Pietroforte, R., Costantino, N., Falagario, M. and Gould, J.S. (2007). A review of the abstracts of Construction Management and Economics, 1983–2006, *Construction Management and Economics 25th Anniversary Conference,* Reading. P. 1523-32.

Pietroforte, R. and Stefani, T. (2004). *Journal of Construction Engineering and Management*: a review of the years 1983–2000. *Journal of Construction Engineering and Management*, **130**, 440–8.

Powell, C.G. (1980). *An Economic History of the British Building Industry*, London: Architectural Press.

Raftery, J. (1991). *Principles of Building Economics.* Oxford: BSP Professional Books.

Riggleman, J.R. (1933). Building Cycles in the United States, 1875–1932. *Journal of the American Statistical Association*, 28(182), 174-183.

Ruddock, L. (ed.) (2009), *Economics for the Modern Built Environment*, London: Taylor and Francis.

Ruddock, L., Gruneberg, S. and Ruddock, S. (2019). Assessing the true value of construction and the built environment to the economy, *Engineering, Construction and Architectural Management*, 26, 5, pp. 738-739

Runeson, G. (2000). *Building Economics*, Deakin: Deakin University Press.

Runeson, G. and de Valence, G. (2015). A critique of the methodology of building economics: Trust the theories, Cons*truction Management & Economics*, 33 (2), 117-125.

Strassmann, W.P. (1970) The construction sector in economic development, *Scottish Journal of Political Economy*, Vol. 17, Issue 3, 391-409.

Stinchcombe, A.L. (1959). Bureaucratic and Craft Administration of Production: A Comparative Study, *Administrative Science Quarterly*, 4, 168-87.

Summers, L. (2016). The Age of Secular Stagnation: What It Is and What to Do About It, *Foreign Affairs*, February, 487-95.

Turin, D. (2003). Building as a process, *Building Research & Information*, 31:2, 180-187.

Turin, D. (1978). Construction and development, *Habitat International,* 3(1-2), 33-45.

Turin, D. (ed.) (1975). *Aspects of the Economics of Construction*. Goodwin, London

Turin, D. (1966). *The Place of Construction in Economic Development*, London: BERU.

Winch, G. (2006). Towards a theory of construction as production by projects, *Building Research & Information,* 34:2, 154-163.

Williamson, O. (1975). *Markets and hierarchies: analysis and antitrust implications: a study in the economics of internal organization*. New York: Free Press.

Winch, W. (2003) Introduction to Duccio Turin's 'Building as a process', *Building Research & Informatio*n, 31:2, 179-179.

Winch, G. (1989). The construction firm and the construction project: a transaction cost approach. *Construction Management & Economics*, **7**, 331–45.

[1] Most of the papers cited here are from *Building Research & Information, Construction Management & Economics,* and *Engineering, Construction and Architectural Management*.

[2] This report was reprinted, reissued, updated and revised over the next 10 years, until Duccio Turin's untimely death in 1976. His Festschrift in *Habitat International* (1978, 3, 1-2) reprints 'Construction and Development' from 1973, with papers from the contributors on construction statistics, costs and developing countries, reflecting the range and influence of his work. On his work at UCL the editors' memoir notes: "His UK research programmes initially were concerned with the available statistics on the UK construction industry … He introduced his ideas [to the BERU] about the building process, about housing and construction, and about the particular issues in developing countries" (p. 18).

[3] Turin and Patricia Hillebrandt were colleagues at UCL when Turin was Director of the BERU, which published his *The Construction Industry: Its Economic Significance and its Role in Development* in 1969. Hillebrandt and John Andrews founded the Building Economics and Management MSc in 1974, which runs today as the Construction Economics and Management MSc at UCL.

[4] After retiring in 2003 from Reading University, and as a founding editor of CME, Ranko Bon became an artist. There is a 2016 addendum to his 1987 entry on his blog residua.org, called 'Building economics be damned', where he says the book "went over the head of the entire field—students, teachers, and the research community. To this day, only a few among my former colleagues appreciate it for what it is worth. The only remaining hope is that someone somewhere will pick it up one fine day and bring it back to life, as it were. Not the book itself, but the ideas it offers. Alas, that hope is also thinning at a clip."

[5] Reprinted in a 2003 special issue of BRI but first published in the Proceedings of the Bartlett Society in 1967. In his introduction to the paper Graham Winch says it was translated into French, German and Italian, and "Turin argues for the importance of viewing construction as a process, but he does not lose sight of the relevance of the contractual arrangements between the parties." (2003, p. 179).

[6] Runeson and de Valence (2015) provided their answer to this question in a CME paper 'A critique of the methodology of building economics: trust the theories' that argued predictions and theory are inseparable.

[7] In Gann and Salter (2000) the origin of this figure is sourced to Gann et al. (1992).

[8] The full proceedings can be downloaded from http://centaur.reading.ac.uk/31329/

[9] The work continues. Both the Elgar *Research Companion on CE* and volume 3 in the Measuring Construction series*,* again edited by Best and Meikle, are due in 2021.