Position Paper 2.21: P2

Construction Production Systems: Delivering Value for Money

Project 2.21:

New project management models for productivity improvement in infrastructure

Sustainable Built Environment National Research Centre

Project Partners

Project Team

Project leader

Prof. Russell Kenley (Swinburne)

Research team members

Professor Geoff West (Curtin)
Dr Toby Harfield (Swinburne)
Amin Vafaeikararoudi (Swinburne)
Juliana Beddgood (Swinburne)
Raphael Dua (Balmoralhill Pty Ltd)

Industry team members

David Bobbermen (QTMR)
Chris Harrison (RMS)
David Grenfell (JHG)

Synopsis

Construction productivity is important for Australian infrastructure clients, including State and Commonwealth governments. This can be seen from the continuous and strident calls for construction industry improvement. The difficulty lies in the confusion of acceptable metrics.

One solution is presented in this Position Paper: the case for adopting a systemic view of the construction management system to enhance value for money in infrastructure procurement. Previous research has examined productivity from the perspectives of industry, firm, project, and activity. A gap has been identified indicating that scant attention has been paid to any link between production systems and productivity in construction. This paper proposes that location-based management, an identified production system which uses the principle feature of location or physical space in construction projects, has the potential for productivity improvement.

The convergence within a production system of the productivity efforts across activities, projects and firms, associates the expected value for money outcome for both infrastructure clients and providers. This is particularly true for transport authority capital works and maintenance projects. Systematic construction productivity driven by procurement processes embedded in location-based management provides an alternative way forward.

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CONSTRUCTION PRODUCTION SYSTEMS: DELIVERING VALUE FOR MONEY

New production systems have great potential to deliver better value for money in the procurement of infrastructure works. Representing around 10% of GDP, productivity in the construction sector is of national significance. Despite an extensive body of work devoted to productivity, production systems are largely absent from the academic literature. This gap highlights an opportunity to improve infrastructure procurement through focussing on new production systems.

Introduction

This project was bourne from the idea that, to make a radical improvement to the productivity of construction work, it is first necessary to deconstruct the way we do things. Adopting the principle that you can't change what you don't understand, this project aims to deepen our understanding of the way we organise construction work.

The concepts are neither radical nor new. In fact, the ideas come from direct observation of construction management and project administration. And yet, they seem radical and perhaps even confronting. Any change can seem a challenge to what we know.

This position paper presents the case for adopting a systemic view of the construction management system to enhance value for money in infrastructure procurement. It explores the productivity literature to identify a gap in previous work, which has examined productivity from the perspectives of industry, firm, project, and activity. Production systems have not been directly linked to productivity in construction.

Project 2.21 is about identifying the way location is already used in the management of projects. The case for location-based management as a production system is now made. This paper considers the potential for productivity improvement.

Productivity

Productivity in the construction industry has long been a focus for governments, industry and academia. This interest is because construction is an enabling or leading sector, with a key role in growing and sustaining general economic activity. The 1990s saw an explosion of interest in improving productivity in construction in a number of countries. This was driven in part by the UK government, through productivity reports (Latham 1994, Egan 1998, Bourne 2000) and partly through collaborative industry and corporate sector initiatives, for example *Constructing Excellence*.

The *Royal Commission into Productivity in the Building Industry in New South Wales* (Gyles, 1992) aimed to articulate issues relevant to Australia.

The recommendations from these commissions were admirable although simplistic. For example, Latham (1994) called for efficiency savings of 30% over five years and Egan (1998) set per annum targets of 10% reduction in both cost and time. The strategies adopted by governments became aspirational targets and in many cases remain as such. The UK Cabinet Office (2011) had a goal of 20% reduction in costs for construction between 2011 and 2013. Another aspirational example is found in the *New Zealand Productivity Roadmap* aiming for the “magic” 20% reduction by 2020 (Kane, 2012).

Implementation of the recommended strategic targets by these governments, and other jurisdictions, is usually through the use of regulation and procurement processes to drive productivity improvement. Procurement is the obvious choice for mandated integrated design (BIM) and supply chain management to drive efficiency and elimination of waste. The UK and Singapore (BCA Singapore, 2011) central governments are major clients for infrastructure construction, which is why their procurement initiatives have become models for creating value for money strategies in other countries with a significant amount of government construction (Infrastructure Australia 2013).

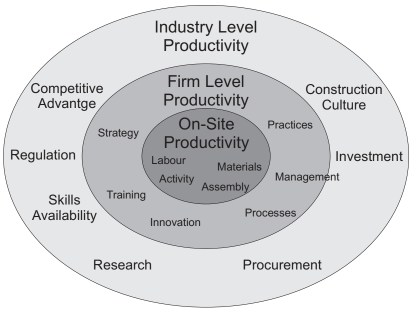

Figure 1: Construction sector productivity driver framework Adapted from Davis (2007)

Productivity typologies

Davis (2007), using official government statistics in a report for the New Zealand Department of Housing and Building, defined productivity as the measurement of inputs and outputs of resources (Figure 1). This type of financial focus motivates government economic strategies that are attempting to provide confidence that the public purse is providing value for money.

Davis did an extensive literature review to create a framework for measuring productivity based on three levels of construction activity: on-site productivity; firm productivity and industry productivity.

1. The site level is affected by labour organisation, activity scheduling, materials supply, system assembly (eg off-site manufacture) and design. These factors are applicable for infrastructure construction work.
2. Firm level productivity is affected by management across projects, innovation and firm practices. This list implies success factors from management research.
3. Industry level inputs and outputs are skills, investment, research, competitive advantage and regulation. The culture and practice of procurement within the jurisdiction should be added to the Davis list that indicates items linked to government regulation and policy.

However, many research and reports on construction sector productivity have different perspectives based on the author’s academic discipline perspectives (Russell et al, 2014). The Davis (2007) *strategic management analysis* of productivity differs from the *construction management* analysis by Yi and Chan (2014). Similarly, a reader’s interpretation will depend on their own background.

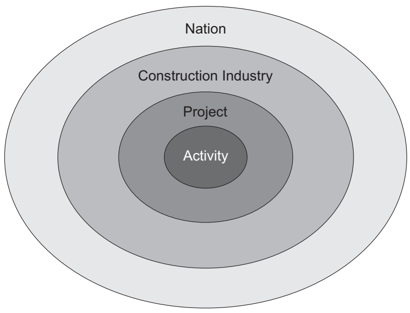

Figure 2: Construction Labour Productivity (CLP) framework Extracted from Yi & Chan (2014)

The main focus of productivity within the construction management literature is construction labour productivity (CLP). Yi and Chan (2014) reviewed 129 CLP research papers from 10 construction journals. The papers published between 1983 and 2011 were categorised into three productivity levels: industry, project and activity.

The lack of firm level of CLP measurement is problematic because the industry level measurement criteria they use includes topics that belong in a category related to the firm. Identified topics include: management (eg. work-flow reliability—a lean tool), tools, machinery and the automation and integration of information systems.

Although the Davis (2007) productivity framework includes an ‘on-site’ category, a more sensitive subdivision of on-site processes is provided by Yi and Chan who suggest ‘project’ and ‘activity’. They separate the way a project is managed from the way activities are planned and controlled.

This comparison of measurement factors and analysis levels provides some indication of the complexity of measuring construction productivity. Ultimately different types of frameworks based on academic discipline analysis leads to differing interpretations of construction productivity.

Four commonly accepted precepts provide the foundation for construction industry productivity:

1. The construction industry is a labour oriented industry.
2. Construction has a significant amount of craft/trade-based activity.
3. Labour supply/demand has a large influence upon construction firm performance.
4. A significant number of construction projects are unique.
5. Construction has a higher labour component that other production industries.

We suggest that effective productivity gains are possible if appropriate metrics are adopted to support interventions at four levels of analysis:

1. Industry
2. Firm
3. Project
4. Activity

Figure 3 illustrates this alternative breakdown of levels for productivity metrics.

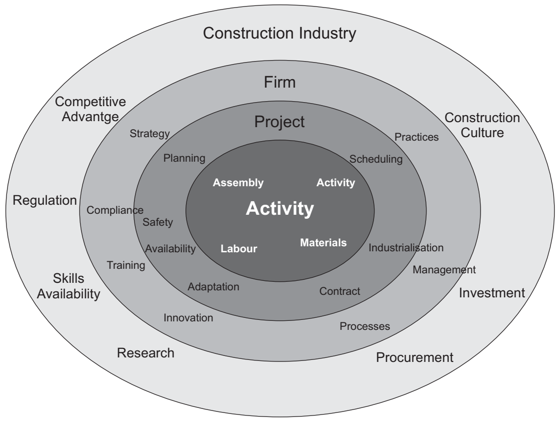

Figure 3: Proposed construction productivity levels

Construction Contributions to National Productivity

Construction is of national interest for most countries. Industries, firms and projects are all important to the economic well-being of developed and developing nations. For example, over one million people are employed in the construction sector in Australia and ABS statistics indicate that the annual contribution to GDP averages approximately 10%. In older societies the percentage of GDP averages between 5% and 10%, but the total monetary value is significant. In Australia, the official building activity generated for 2013 is $53.2billion (ABS, 2014). The Australian Construction Industry Forum estimates total construction activity will be approximately $220billion for the 2014-15 financial year.

Therefore, construction industry level comparison of productivity trends and comparisons between nations is a topic critical to all governments and industry participants. At the same time governments often perceive this key industry to be delivering poor value for public sector investment. For example, using a multi-factor productivity analysis for late 1980s figures, New Zealand Treasury claimed that their construction sector was only 50% as productive as the UK construction sector for the same time period (Page, 2010).

Equally, governments want to know if their construction industry growth strategies are effectively providing economic gains. However, international comparisons are notoriously difficult. Nasir et al. (2014) compared growth rates for 20 advanced economy countries based on an international database of economic activity between 1979 and 2003. The compounded growth rates for construction labour productivity was variable as would be expected over a number of business cycles. The macro-level analysis of construction labour productivity included the US, Canada, Australia, Korea, Japan, and major countries in the EU. Only three countries, the US, Germany and Japan, had negative growth rates. The authors suggest that industry level differences such as wage differentials and training systems are linked to productivity gains or losses.

Sezer and Bröchner (2014) reviewed the history of the construction productivity debate and found numerous alternative explanations for low growth that has emerged since 1930. In that year the US Census Bureau collected extensive data on the US construction industry that has become the benchmark for productivity analysis. Low rates of sector productivity have been calculated by US economists using these data. However the authors argue that low growth rates in official statistics are explained partly by measurement difficulties. This is not surprising: the Australian Bureau of Statistics and other government statistics services preface all reports with descriptions of measurement limitations. For example, the building activity official statistics (ABS (2014) 8782.65.001) are based on only 95% of both direct and indirect reports on buildings within defined values (plus or minus GST and purchased land values).

The major problem is that the productivity model (input/output) that works well for manufacturing is not easily transferred to service, extractive and construction industries. The fundamental issue for measuring construction sector productivity is the difficulty of defining inputs and outputs. For example, many construction related datasets (infrastructure engineering) are outside of the building dataset. Construction is a process dependent upon professional services, however, engineering or architectural services are usually located in non-construction datasets. Another problem is that imported construction materials are usually located as an output of the retail sector.

Measurement of sector productivity is becoming even more difficult because of the increasing reliance on off-site manufactured materials. This is one of the most difficult indicators of construction productivity to capture. Are off-site manufactured construction components an input for construction or an output for manufacturing?

Apparently what can be measured to indicate construction industry productivity (excepting per hour trades labour productivity) is currently impossible to define. The difficulty of measuring multi-factor construction productivity for the unique product to be produced has a long history (Isaac & Navon, 2014). However, measuring project productivity provides an opportunity to move from the narrow CLP concept to focus on project management processes.

A Systems Perspective

As noted above it is possible to consolidate the Davis (2007) and Yi & Chan (2014) defined levels for productivity analysis: Industry; Firm; Project; and Activity. However, these categories do not address the real problem of how to improve productivity.

In construction industry productivity research below the industry level, where factors may be influenced by government, researchers tend to overemphasise measurement of human activity performance and establishing benchmarks. Improvement in productivity requires a more strategic approach than just measuring one form of activity.

Accordingly, it is necessary to adopt a more systemic view to expose the role of production systems at each of the levels previously categorised. A close reading of the analysis by Yi and Chan (2014) reveals production systems (such as Lean Production) play a role at three levels: industry, project and activity. However, neither Yi and Chan nor Davis identified production systems as a topic in their own right (Koskela, 2000).

A static view of complex systems into constituent parts is of limited value when elements are in constant dynamic interaction. Just as the complex interaction between parts of a safety system can lead to safety failures throughout the system (Lingard, 2013), construction sector productivity is more than just the summation of productivity of individual activities. The complex interaction between activities within construction production systems, involves system dynamics factors such as work readiness, work flow reliability, logistics, production buffers, mobilisation and demobilisation.

The measurement of performance at the activity level is at best only an indicator of the productivity of the entire system. If improved activity efficiency is not reflected by improved performance of the production system, the improvement is only valuable to the one performing the activity and not the project, the firm or even the industry.

It is extremely difficult to collect data about overall system productivity. This lack of production system data has resulted in a dearth of journal papers with this focus. It is not surprising therefore that Yi and Chan (2014) did not differentiate production systems in their review of 135 papers from ten construction journals.

Production System

Productivity interventions imply alternative project management processes through production system methodologies. Arguably the best known intervention is Lean Production, also known as Lean Construction (Koskela, 2000).

Several methodologies have been developed for managing construction production in which location is the unit of analysis for scheduling (Russell et al, 2014). Collectively termed location-based methodologies (Kenley, 2004), each uses their own terminology and logic, but they have a common goal of systemic waste reduction through the mechanism of physical place.

Seppänen et al. (2014) provide evidence from the use of the Location-Based Management System (LBMS). The goal of their research is to determine if implementing LBMS produces quantifiable improvement. Three areas of identified project waste were measured: production problems, changes in production rates, and changes to productivity based on detailed data of actual quantities, manpower and progress related to LBMS generated alarms through the construction management system.

The findings were that LBMS generated alarms (alerts to slow production) led to responsive control actions that prevented 50% of production problems. Importantly, overall production was able to be increased by fixing production interference and thereby decreasing labour consumption rates (labour hours per unit) rather than by simply adding more resources. These findings challenge the traditional view that production rates are fixed and that production can only be accelerated by adding more resources.

This research provides evidence that general contractors are able to influence production rates leading to decreasing project durations through real-time production control. These findings provide a clear indication that the construction project production system is dynamic. If you limit the productivity focus only to resources, then the only way to reduce time (task duration) is to increase resources. Whereas activity time (units x consumption rate x resources) is more complex. The possibility and potential benefit of active production control (as opposed to managing contracts) is the key conclusion of the Seppänen et al. (2014) study and highlights that time can be reduced without extra cost through production management.

Vilasini et al. (2014) address the problem of how to streamline process improvements in an alliance consortium by applying lean construction philosophies. On-site processes were observed, rated and intervention points mapped. The researchers found that a large number of 'small' waste processes added up to a significant amount of waste. Their focus on waste detection assisted in the development of a specific process for productivity measurement. Their waste reduction framework resulted in a systematic rating of construction processes to provide a 'value add' for completing the project. Adding value may be good for privately funded construction, but is particularly an imperative for publicly funded construction.

Figure 4 illustrates the concept that the production system cuts across the normally accepted categories of productivity: Activity; Project and Firm. The idea is that for a production system to be effective it must be adopted at the firm level and become part of the culture of the firm.Thus, projects will be managed according to the production system and ultimately so will the planning and control of construction activities.

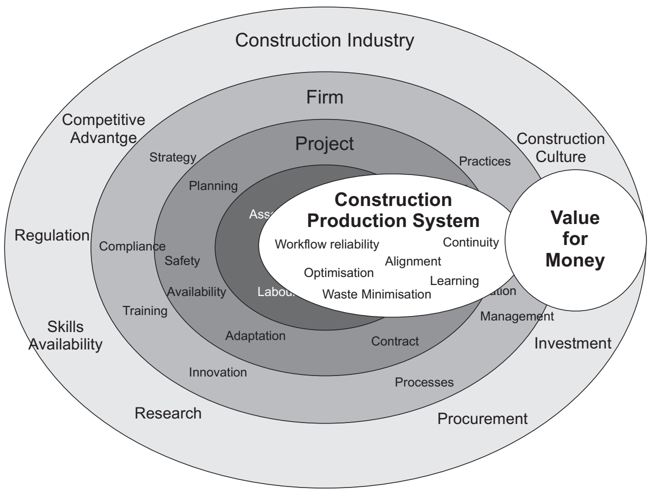

Figure 4: The role of construction production systems in delivering value for money

The adoption of a systemic approach to production in this way will deliver better value to both the firm and its clients, and thus the industry.

Value for Money Imperative

In the UK and Australia, a significant amount of annual construction is procured by governments (Manley, 2006). Buildings (hospitals and schools), transportation infrastructure (roads and railways and working services such as ports) are considered fundamental for a healthy and growing economy. Construction sector support is usually announced in State and Commonwealth bud-

State	2010-11	2011-12	2012-13
NSW	16.6	15.7	14.9
QLD	17.1	14.0	13.5
WA	7.6	6.0	5.9
VIC	6.4	5.2	4.6
SA	3.6	2.1	1.7
Totals	**51.3**	**43.1**	**40.6**

Table 1: Planned state government infrastructure expenditure ($billion)

gets. Table 1 lists the financial year promises from five states over three years.

An important issue limiting a mechanism to measure construction industry productivity is the multi-factor nature of public investment. The simple input/output model applied to financial metrics provides reasonable implications (Lam & Gale, 2014). However, validating spending on behalf of the 'taxpayer' now links financial investment with the concept of 'value for money' (VFM) which includes a number of non-price factors.

The expansion of the VFM concept into Australian government procurement and policy has been via the Audit Office (Jacobs, 1998). In an address to students of the Graduate Certificate in Performance Audit in 2002, the Auditor-General for Australia spoke of the necessity for accountability and responsibility in controlling procurement strategies for government activities (Barrett, 2002). As noted governments do have the ability to regulate and mandate skills, training, standards, and procurement systems to drive productivity improvement.

Transport Authority Value for Money

Much of the Value for Money literature focuses on Public/Private Partnership delivery (Yuan et al., 2009; Manley, 2006). However, procurement is an agreed avenue for the application of VFM principles according to Austroads. All Australian states are Austroads members which suggests that their tenders should be based on VFM principles.

> **Austroads**: *Value for money should encompass both quality and price, and may also consider relevant social and industry capacity issue. The tender with best value not only satisfies the assessment criteria but also is expected to result in the satisfactory completion of the specified work, to the specified quality, environmental and safety standards, within the specified time, for the lowest price (Austroads, 2009, p. 13).*

Three examples of government procurement based VFM priorities are these transport authority major construction project directives:

> **Queensland:** *Achieving value for money requires consideration of: contribution to the advancement of Government Priorities; non-price factors such as fitness for purpose, quality, service and support and sustainability considerations; and cost related factors including whole-of-life costs and transaction costs associated with acquisition, use holding, maintenance and disposal (QTMR, 2009).*

> **New South Wales:** *The best value for money tender is the tender that satisfies the assessment criteria in the Information Documents, as well as other tender details that require evaluation and is expected to result in the satisfactory completion of the specified work, at the specified quality, to the specified environmental and safety standards, within the specified time, for the lowest price and performed in the spirit of co-operative contracting (NSW RMS, 2011).*

> **Western Australia:** *value for money is any feature of a Tender that provides a benefit to the Government of Western Australia and the community. It is assessed during tender evaluation by identifying the lowest Comparative Price Tender (this Tender then becomes the benchmark for the value-for-money assessment); if the next higher priced Comparative Price Tender has a higher Non-Price Assessment Score than the benchmark, identifying the additional benefits (if any) offered and assessing if the additional benefit is worth the additional price; repeating step (ii) with the remaining Tenders; and determining which of the Tenders, if any, offers the best value for money (MR WA, 2012).*

Clearly the project delivery process incorporates VFM intentions. In addition Annual reports reference VFM, indicating implementation of VFM policy. For example, in the *Queensland Department of Transport and Main Roads Annual Report (2012-13)*, the Director-General's opening statement of the year's accomplishments is sub-titled Delivering Better Value for Money (Vol1, p. 8). Clearly the operational expectation is to "Use funding sources which provide value for money." (Vol 1, p.17).

Productivity Improvement through Value for Money Policy

As noted earlier the different perspectives of academic disciplines effects measurement factors (Kenley, 2014). These differences are also reflected in the state road authority annual reports. The Annual Report 2012-13 for the New South Wales Department of Transport: Roads and Maritime Services focuses on productivity improvement.

NSW RMS focus on Business Results can be reported as 'Value for Money' productivity gains (p. 43 & 61). This sub-title provides a clearly stated goal and implementation process:

> *RMS ensures that resources are allocated to deliver best value for money and assess new ways to deliver more with less.*

Key savings of $137 million are attributed to strategies to reduce expenditure by providing a more cost effect service for stakeholders. For example, increasing the number of public services available online and restructuring internal organisational services such as payroll.

In addition a major new initiative based on a recommendation by the NSW Commission of Audit was to establish a Project Management Office to provide more involvement of the private sector for road maintenance. The contestability delivery model for maintenance, renewal and improvement of works were identified as an opportunity for greater value for money (Lam & Gale, 2014).

The Way Forward

The difficulty of finding comparable metrics suggests that the systems view of the construction sector is an important first premise. If this is the case then a production systems perspective will be the most effective level of analysis.

Contestable construction delivery for capital works and maintenance suggests the opportunity for procurement driven construction productivity improvement. For example, these initiatives could be joined with systematic construction productivity focused methodology such as Location-Based Management discussed above.

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