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CONSTRUCTIVE CONFUSION OR PARADIGM PROLIFERATION: COMPETING EXPLANATIONS FOR LOW CONSTRUCTION PRODUCTIVITY GROWTH

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The objective of this paper is to develop a system to categorise the explanations found in previous research and thus improve our understanding of the analysis of construction productivity. Despite the efforts made by governments, industry organisations and firms in many countries, the rate of growth in construction productivity as measured by national statistical agencies has consistently been low compared to many other industries. Research into explanations for low construction productivity growth has found a wide range of factors and possible causes that may be at work, and there is no agreement on the most important of these. Explanations include: the methodology of productivity analysis and measurement; regional and sectoral effects on industry productivity; the project-based nature of the industry and the role of project management; procurement and delivery systems and the effectiveness of construction industry policy and intervention; and the contribution of research and development and innovation to construction industry productivity growth. By categorising this research the differences, commonalities and linking factors can be identified and the various analytical paradigms evaluated. The competing explanations of the causes of low construction productivity growth are then assessed in terms of their completeness (whole of industry or part), applicability (time, place and circumstance) and generality (a data artefact or not).

KEYWORDS: construction productivity, explanatory categories, paradigms.

INTRODUCTION

The rate of growth of productivity in Australia, the UK, US and other major economies in the OECD become an issue in the late 1960s, when declining output per hour worked and output per person employed became the focus of a large research program that sought to interpret and analyse the causes of what became known as the productivity slowdown. At this time the construction industry's low productivity growth attracted attention. The rate of growth of productivity of the construction industry has been poor since the 1960s, even by comparison with a long-run overall industry average in the order of two to three percent a year.

Despite the efforts made by governments, industry organisations and firms over the past few decades, the rate of measured growth of construction productivity has remained low compared to many other industries. The answers typically offered in explanation of construction productivity cover a wide range of factors and possible causes that may be at work. The approach taken in this paper is to review previous research across five areas that have been suggested as important influences on construction productivity.

Industry, Projects and Institutions

The different aspects of construction productivity measurement and performance reviewed above apply at three distinct levels. Which of these three levels is the most appropriate for productivity analysis of construction will depend on the purpose of the analysis. At the industry level the focus is on the measurement of output within the national accounting framework, so the paper firstly looks at the measurement of rates of productivity growth. This is a large topic and incorporates a rage of issues relevant to the topics that follow.

The second topic is the heterogeneous nature of construction products, both by type and location, At the project level, to a great extent each project in each of its categories is designed and built to serve a special need. Although specific design skills are needed over and over again, the outputs differ in size, configuration, location and complexity. Such uniqueness impacts substantially on construction productivity and the construction process. Thirdly, the site-based methods of project management used are discussed. As a subset of these factors the work sampling studies carried out on specific tasks, processes or teams should be included.

Finally, there is also another set of factors that can be called institutional, and these include procurement methods, R&D and innovation, technological progress, regulation and the legal framework. The paper collects the limited research on the effects of location and the project based nature of the industry. The last two topics addressed are procurement and delivery systems and construction industry policy, and R&D and innovation.

METHODOLOGY OF PRODUCTIVITY MEASUREMENT

The measured rate of construction productivity growth may be low because of the measurement of output as value added, the total value of goods and services produced after deducting the cost of goods and services used in the process of production, adjusted for movements in prices and changes in quality. The construction deflator may not fully take these movements into account, and therefore real output is underestimated. Also, the significant role of changes in the quality of construction has not, so far, been rigorously measured.

Output of the building and construction industry is estimated by deflating current price figures by input price indexes. A number of researchers have criticized the use of input price indexes for deflating construction expenditure, for being unrepresentative of the inputs priced and geographical coverage, and being based on inaccurate weights. The Stigler Report (1961: 29) recommended a significant increase in research on construction deflation, and suggested a residential deflator based on the price per square foot of a range of categories of new homes. This led to the adoption by the BEA in 1968 of a new, hedonic price index for housing.

A number of alternative deflator have been developed. Allen (1985) used a price per square foot index for deflating non-residential building, assuming that this is a good proxy for output. According to Allen's (1985) estimates about half the decline in construction productivity during the 1960s and 1970s was due to the overdeflation of construction output. Cassimatis found that price indexes cannot provide adequate deflators for construction: "the feeling persists that construction productivity is greater than the measurements show ...

largely due to the fact that there are no adequate price indexes that can be used as deflators of the gross product" (Cassimatis 1969: 79-80).

Table 1. Representative Papers: Methodology of productivity analysis and measurement

Stigler Report (1961)	Recommended a significant increase in research on construction deflation
Cassimatis (1969)	Argued that price indexes for construction based on unit numbers at market prices cannot provide adequate deflators for construction
Stokes (1981)	Found no conclusive evidence that real output was understated
Allen (1985)	Used a price per square foot index for deflating non-residential building
Bowlby and Schriver (1986)	Developed a hedonic price index for construction as an alternative to the existing US deflators
Pieper (1990)	Also argued that deflation by input price indexes does not produce suitable estimates of output at constant prices
Chau and Lai (1994)	Measured the relative labour productivity of construction from Hong Kong national accounts data
Lowe (1995)	Describes the estimation indexes of Statistics Canada
Allmon et. al. (2000)	Means's cost manuals) were used to trace benchmark values for construction tasks
Goodrum, Haas, and Glover (2002)	Developed an alternative productivity measure based on individual work activities
Ive et. al. (2004)	International comparison that addressed statistical data issues on definition and labour force numbers
Briscoe (2006)	Identifies a range of problems with reliable and accurate data collection and statistical analysis
Crawford and Vogel (2006)	Data constraints limit the ability to identify drivers of construction productivity
Yu and Ive (2008).	Finds that British indices measure the price movement of traditional building trades but almost completely ignore mechanical and electrical services

Pieper (1990) also argued that deflation by input price indexes does not produce suitable estimates of output at constant prices and, given the extensive use of input price indexes as deflators in estimating the constant price of output for the construction industry, productivity measurement for this industry is problematic, to say the least. Pieper concludes that, for the US, "evidence indicates an overdeflation of construction of at least 0.5% per year between 1963 and 1982."

Chau and Lai (1994) developed a system for measuring the relative labour productivity of the Hong Kong construction industry. Their approach used a method of measuring the relative labour productivity of the industry, from national accounts data, and then derives the trend of construction labour productivity. This discussion of relative rates of growth of labour productivity uses an implicit price deflator for net output of the construction industry obtained through double deflation, but does not discuss the nature of the price indexes used or their applicability. The price indexes are based on a construction output price index and a material cost index using the methodology developed by Chau and Walker (1988).

Lowe (1995) describes the use of estimation indexes by Statistics Canada, using surveys sent to subcontractors. Around 100 different items are priced for five building types and each of five elements has its own index. A recent analysis of British building price indices by Yu and Ive (2008) found that these indices measure the price movement of the traditional building trades but almost completely ignore mechanical and electrical services.

Cannon (1994) questioned the accuracy of contractor statistics and Briscoe (2006) asked "How useful and reliable are construction statistics?" These papers identify a range of problems with data collection and analysis, including defining the scope and coverage of the industry; measuring outputs across different types of activity; identifying construction firms; measuring capital formation and capital stock, and inconsistent employment statistics. Crawford and Vogel (2006) also draw attention to data limitations for productivity analysis.

REGIONAL AND SECTORAL EFFECTS ON IPRODUCTIVITY

Other hypotheses for the decline in construction productivity are a decline in the capital-labour ratio (Blake et al. 2004), changes in the age-sex composition of the labour force (Cremeans 1981), a shift towards non-union construction (Allen 1984), an increase in government regulation (Tucker 1986) or cyclical and business cycle effects. Project characteristics such as the increased size and complexity of projects, resulting communication difficulties, and fast-tracking projects where design and construction phases overlap also affect coordination. There have been a few papers that address the effects of these on productivity.

Cremeans (1981) discussed a number of hypotheses that had been proposed to explain the significant decline in construction industry labour productivity in the 1970's.Only one of the hypotheses, the increased proportion of younger, less experienced workers, was supported by the available data. Bowlby and Schriver's (1986) analysis of US productivity data indicated seven compositional changes in building, and they suggested that these would account for much of the productivity slowdown.

Table 2. Representative Papers: Regional and sectoral effects on industry productivity

Cremeans (1981)	Found younger, less experienced workers the main cause
Bowlby and Schriver (1986)	Identified seven compositional changes in building, and these account for much of the productivity slowdown
Tucker (1986)	The increased size and complexity of construction projects
Ive et al. (2004)	The out put-structure of a country's construction industry will influence average labour productivity
Blake et al. (2004)	UK construction has lower capital per worker than France, Germany and the US

PROJECT-BASED NATURE OF THE INDUSTRY AND THE ROLE OF PROJECT MANAGEMENT

A large number of papers have recommended that construction productivity could be improved through the use of flexible organisation structures, favourable union attitudes, higher workmen motivation, and improved overtime and change order strategies. Most of these surveys found cost control, scheduling, design practices, labour training, and quality control are the functions that are consistently seen as having room for improvement. Often the fragmented nature of the industry is seen a hindrance to improving productivity (Ganesan 1984). However, Chau and Lai (1994) suggest that productive efficiency is increased by the division of labour.

Borcherding (1976) identified the factors having an adverse effect on construction productivity as union attitudes, workman selection practices and motivation, inflexible bureaucratic organisation structures, overtime; and change orders. Using these factors, Herbsman and Ellis (1990) developed a statistical model of the quantitative relationships between influence factors and productivity rates.

Table 3. Representative Papers: Project-based nature of the industry and the role of project management

Borcherding and Oglesby (1974)	Concluded well organised construction jobs which permit workers to be productive lead directly to job satisfaction
Borcherding (1976)	Identified six factors having adverse effects on construction productivity
Kellog et. al. (1981)	Argued that the fragmented nature of the industry impedes productivity growth
Ganesan (1984)	Also argued fragmentation affects productivity
Hague (1985)	Found financial incentives and any other method for encouraging productivity has had arguments for and against
Koehn and Caplan (1987)	Productivity improvement efforts should be concentrated on planning, scheduling, supervision, and labour
Briscoe (1988)	The quality of construction management is an important factor which helps to explain low productivity
McFillen and Maloney (1988)	Found contractors did little to encourage good performance, so workers reported little incentive to be highly productive
Herbsman and Ellis (1990)	Developed of a statistical model of quantitative relationships between influence factors and productivity rates
Chau and Lai (1994)	Argue the fragmented nature of the industry is often seen a hindrance to improving productivity
Dai, Goodrum, and Maloney (2007).	Foremen reported project management factors having more impact on their productivity, and craft workers reported factors related to construction materials having more impact

Koehn and Brown (1986) argued that construction productivity is affected by a wider range of variables which they divided into the six areas of management, labour, government, contracts, owner characteristics and financing. Koehn and Caplan (1987) but focused on small to medium size construction firms rather than large construction firms. The study concluded that productivity improvement efforts should be concentrated in planning, scheduling, site and labour management functions. Jenkins and Laufer (1982) also focus on the management issues, and discuss them in the context of motivation of workers. They suggested that while motivation does not directly influence the rate of working, motivation directly impacts upon the percentage of working time spent productively.

Arditi and Mochtar's surveys of the top 400 US contractors in 1979, 1983 and 1993 identified areas with potential for productivity improvement. The functions needing more improvement in 1993 compared with the previous survey were prefabrication, new materials, value engineering, specifications, labour availability, labour training, and quality control, whereas those that were identified as needing less improvement were field inspection and labour contract agreements (Arditi and Mochtar 2000).

Allmon et al. (2000) presented an approach to long-term productivity trends in the US construction industry over the past 25–30 years. Means's cost manuals (the main US source of estimating data) were used to trace the values for these tasks, and changes in these values were taken as productivity trends. Unit labour costs in constant dollars and daily output factors were compared over decades for each task. Direct work rate data from 72 projects in Austin, Texas over the last 25 years were also examined. The combined data indicated that productivity had increased in the 1980s and 1990s. Depressed real wages and technological advances appear to be the two biggest reasons for this increase. Their data also indicated that management practices were not a leading contributor to construction productivity changes over time.

PROCUREMENT SYSTEMS AND THE EFFECTIVENESS OF CONSTRUCTION INDUSTRY POLICY AND INTERVENTION

Some researchers have and identified institutional factors responsible for construction productivity levels. Labour issues include organised labour, the competency of project participants, the tendency of site management to spend more time providing information and writing reports than actually managing the project, and the inadequacies of an educational system which produces graduates with excellent skills in analysis and design but with little knowledge of methods to turn designs into realities (Tucker 1986). Other institutional issues are the tendency of construction firms to become larger and more specialised, legal restrictions on the management of construction projects and the complex regulatory regimes the industry works under.

Table 4. Representative Papers: Procurement and delivery systems and the effectiveness of construction industry policy

Cassimatis (1969)	The major factors affecting the efficiency of organisation in construction are institutional
Tucker (1986)	Institutional issues were the tendency of construction firms to become larger and more specialised, legal restrictions on the management of construction projects and insufficient research in construction and project management methods
Sidwell (1987)	Described the Australian construction industry as thoroughly conservative and slow to change in any fundamental way
Cox and Townsend (1998).	Construction has not developed the supply chains and procurement methods like other industries
Craig (2000)	Compared traditional and D&B procurement for innovation
Dubois and Gadde (2002)	The separation of design and construction creates inefficiencies

The limitations of the traditional procurement method have contributed to the poor performance of the construction industry and have prompted the development of alternative procurement strategies designed to facilitate improvements in the way buildings and structures are delivered (Cox and Townsend 1998). Craig (2000) concludes that the traditional tendering process for building works does not encourage design innovation by tenderers, because tendering rules produce direct price competition for a specified product.

R&D, INNOVATION AND PRODUCTIVITY

The construction industry has not established an impressive track record in innovation or technical advancement. The main effort in industry development has been concentrated in procurement, planning, management and design improvements. Nevertheless, there have been some significant advances in construction technology over the last two decades in both the materials used and the application of new construction methods (Fairclough 2002).

Gann (2003: 554) cites Bowley (1960) as showing that construction is an adopter of innovations from other industries, rather than a source of innovation. Bowley's work "shows that demand for new types of buildings is usually more important in stimulating radical technical and organizational innovation than the need to erect better and cheaper buildings to accommodate existing functions." Cassimatis (1969) concluded his study with a chapter on institutional factors, because "once the contract is awarded, competitive forces do not always prevail" (Cassimatis 1969: 118). Institutional factors that affect the performance of the industry are its openness to innovation and capturing of economies of scale.

Koch and Moavenzadeh (1979) focused on the role of technology in highway construction, and found there had been substantial gains in both labour and capital productivity over the previous 50 years in the US. They concluded that future gains in efficiency can be expected to be less than the previous gains, so new means of accomplishing technological change in the construction industry are needed. Arditi (1985) conducted a study of large construction firms to determine potential areas for construction productivity improvement. One of the study's conclusions was that more productive construction technology such as industrialised building processes are important in achieving higher levels of construction productivity.

Hobday (2000) and Gann and Salter (2000) argue that the construction industry can, and should be, more innovative. Many papers follow Tatum's (1986) analysis of the industry in terms of advantages and constraints to innovation, and despite the Tatum model of construction innovation being two decades old it still captures many of the key features of the discussion raised by more recent efforts such as Reichstein et al. (2005), Fairclough (2002) or Slaughter (1998). Ivory (2005) suggested that client will not be prepared to pay for innovation.

Table 5. Representative Papers: Contribution of research and development and innovation

Rosefielde and Mills (1979)	Argue the rate of technological progress in the construction industry may be slow because buildings are heterogeneous
Koch and Moavenzadeh (1979)	Focused on the role of technology in highway construction and concluded new means of accomplishing technological change are needed
Arditi (1985)	Recommended areas that research should concentrate on
Tatum (1986)	Construction has many features that favour innovation
Gann (1997)	Discusses the role of government funded R&D
Gann and Salter (2000)	Construction has the potential to be more innovative
Fairclough (2002)	Construction lags in R&D and innovation
Hobday (2000)	Argues that the nature of construction projects and teams creates opportunities for innovation
Zhi, Hua, Wang and Ofori (2003)	Seven factors influencing TFP growth in the construction industry of Singapore over 1984–1997 were identified
Ivory (2005)	Argued clients will avoid risk associated with innovation

CONCLUSION

Construction productivity is an important topic, and an issue both for the industry and its clients. The rate of growth of productivity in the industry in OECD countries has lagged that of other industries for at least five decades, and the earliest studies that identified a problem date from the late 1960s in the US with Cassimatis' (1969) analysis of labour productivity growth in construction between 1947 and 1967.

This paper has collected a wide range of previous research addressing a range of factors that could affect productivity. The bringing together of these different literatures on productivity analysis and measurement, project procurement and delivery systems, construction industry policy and intervention, and R&D and innovation allows a broader perspective on the construction industry's productivity performance.

These competing explanations of the causes of low construction productivity growth can be assessed in three ways: their completeness (whole of industry or part); their applicability (time, place and circumstance); and their generality (a data artefact or not). Clearly, no single explanation is complete, because each one focuses on a specific issue. The diversity of products and fragmented nature of the production process makes this perhaps inevitable, however measurement issues are both prevalent and relavent accross all sectors of the industry.

In terms of applicability, the breadth of management issues raised by researchers points to some possible serious problems with both the management of projects and management of workers. After several decades of development of project management techniques the average performance of projects does not appear to have improved greatly, with the more recent research finding similar problems as those found in the early work.

Lastly, it is possible that the R&D profile of the industry is as much an artefact of the data as a real problem. Construction is an industry that readily adopts research developments in other industries, the use of computers and the constant flow of new products from manufacturers supplying materials and equipment being good examples. R&D expenditure within the industry will not be very high in this case.

While this review of the construction productivity literature is not complete, because this is a very large field indeed, it has highlighted two key characteristics. The first is the importance of measurement and data to the research. More papers have been published on these issues than any other and they continue to be central to the discussion about the industry's productivity performance. This belongs to a broader set of issues about the structure and use of price indexes in the national accounting framework, an area where construction economists might have an opportunity to make a contribution. Recently there has been a shift from the use of deflators and their effects on measured output (or more precisely the ratio of output to labour input) to concern over the boundaries of the production system and more accurate measurement of specific factors such as capital inputs adjusted for quality and employment adjusted for firm size.

The second is the diversity of other issues raised that are suggested as affecting productivity. Influences on productivity growth in the construction industry, apart from the nature of the product, can be traced to the nature of the methods used in delivering and managing the processes involved. Construction is a labour intensive industry in comparison with manufacturing industries, but there has been a significant increase in the prefabricated component of construction, which could have been expected to lead to productivity growth. Also, construction methods have tended to become more capital intensive as the number of cranes and the variety of equipment and hand tools used has increased. However the productivity growth that one would expect to observe as a result of these trends has not occurred, according to measurements of productivity growth by the major national statistical agencies and reports like the UK studies by Ive et al. (2004) and Blake et al. (2004).

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CIB Joint International Symposium 2009

CONSTRUCTION FACING WORLDWIDE CHALLENGES

Dubrovnik, September, 27-30

Introduction

This volume contains executive summaries of papers submitted to the CIB Joint International Symposium, Construction Facing Worldwide Challenges, held in Dubrovnik, Croatia, from September 27 to 29, 2009. The associated compact disk contains the full papers. This is the annual meeting of two CIB Commissions and one Task Group:

- W055 Building Economics
- W65 Organisation and management of construction
- TG65 Management of Small Construction Firms

The two commissions and the task group operate under the umbrella of International Council for Research and Innovation in Building and Construction (CIB). CIB was established in 1953 as an association whose objectives are to stimulate and facilitate international cooperation and information exchange between governmental research institutes in the building and construction sector, with an emphasis on those institutes engaged in technical fields of research. CIB has developed into a worldwide network of over 5000 experts from about 500 member organisations active in the research community, industry, and education, who cooperate and exchange information in over 50 CIB Commissions covering all fields in building and construction related research and innovation.

The symposium is organised by the Faculty of Civil Engineering at the University of Zagreb, and it is supported by several international associations: International Project Management Association (IPMA) and International Construction Project Management Association (ICPMA), Croatian Association for Construction Management (HUOG), and Croatian Association for Project Management (CAPM).

The volume contains twelve sections according to the themes covered at the symposium:

1. Education and Training
2. Construction Performance
3. Economic Aspects of Construction
4. Information and Knowledge Management
5. Human Resource Management and Culture
6. Sustainable Construction
7. Management of SMEs
8. Academic and Industrial Collaboration
9. Project Portfolio Management in Construction Sector
10. Management and Economics of Complex Projects
11. Project Management as a Facilitator of Business Success
12. Construction Project Management at All Levels

All the papers were reviewed by the International Scientific Committee and about 250 delegates attended the symposium.

We would like to thank all the authors for their contributions. Our deepest gratitude goes to the members of the Organising Committee, international members of the Scientific Committee, as well as supporting associations, sponsor companies, and the City Council of Dubrovnik who made this symposium possible.

Anita Cerić
Mladen Radujković

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