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SUPERIOR CONTRACTOR PERFORMANCE: A BARRIER TO LEAN CONSTRUCTION ADOPTION IN AUSTRALIA

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ABSTRACT

The Australian construction industry produces twice as much value per dollar while enduring four times the competition than manufacturing. Impressively, this sector outpaces six of nine major industries in the country. However, their quantitative success may dampen Lean Construction's adoption, hurting the industry long-term.

Practices significantly transform the value of the inputs, and contractors do it better than manufacturing. However, the industry is much riskier than manufacturing, so contractors hesitate to change to new ones quickly. It appears that organisations will not rapidly adopt Lean's methodology partially due to the success and risk of the Australian construction Industry.

This paper proposes a survey methodology of practices to convince contractors of Lean Construction's improvement potential. Obviously, they should search wherever there may be promising methods. However, this research outlines a straightforward process to validate valuable practices that can be executed internally in the industry and clarify practices' value and timely completion. The aim is to convince already superior performing contractors to see the LC approach as a competitive opportunity.

KEYWORDS

Construction contracting management, best practice, performance improvement, innovation.

INTRODUCTION

The Australian construction industry produces twice as much value per dollar as manufacturing while facing four times the competition (ABS 2020). Additionally, the sector outpaces six of the nine other major industries. Construction contractors are producing more positive results than the industry they are supposed to learn. The Australian sector achieves more significant levels of efficacy than the exemplar industry (manufacturing), weakening the core argument for LC implementation.

However, the Australian construction industry suffers from many issues that started the LC movement, such as stagnant productivity, time delays, cost overruns, poor quality and client dissatisfaction (Fauzan & Sunindijo 2021).

So, the challenge is to create a strong argument for implementation. However, we know that contractors' practices are difficult to change due to the risk, low margins and hyper-competition. Successful contractors' valuable practices should be shared with the

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rest of the industry. However, due to the risk and hyper-competition, these high-performing organisations do not declare their excellent results nor invite outsiders to observe their operations. There are many reasons, including that this knowledge can leave with the employee separation.

Additionally, that manager may recruit staff to join them. So discovering and documenting effective practices is not easy. So, as a critical intermediate step to LC adoption, we assert that a new principle be added: Ontime adherence to proven practices disproportionately enhances performance. Capturing actionable tasks for clarity with a single performance measurement is an important step. This paper suggests an approach.

LITERATURE REVIEW

Koskela (2011) describes a general decline in management research since 1959. He suggests the focus of researchers is more aligned to social science and that production techniques research has largely gone away. Studies on how to make things more efficiently with higher quality and less cost have been small in number in management research. A common theme in management research is "describing the world" rather than improving it. Lim et al. (2011) assert that the means for achieving construction organisational capability has been lightly explored. Caldas et al. (2009) found that the construction process and the underlying practices have been less studied than those involving the use of technology. There is limited professional research literature about construction contractors' practices even though these firms perform a significant portion of construction (Arditi and Chotibhongs 2005). Additionally, on-site management practice research is "somewhat sparse (Thomas and Horman 2006).

Construction projects are unique and risky; however, the contractors in Australia have produced disproportionate value with greater competition compared to manufacturing (ABS 202). As in many parts of the world, most of these projects require on-site production, are one-of-a-kind, and possess input-output conflicts and interrelatedness complexity. In addition, the uncertainty that occurs before and during the work creates rare risk levels compared to other business sectors (Salem et al. 2006). As a result, construction companies and industry practitioners have created many assessment methods to distil construction project performance. For example, time, cost, and rework are quantitative metrics, while qualitative ones include safety, leadership and sustainability.

CONSTRUCTION INDUSTRY PERFORMANCE

Among the nine major Australian industries, construction's labour productivity as measured by Gross Value Added (GVA) per hour was the third-highest (Leviakangas 2017). Furthermore, current construction industry practices produce more than twice the value per dollar than manufacturing, with four times the competition. See Table 1.

Table 1. Comparison of Australian Construction and Manufacturing (Australian Bureau of Statistics FYE 2020)

Metric	Construction	Manufacturing	Comments
Number of Businesses	394,496	86,226	Construction has four times the competitors
Average Entrants Annually 2016-2020	6.3%	1.9%	Three times the number of new competitors each year
Turnover at Current Prices	$210,659,704,000	$405,091,000,000	Construction has approximately half the turnover
Value Added	$126,293,000,000	$107,479,000,000	Construction adds 59.9% value per turnover dollar, whereas manufacturing contributes 26.4%

Many researchers have provided credible evidence that LC is the answer to many of the industry's ills. However, its implementation has not been fully adopted in Australia. The slow uptake of innovative methods appears to partially cause the lack of improvement in Australia's multifactor productivity over the last two decades (Stevens and Smolders 2021).

The literature has noted several benefits to construction contractors by implementing LC Practices, such as reducing project time, increased asset and labour productivity, improved safety, better cost performance, reduced input waste, and specification adherence (Ghosh and Burghart 2021). However, there is no universal LC definition but rather an interwoven series of concepts from different sources (Koskela 2020). The formal purpose of LC is to deliver more value to Project Owners by reducing variation in workflows. The initially agreed project schedule is highly probable due to the predictability of estimated workdays needed. Ghosh and Burghart (2021) assert that the primary barrier for LC adoption is the need for a new belief system. Babalola et al. (2019) conducted a systematic literature review and found that approximately 20 different economic, social and environmental benefits were linked to implementing LC practices. However, a critical mass uptake of LC's many practices and their sustained implementation is required to attain these goals. With these many benefits available, it is puzzling why significant adoption has not occurred. One assertion is that its broad-based terminologies and principles lack realism and practical application to inspire confidence enough to adopt (Green and May 2005). Leong et al. (2015) echo the same sentiment; the lack of response towards LC is due to an instruction of what workers and managers should be done operationally on the project and in the organisation. The inputs and processes identified by advocates are broad-based and therefore unclear for downstream workers and managers. However, Lean methods in the construction industry are still evolving and have not reached a maturity level compared to the manufacturing sector's adoption history (Babalola et al. 2019).

CONSTRUCTION CONTRACTOR PRACTICES

In the 2022 edition of the Oxford American College Dictionary, practice is defined as a noun: 1. the actual application or use of an idea, belief, or method as opposed to theories about such application or use. A process is defined as: 1. a series of actions or operations conducing to an end.

Seymour (2013) asserts that engineers and those around them tend to answer the "what" is to be done ably but not "how" things come to be. These "series of actions or operations" can be interpreted as practices that make up a process. They are "construction design, components and materials, workers, equipment, space, connecting works and external conditions" (Koskela 2000). Construction processes consist of many tasks. Each task may have up to 7 preconditions before it can be completed. These are human-enabled. This set of preconditions and the task itself creates many activities to monitor for the executive. Variations in on-time practice execution is high and thus impact follow-on activities. Delays are common, but early unplanned completions are lost opportunities to advance the schedule. An uncompleted task has a ripple effect to follow on tasks (Liu et al. 2011). Hence, it is critical that they are monitored and, thus, managed and measurable if one is to complete projects efficiently.

Tailoring LC practices to the organisational context is absent in application. London (2008) argued that LC principles do not account for the organisational context. Instead, they appear to suggest that the organisation changes itself to fit the methodology.

What is needed is LC application on project processes and organisational needs. These include many areas such as culture, value streams, development, growth, and human interaction (Koskela 2020). LC Practice definition and implementation are influenced by each industry manager's interpretation of the practical diffusion of concepts within different contexts (Kifokeris 2021). Koskela (2020) examined LC implementation in Swedish Built Environment firms and found widely different interpretations and implementation approaches. Additionally, noting the vast differences in 27 company market services. Hines et al. (2004) suggested LC has been confusing in its definition and, thus, has lacked consensus among practitioners. However, as a starting point, Koskela's (1999) practices should be created and formalised "to do as little of what is unnecessary as possible."

Lessons Learned Programs (LLP) take several forms to capture practices. Charrettes or structured workshops have been held to collect efficacious tasks and have been in use since 1996 (Gibson and Whittington 2010). Several other methods have been used, such as meetings, interviews, electronic means, paper forms, word of mouth and outside consultants (Caldas et al. 2009). Another avenue is general business reading and the distillation of common business practices or policies (Ogunlana et al. 2003).

It is self-evident that the construction industry does not have the same knowledge from company to company. Moreover, construction firms typically do not distribute practice knowledge evenly across the organisation (Caldas et al. 2009). The need is evidenced by quantitative and qualitative data about the construction industry and its performance.

VALIDATION OF PRACTICES

The construction industry relies on informal coordination and decentralised decision-making, which impedes company optimisation and innovation (Brosseau and Rallet 1995). The scientific methodology must be employed if the construction research is to have two critical characteristics for acceptance by academics and practitioners: a) validity and b) reliability (Lucko and Rojas 2010). This type of research is common in other disciplines. However, it must be a focus, and continued good scholarly work is needed to construct academic programs to keep their prominence in elite universities (Halpin 2007). Validation of the promising practices usually follows after selection. Value analysis has been executed by meetings, subject matter experts, electronic surveys, and informal conversations (Caldas et al. 2009). Once a practice is confirmed as "best," the value should be clear, and there is little debate.

Pre-construction planning is a well-accepted beneficial process that contains many steps and has been the subject of several studies. The value of this type of planning is high and, therefore critical (Laufer 1987; Menches et al. 2008; Hanna and Skiffington 2010). Menches et al. (2008) modelled project characteristics, planning and performance in the electrical contracting industry. Each of these factors was quantified, and predictors were discovered. However, project outcomes were limited to self-reported "successful" and "unsuccessful" and did not quantify efficiency in exact percentages or quartiles.

The work acquisition process was examined, including its markup practices, turnover to project management, and resulting financial performance. It was concluded that large deviations in markup affect backlog. This deviation results in an unpredictable workflow, which causes disruptions to the firm's ability to work steadily. When the amount of work is overcapacity, employees rushing to complete their tasks make mistakes and thus cause extra expense. Conversely, when the amount of work is substantially below capacity, the overhead expense percentage of the revenue rises. Both of these situations create a pronounced effect on net profit before tax. A quantified model was proposed (Kim and Reinschmidt 2006).

MEASURING CONSTRUCTION CONTRACTOR PERFORMANCE

Construction companies and industry practitioners have created many assessment methods to distil construction project performance. Time, cost, and rework are quantitative metrics, while qualitative ones include safety, leadership and sustainability (Salem et al. 2006). Some studies have taken a predictive approach to the constructor's future performance. This assessment of the probability of success used a multifactor approach (Waara and Brochner 2006; Hartmann et al. 2009). In other studies, the focus has been on determining a contractor's failure probability. (Suarez 2004; Dikmen et al. 2005; Marsh and Fayek 2010; Mahamid 2012). Others have sought to quantify organisational flexibility. The reason is clear; the ability of the construction business to "flex" allows it to effectively manage the constant change in the industry (Lim et al. 2011). These are based on a generalist view.

Improving operating practices will speed up the work cycle. The work cycle is alike a "flywheel"; the faster it spins; a company will enjoy better business outcomes (Collins 2001). In construction, higher adherence to each step increased speed. Tracking creates an opportunity to coach employees and improve their skills and practice. Tracking can be classified in one of two ways: proactive and reactive (Bassioni 2005). Proactive tracking can be defined as those activities which are behaviours; reactive tracking is monitoring results.

Organisational effectiveness (O.E.) is a relatively new term in construction research. It was widely ignored before the 1990s in construction research (Dikman et al. 2005). Since that time, there have been a few examinations specifically about the organisational effectiveness of construction firms. Some researchers (Maloney and Federle 1993) proposed a model of how superior O.E. should be executed. However, they did not describe specific actions that a firm should undertake, only the approach that should be utilised.

Others such as Sinha and McKim (2000) interwove several common business management approaches, such as total quality management (TQM), business process reengineering and benchmarking to seek a common thread of thought. The "unifying theory" is elusive. This is to be expected. Construction has a complicated value chain of many different stakeholders and a dual challenge of managing projects and the overall firms (Dikman et al. 2005). Construction contractors are rewarded or penalised based on two organisations within their companies: 1) The project organisation 2) The home office organisation. Each has an effect on the overall yearly result. It is this complexity in construction that creates a very fluid environment. Sometimes these two organisations conflict in actions and goals. Examples include sharing of common assets, such as equipment or craft persons. However, a project manager would want the best people on his job; the organisation is building many equally important jobs. This causes conflict and complexity. Peters and Waterman (1982) conclude that the firms that do well "manage ambiguity".

Some studies suggest accomplishments or ratings determine the level of organisational effectiveness. This is a results-oriented methodology characterised by an observational or empirical approach. Project participants either report back, or a third party observes outcomes. At the end of the project, conclusions are made about the project. Examples include construction company performance models (Kim and Reinschmidt 2006; Lim et al. 2011; Ling et al. 2012), conceptual framework (Bassioni et al. 2005), factor analysis (Mahamid 2012), Delphi studies (Yeung et al. 2009) and competitiveness ratings (Tan et al. 2011). These overall models that attempt to guide the contracting community abound in research. Bassioni et al. (2005) attempted to define a general framework of organisational effectiveness with "driving factors and results factors". These can be classified as "before" and "after" factors.

Several studies have advocated a more robust set of critical success factors (Bassioni et al. 2008; Cox et al. 2003; Skibniewski and Ghosh 2009). Critical success factors research lists several dozen areas that prove to be helpful to organisational effectiveness. Some are based on conditions in that the company finds itself. Others are outcome-based and prejudged to be repeatable. Several more are concentrated on processes. However, the void of individual practice or method research is large. Thomas and Ellis (2007) noted: "Unfortunately, there is nothing in print that defines a process that a contractor should follow."

ADHERENCE TO PRACTICES

Martilla and James (1977) created a process for marketing that rated "customer importance" and "company performance" or the Importance-Performance Analysis (IPA).

Abore and Busacca (2011) suggested that IPA's effectiveness is dependent upon identifying key value drivers. It is critical that practices research carefully collect each observable method and test each practice with a limited group of knowledgeable participants. Research also requires objective metrics, such as a financial ratio, to clarify practice effects (s). Platts and Gregory (1990) suggested that there should be a connection when using this approach in operations to tie an audit to strategies that a manufacturer pursues. Slack (1994) asserted that "there seems no reason why it cannot also be used more generally to include service operations". Construction is a service business, and using this approach may be an efficient method to improve contractor operations.

Menches and Hanna (2006) captured and tested 64 management practices. Their methodology judged successful projects by compliance with practices. Each project's grade resulted from what percentage of methods were actually completed. There was no objective, independent variable such as a cost or schedule metric to compare and analyse the effectiveness of compliance.

Ogunlana et al. (2003) studied the performance enhancement of a single company created by implementing generic policies of human resources and financial management at the same time. Using company internal numbers gives an accurate picture. It can show improvement easier by using a trend line over time.

METHODOLOGY

This paper will propose a quantitative process to show the value of Lean Construction to Australian Construction Contractors.

Then design a system to find correlations between a specific set of practices, their importance, their performance and their effect on overhead efficiency of managing direct project cost against peer averages.

Converting LC Practice Language

Practice statements should be created in the language of the targeted country. As part of the research process, further refinement was needed in the wording of each. See Table 2 for suggested restatement of standard LC practices in construction-centric terms.

Table 2: A Suggested Restatement Of LC Practices In Construction-Centric Terms (Stevens 2014)

Lean Construction Practice	**Possible Restatements into Commonly Understood Practices for use with Importance and Performance Assessment (IPA)**
Last Planner® System	"We plan with our project stakeholder group in writing one week or more at a time. The project team uses a complete list of things to consider when ensuring an area and the team are ready for work to be installed."
One-Piece Flow	"Each person in our company executes tasks from beginning to end as practicable."
Heijunka - Levelled Workload	"We look ahead at least 6 weeks to ensure our field and office staff are not overloaded with work."
Standardised Work	"We have one company standardised way to perform each office or field task."
Visual Management	"Our preference is to use visible means (versus written means) to communicate information to all company employees."
Use of Reliable and Proven Technology	"Our software is established and proven; we have few, if any problems with it."
Jidoka – Build In Quality	"We consistently discuss and implement value-adding ideas."

Once finalised, a survey should be given to construction firms that agree to participate. Each statement will be formatted in an IPA survey. The scale used is 1 (low) to 7 (high). This allows practices to identified to be more critical – rated 5, 6, and 7 and to see the implementation opportunity – performance – for these highly-rated practices.

A fictitious practice statement and its response data are shared in Figure 1.

16. We use a proven method to apply overhead costs to each bid.										
Answer Options								Rating Average	Response Count	Disparity
Importance to the Success of our Company	0	0	2	1	2	4	19	6.32	28	0.78
Our Company's Performance	0	1	3	2	2	8	8	5.54	24	

Figure 1. Fictitious Example of Practice Statement Survey Result

The rating of importance and performance provides a) a learning opportunity for survey participants about valuable practices, b) an affirmation to Lean Construction of the perceived value of each of its practices, c) an Implementation assessment across the industry.

Thought was given to using these measures in combination and creating a value or index number based on that combination. Also, several measures were considered to be used alone and be designated as the sole criterion for determining performance. Each concept has benefits and drawbacks. For example, most for-profit firms manage their business to minimise substantial tax liability. This practice creates artificial outcomes such as favorable net worth, owner's equity, and outstanding debt obligations between competitive companies with considerable revenue. Therefore, measurements such as return on net worth or return on assets were less credible.

From this researcher's experience, the Overhead to Direct Cost (OH/DC) ratio fits the goals of this study. This measure attempt to distil an efficiency measure of overhead (office efficacy) in managing direct cost (project expenses). It possesses less overall error; it directly measures any contractor's two largest cost categories. The number size makes these less sensitive to differences between two peer firms' accounting categories. Although, the classification of overhead expenses and direct costs is not standardised. One metric met the efficiency criteria best for the contractor: a construction firm's overhead to direct cost ratio against median Peer Performance.

In summary, overhead expenses are overall, and direct costs are specific and targeted for a specific project. The interaction of these two cost variables can be directly linked to speciality contractor performance. Therefore, the OH/DC ratio was chosen as the dependent variable to measure good operating practice importance and performance.

The OH/DC ratio of participating construction firms was used as an objective measure for company performance against Risk Management Associates data of defined categories of firms.

Accurate outcome measurement is critical when measuring correlation both for the benchmark and the company. Construction Contractor benchmark data was sourced from Risk Management Associates, Philadelphia, Pennsylvania. This banking clearinghouse aggregates information from source documents such as credit line applications, tax returns and business loans.

Participating companies furnished audited Financial reports (Balance Sheet and Profit and Loss statement). These were viewed as the most accurate gauge of a company's financial health available by the researcher.

Table 2. Comparison of Adherence of Company Practices and OH/DC Performance

Organisation	Average Importance Rating of Practices	Average Performance Rating of Practices	Average Disparity Between Importance and Performance	Percentage of Peer OH/DC % Difference
Sample Company A	5.09	4.46	-0.64	+69.60%
Sample Company B	5.77	4.38	-1.40	-17.76%

The importance, performance, disparity and peer comparison distilled the primary operating performance of participating firms. Employees determined the importance and performance ratings. The overhead to direct cost peer comparison provides a relative efficiency.

This paper investigated the correlation between critical practices (ones rated 5,6 and 7), their disparity in performance and Peer OH/DC % Difference. It is logical to assume that timely execution of valued practices results in higher than average efficiency.

This study determined several good operating practices. These are "predictors" according to SPSS software nomenclature. This is an essential part of this research for a couple of reasons: a) for companies in distress, these "best practices" should be the first steps implemented to improve organisational effectiveness; and b) this research proves that there are best practices through a scientific methodology.

In Figure 2, a 40% of Importance-Performance rating disparity correlates to an average Peer OH/DC % for this set of practices. See regression line interception with the percentage of performance. Predictably, increasing adherence to the timely completion of standardised company practices correlated with higher efficiency.

DISCUSSION

Undoubtedly, construction contracting organisations are vigilant for ideas, systems, or practices that increase safety, improve quality, lower costs, and raise multifactor efficiency. Hypercompetition forces them to. However, great credit should be given to the industry and its organic value generation against the significant competition.

The Australian construction industry is producing significantly more value with greater competition than manufacturing. Then the answer may not be a grand transformation but a continuing upgrade and refinement of existing practices. This steady improvement process may involve adopting techniques from other industries, including manufacturing and their Lean Production mastery.

Many metrics have been created to measure efficiency. Projects are problematic to measure due to the many variations, such as size configuration, schedule, location, and stakeholders involved. However, organisations are more uniform when comparing them, such as contractor type and size. To test practice efficacy, a company is a better organism in which to measure.

The objective measure that was determined to yield greater accuracy in measuring financial normality was United States banking data. The source of this information was Risk Management Associates, Philadelphia, Pennsylvania. Many financial measures were considered. The information for cost was also collected to complete accounting and kept separate.

Of course, the industry's practices should be improved; however, there should be more confident that construction organisations have efficacious practices, and many of them should be improved but not replaced.

CONCLUSION

Australian Construction organisations produce more value with greater competition than manufacturers as well as other sectors. Therefore, LC’s insistence on the rapid transformation of construction appears misplaced. Instead, this paper asserts that credible evidence of value that can help adoption should be steady and incremental.

This research did not present the complete list of the LC practices in Australia's construction-centric and native language. Future work could be a starting point for a

Delphi panel to edit, delete, add, and test. Numerous statistical tests can be executed once a statistically significant sample size is attained.

One limitation in this study was using RMA data, mainly from the United States economy. It does not easily translate to Australia's unique construction industry but it the only available source of credible financial content. These areas could further explain practices' relative value for construction contractors.

Improvement is always a challenge for any industry. Construction's stagnant multifactor productivity is a significant problem. Therefore, a refocusing should occur on helping the industry find and test practices wherever they are utilised, including other construction firms. This research proposed a methodology that will test the value of methods. The outline of such a methodology was presented. This approach can be further developed and implemented by sponsoring organisations such as associations or universities.

REFERENCES

Arditi, D., & Chotibhongs, R. (2005). Issues in subcontracting practice. Journal of Construction Engineering & Management, 131(8), 866-876.

Bassioni, H. A., Price, A. D. F. & Hassan, T. M., (2005). Building a conceptual framework for measuring business performance in construction: an empirical evaluation. Engineering, Construction Management & Economics, 23, 495-507.

Bassioni, H. A., Hassan, T. M., & Price, A. D. F. (2008). Evaluation and analysis of criteria and subcriteria of a construction excellence model. Engineering, Construction and Architectural Management, 15(1), 21-41.

Caldas, C. H., Gibson, G. E., Weerasooriya, R., & Yohe, A. M. (2009). Identification of effective management practices and technologies for lessons learned programs in the construction industry. Journal of Construction Engineering and Management, 135(6), 531-539.

Collins, J. (2001) Good to Great: Why Some Companies Make the Leap and Others Don't. Pages 139-141. Harper Business. 1st Edition.

Cox, R. F., Issa, R. R. A., & Frey, A. (2006). Proposed subcontractor-based employee motivational model. Journal of Construction Engineering and Management, 132(2), 152-163.

Dikmen, I., Birgonul, M.T., & Kiziltas, S., (2005). Prediction of Organizational Effectiveness in Construction Companies. Journal of Construction Engineering and Management, 131(2). 252-261

Fauzan, M., & Sunindijo, R. Y. (2021). Lean construction and project performance in the australian construction industry. IOP Conference Series.Earth and Environmental Science, 907(1)

Green, S.D. & May, S.C. (2005). LC arenas of enactment models of diffusion and the meaning of 'leanness. Build. Res. Inf. 33 (6), 498e511.

Halpin, D.W. (2007) Fifty Years of Progress in Construction Engineering Research. Journal of Construction Engineering and Management, Vol. 133, No. 9, 635-639.

Hanna, A. S. & Skiffington, M. S., (2010). Effect of Preconstruction Planning Effort on Sheet Metal Project Performance Journal of Construction Engineering and Management, Vol. 136, No. 2, 235-241

Hartman, A., Ling, F., & Tan, J., (2009) Relative Importance of Subcontractor Selection Criteria: Evidence from Singapore. Journal of Construction Engineering and Management, 135(9), 826-832.

Kim, J.K., & Reinschmidt, K.F. (2006). A dynamic competition model for construction contractors. Construction Management and Economics, 24, 955-965.

Koskela, L. (1993). Application of the New Production Philosophy to Construction. CIFE Technical Report #72. Stanford University.

Koskela, L. (1999). We Need A Theory of Construction. 7th Annual Conference of the International Group for Lean Construction, Berkeley, California, USA.

Koskela, L. (2000). An exploration toward a production theory and its application to construction. Ph.D. Dissertation. VTT Technology Centre of Finland, Espoo, Finland

Koskela, Lauri. (2011). Fifty years of irrelevance: the wild goose chase of management science. 19th Annual Conference of the International Group for Lean Construction. Lima, Peru. Proceedings

Koskela, L. (2020). Theory of lean construction. In P. Tzortzopoulos, M. Kagioglou, & L. Koskela (Eds.), In Lean construction: Core concepts and new frontiers (pp. 3-13). New York: Routledge.

Laufer, A. (1987). "Is construction project planning really doing its job? A critical exam of national focus, role and process." Construction Management Economics, 5, 243–266.

Lim, B. T. H., Ling, F.Y.Y., Ibbs, W.C., Raphael, B. & Ofori, G. (2011) Empirical Analysis of the Determinants of Organizational Flexibility in the Construction Business. Journal of Construction Engineering and Management, 137(3), 225-237.

Ling, F., Li, S., Low S.P., & Ofori, G. (2012) Mathematical models for predicting Chinese A/E/C firms' competitiveness. Automation in Construction. 24, 40-51.

Liu, M., Ballard, G., & Ibbs, W. (2011) Work Flow Variation and Labor Productivity: Case Study, Journal of Management Engineering. 27, 236-242

London, K. 2008. Construction supply chain economics. Oxfordshire, U.K.:Taylor & Francis.

Lucko, G., & Rojas, E.M., (2010) Research Validation: Challenges and Opportunities in the Construction Domain. Journal of Construction Engineering and Management, 136(1), 127-135.

Mahamid, I., (2012) Factors affecting contractor's business failure: contractor's perspective. Engineering, Construction and Architectural Management Vol. 19(3), 269-285.

Marsh, K., & Fayek, A.R., (2010) SuretyAssist: Fuzzy Expert System to Assist Surety Underwriters in Evaluating Construction Contractors for Bonding. Journal of Construction Engineering and Management, 136(11), 1219-1226.

Martilla, J.A., & James, J.C. (1977). Importance – Performance Analysis: An easily applied technique for measuring attribute importance and performance can further the development of effective marketing programs. Journal of Marketing, 41(1), 77-79.

Menches, C.L. & Hanna, A.S. (2006) Conceptual Planning Process for Electrical Construction. Journal Of Construction Engineering & Management.132 (12). 1306-1313.

Menches, C.L.,Hanna, A.S., Nordheim E.V.& Russell, J.S. (2008) Impact of pre-construction planning and project characteristics on performance in the U.S. electrical construction industry. Construction Management and Economics, 26, 853-867.

Ogunlana, S. O., Li, H., & Sukhera, F. A. (2003). System Dynamics Approach to Exploring Performance Enhancement in a Construction Organization. Journal Of Construction Engineering & Management, 129(5), 528

Platts, K.W., & Gregory, M.J., (1990) "Manufacturing Audit in the Process of Strategy Formulation", International Journal of Operations & Production Management, Vol. 10(9), 5 - 26

Salem, O., & Mohanty, S. (2006). Project management practices and information technology research. Journal of Construction Engineering and Management, 134(7), 501-508.

Seymour, D., 2013. Lean Construction: the ethnographic contribution. LCJournal, 9, 36–46.

Skibniewski, M. J., & Ghosh, S. (2009). Determination of key performance indicators with enterprise resource planning systems in engineering construction firms. Journal of Construction Engineering and Management, 135(10), 965-978.

Slack, N. (1994). The Importance-Performance Matrix as a Detriment of Improvement Priority. International Journal of Operations and Production Management. 14(5) 59-75.

Stevens, M. (2014) Increasing Adoption of Lean Construction by Contractors. 22nd Annual Conference of the International Group for Lean Construction. Oslo, Norway. Proceedings

Stevens, M. & Smolders, J. (2020) Australian Construction Multifactor Productivity is the same in 1998 as in 2019: Why? Australian Institute of Building Construct Magazine. 4th ed. 2020

Suarez, J. J. (2004). A neural network model to predict business failure in construction companies in the United States of America. (PhD, University of Florida).

Tan, Y., Shen, L. Y., & Langston, C. (2011) A Fuzzy Approach for Assessing Contractors Competitiveness. Engineering, Construction and Architectural Management. 18(3) 234-247.

Thomas, H.R. & Horman, M.J. (2006) Fundamental Principles of Workforce Management. Journal of Construction Engineering and Management, 132(1), 97-104

Thomas, H.R. & Horman, M.J. (2007) Contractor Prebid Planning Principles. Journal of Construction Engineering and Management, 133(8), 542-552

Waara, F., & Brochner, J., (2006) Price and Nonprice Criteria for Contractor Selection. Journal of Construction Engineering and Management, 132(8) 797-804

Yeung, J. F. Y., Chan, A. P. C., & Chan, D. W. M. (2009). Developing a performance index for relationship-based construction projects in Australia: Delphi study. Journal of Management in Engineering, 25(2), 59-68.