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WHERE IS THE EVIDENCE OF PERFORMANCE IMPROVEMENT IN THE LEAN CONSTRUCTION LITERATURE?

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ABSTRACT

This paper critically evaluates the evidence of performance improvement within the lean construction literature. Through a systematic review of 1,351 papers presented at the International Group for Lean Construction (IGLC) conferences between 2013 and 2024, we identify a significant gap in evidence-based studies explicitly addressing performance improvement, with only 52 papers (3.8%) focus on this critical issue. Our findings highlight a predominant focus on building projects, while infrastructure and industrial sectors remain largely overlooked. Additionally, we classify the various performance metrics used in the literature, revealing a lack of standardisation in measuring project outcomes, which complicates benchmarking efforts. We advocate for the adoption of a consistent performance measurement framework to enable meaningful comparisons across similar projects, facilitating the identification of performance improvement and waste reduction. We argue that a structured, industry-wide approach to benchmarking and performance evaluation is essential for the sustained adoption of lean construction and the realisation of its full benefits.

KEYWORDS

Lean construction, performance improvement, productivity, measurement, standardisation.

INTRODUCTION

Performance improvement is a central objective in the lean construction community, yet efforts to measure and enhance project outcomes remain inconsistent and fragmented. While lean construction principles emphasise continuous improvement and waste reduction, the measurement of performance improvement has not been systematically embedded in construction project management practices. This gap presents a significant challenge: without robust and consistent performance metrics, identifying the underlying causes of inefficiencies and implementing targeted improvements becomes difficult. In this paper we explore the position of performance measurement and improvement in literature, and by extension in lean construction practices.

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This paper presents findings from a systematic literature review and is structured to guide the reader through a background section that sets the motivation and aims for the study, followed by a detailed explanation of the research methodology. Our findings, first explore what was measured in these papers before examining the evidence of performance improvement in lean construction. We conclude the paper by presenting real examples demonstrating how consistent measurement practices can enhance situational awareness and pinpoint project inefficiencies.

BACKGROUND

PERFORMANCE MEASUREMENT IN LEAN CONSTRUCTION

The construction industry has the potential to adopt performance measurement practices from manufacturing to foster a culture of continuous improvement (Marosszeky & Karim, 1997). Lean construction principles emphasise the importance of systematic performance evaluation to reduce costs and increase productivity. However, despite the widespread acknowledgment of lean methodologies, their full potential has yet to be realised due to inconsistent adoption and a lack of comprehensive performance measurement frameworks.

A major obstacle to improving construction performance lies in the way projects are managed. Tillmann et al. (2012) and Zwikael and Smyrk (2009) noted that project management often focuses on output generation rather than long-term value creation and benefit realisation. Adoption of performance measurement models at earlier stages of project development could facilitate learning and continuous improvement, yet rigid project structures hinder this process.

CHALLENGES IN MEASURING PERFORMANCE

A key barrier to improving project outcomes in construction is the lack of appropriate performance measurement systems (Alarcón & Serpell, 1996). Unlike manufacturing, where performance measurement is integral to continuous improvement, the construction industry lacks standardised metrics for tracking efficiency and progress (Marosszeky & Karim, 1997). The absence of commonly agreed industry-level progress metrics beyond financial and safety measures further exacerbates this challenge (Elfving and Seppänen, 2022).

Current performance measurement practices often rely on short-term planning metrics, such as percent plan complete (PPC), rather than comprehensive system-wide indicators (Lagos and Alarcón, 2021). While these metrics can provide valuable insights, their limited scope prevents a holistic assessment of project performance and improvement. Moreover, an overemphasis on isolated metrics can lead to measurement drift, where optimising one metric in isolation results in unintended inefficiencies elsewhere (España et al., 2012). To address this, performance measurement must link actions to broader project objectives, ensuring that improvements contribute to overall system efficiency rather than local optimisation.

IMPROVING PROJECT PERFORMANCE THROUGH SYSTEMATIC MEASUREMENT

For construction projects to achieve sustained performance improvements, objective comparisons and accessible metrics must be incorporated into decision-making processes. Empirical data, combined with industry experience, can provide new evidence on project performance trends and inform strategic interventions (Alarcón & Serpell, 1996). Benchmarking has long been recognised as a tool for performance improvement, yet its application in construction remains inconsistent. Alarcón and Serpell (1996) highlighted that while benchmarking project results, such as cost and schedule performance, can identify broad problem areas, it does not provide insight into the root causes of inefficiencies or inform improvement strategies. Internal benchmarking, in particular, plays a crucial role in identifying and standardising superior practices while also highlighting areas for improvement. Despite widely recognised benefits, the construction industry's adoption of benchmarking initiatives remains uneven, limiting its potential as a driver for systematic performance enhancement. Benchmarking at both the enterprise and project level enables stakeholders (including clients, contractors, and subcontractors) to compare processes and outcomes, leading to more reliable performance and competitive efficiency (Marosszeky & Karim, 1997).

The adoption of lean metrics, which promote transparency and accountability, represents a critical opportunity for the industry (España et al., 2012). By integrating systematic planning and control measures, construction projects can better prevent work variations that contribute to schedule deviations and inefficiencies (Ballard & Tommelein, 2016; Lagos & Alarcón, 2021). However, traditional project management approaches remain predominantly result-oriented, limiting their ability to detect and prevent deviations early in the process. To truly enhance project performance, the industry must shift towards process-oriented performance measurement systems that align with lean construction principles.

To date, a comprehensive exploration of the adoption of performance improvement and usage of evidentiary data and metrics in the context of lean construction is currently lacking in existing literature. In this paper we aim to evaluate the extent of evidence-based research in performance improvement within lean construction literature. Through this we further aim to identify inconsistencies in the measurement of project performance and propose a structured approach for improving project performance measurement in lean construction.

RESEARCH METHOD

This work involved a systematic literature review to identify relevant articles from lean construction literature, focusing on publications made at the annual International Group for Lean Construction (IGLC) conferences. The systematic literature review approach allows us to rigorously identify, select, and synthesise relevant studies. To that end, the review process began with defining the research questions; then identifying the relevant work; followed by summarising evidence; and finally interpreting the findings. It was decided to only consider publications at the IGLC annual conferences between 2013 and 2024. Indexed IGLC papers were retrieved from Scopus, with exceptions for papers published in 2023 and 2024, which were retrieved from IGLC publication database. We did not consider publications before 2013 to remove any outdated works. We followed the PRISMA Statement to identify relevant articles for the review (see Figure 1).

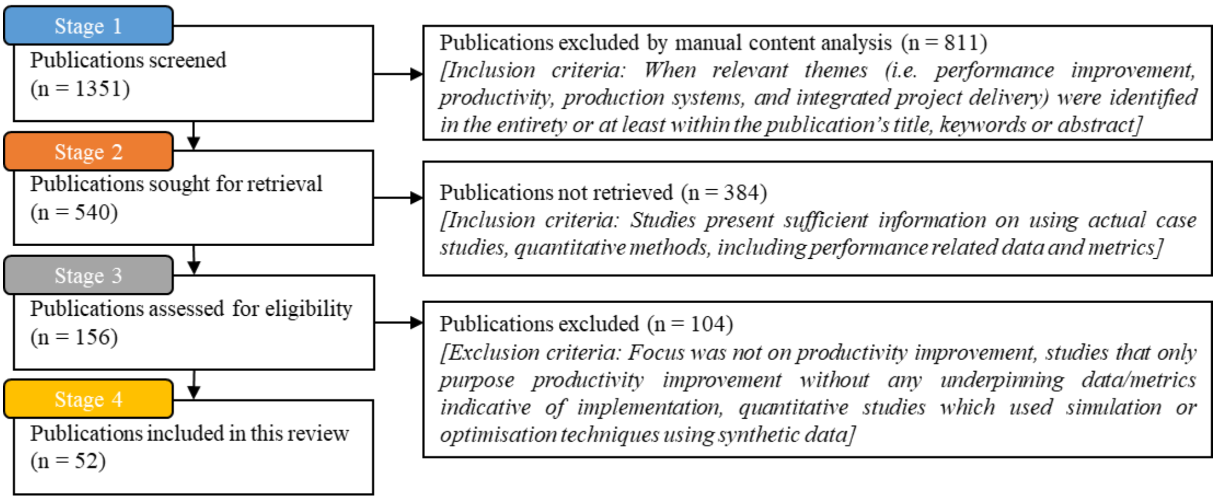

Figure 1: Flow diagram and process of identification of relevant publications

The review encompassed 1,351 papers published from 2013 to 2024. The review followed three shortlisting stages: first, manual content analysis to identify research on project performance

(540 papers shortlisted); second, evaluation for quantitative data and implementation evidence (156 papers shortlisted); and finally, identification of papers specifically addressing project performance and productivity improvement (52 papers).

RESULTS AND FINDINGS

We observed that 29% of the publications retrieved (Stage 2, n=540) were classified as evidence-based research, i.e. these papers show any evidentiary data regarding performance improvement being measured in projects. However, evidence-based research (Stage 3, n=156) only accounted for 12% of the overall IGLC literature in the past 12 years. Within these evidence-based studies, only 52 (33%) specifically address performance improvement. This indicates that only a small subset of lean construction research was dedicated to one of the most pressing issues in the construction industry, i.e. improving performance and productivity.

On average 4.2 papers were published each year under Stage 4. While this focus on performance measurement and improvement are undoubtedly valuable, the relatively low number of evidence-based papers on the topic raises concerns about the depth of research available to address productivity challenges in a comprehensive, data-driven way. These initial findings indicate the level of attention given to construction performance, productivity, and evidence-based approaches within the broader body of IGLC research. The temporal distribution of the literature according to each stage is shown in Figure 2.

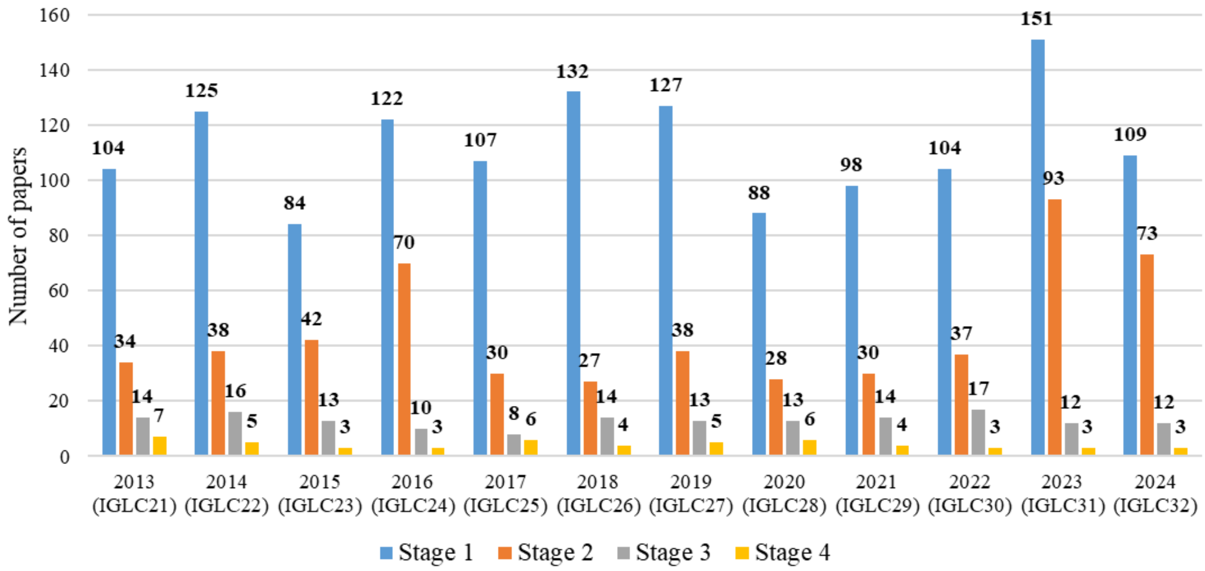

Figure 2: Temporal distribution of the reviewed literature

WHAT WAS MEASURED?

The literature search reveals a diverse range of application areas in lean construction research. Among these, building projects, including both residential and commercial developments, dominate the research landscape, accounting for 56% of the studies considered during stage 5 of this review. This indicates a strong focus on improving construction processes, performance, and productivity within the building sector. Healthcare-related projects represent 13%, highlighting a significant research interest in the unique challenges and requirements of constructing medical facilities.

Infrastructure-related projects are dispersed across multiple categories. Road and water pipeline infrastructure each make up 4% of the studies, reflecting a modest level of research interest in transportation and utility networks. Meanwhile, more specialised infrastructure applications, such as dams, railways, and drainage systems, each account for 2% of the total, suggesting that while these areas are addressed, they receive relatively less attention in the broader research landscape. Industrial facilities and capital projects each contribute 2%, indicating that while these sectors are explored in the literature, they do not form a major focal point. Additionally, 13% of the studies do not specify a particular application area.

Overall, this distribution underscores the predominance of building construction in the research, while infrastructure and industrial applications, though present, receive comparatively less attention. It highlights potential gaps in the literature where further studies could contribute to a more balanced exploration of various construction sectors, particularly in underrepresented areas such as transportation infrastructure, industrial projects, and large-scale capital developments.

FOCUS AREAS

The focus areas of the performance measurement and improvement studies can be broadly classified into five groups: implementation of the Last Planner System (LPS) and Location-based Management System (LBMS), digital engineering, improvement of flow efficiency, and industrialised construction. One-third of the studies reviewed focused on evaluating performance improvement achieved through implementing the LPS. For instance, Verán-Leigh et al. (2022) studied the use of LPS and off-site construction and provided evidence of improved production management, productivity, and overall project performance. Similarly, Power et al. (2020) highlighted the benefits of applying LPS during the commissioning and qualification phase, noting significant advantages such as increased collaboration, improved workflow visibility, and subsequent gains in productivity, schedule alignment, safety, cost efficiency, and client value. In another example, Johansen et al. (2021) reported a remarkable 54% improvement in productivity when LPS was applied to renovation projects. Additionally, the case study by Murguía et al. (2016) demonstrated that implementing LPS during the finishing phase of residential buildings led to improved performance in the production system. While all the studies noted improvements while implementing LPS, they only focused on a specific phase of a construction project. Studies, including overall construction, are still missing from the literature.

Several studies demonstrate that a LBMS is an effective tool for enhancing productivity. Frandson and Tommelein (2014) reported a 14% reduction in the scheduled duration of a hospital construction project with the implementation of LBMS. Additionally, research highlights the positive impact of digital engineering on construction productivity. For instance, Filion et al. (2022) identified three key benefits in their case study: consistent updates to planning, accurate and up-to-date information in 3D models and visual schedules, and improved stakeholder understanding of the project timeline. As a result, delivery milestones were met despite their ambitious nature.

Wider adoption of digital technologies propagated in early 2010's and this was reflected in the publications reviewed which utilise such approaches to tackle performance improvement through digital technology and data analysis. Brown et al. (2019) demonstrated how computer simulation and BIM modelling facilitated the calculation of multiple key performance indicators (KPIs) to forecast production across various projects. More recently, Asmone et al. (2024) showcased how location-based management and computer-vision automated data capture helped identify process waste during internal finishing works. Construction flow significantly impacts productivity, as evidenced by Rathnayake et al. (2023), who established correlations between four process flow metrics and location productivity: excess work-in-progress time had a strong negative correlation, mean location production rate showed a moderately positive correlation, average batch size exhibited a moderately negative correlation, and variability in location production rates had a weak negative correlation. Digitisation and industrialisation of construction processes is a crucial strategy for improving quality and productivity. However, adopting industrialised technologies does not always significantly improve overall production system performance (Viana et al., 2013).

Although numerous studies have examined productivity improvement within individual projects or specific activities, cross-project comparisons using standardised performance criteria remain limited. Ibrahim and Hanna (2019) evaluated 109 projects based on their project delivery methods, providing valuable insights into how different approaches influence performance outcomes. Similarly, Priven et al. (2014) applied the lean workflow index as a key performance metric to compare 12 projects, offering a standardised method for assessing efficiency across various construction settings. These studies highlight the critical need for cross-project comparisons and benchmarking to establish industry-wide performance standards. To bridge this gap, we believe that standardised methods must be developed to do meaningful cross-project comparisons.

PERFORMANCE MEASUREMENT METRICS

A comprehensive review of final 52 selected studies (Stage 5) on performance and productivity improvement in construction reveals a significant variety in the metrics used to assess project performance, with approximately 70 different metrics identified across these studies. These metrics can be grouped into several categories based on their focus. Table 1 presents the top three metrics in each category, ranked by their frequency of occurrence in the selected papers. In the Production/Progress category, the most frequently used metric is Productivity (Output/worker-hour), appearing in 38% of the studies, followed by Production Rate (Output/area/day) at 35% and Percent Plan Complete (PPC) at 31%. These metrics primarily focus on tracking the efficiency and rate of work completion in a project. PPC, for instance, measures the percentage of planned work completed as scheduled. In the Resources/Crew category, Total man-hours is the most used metric, appearing in 33% of the studies, followed by Capacity to Load Ratio (CLR) at 25% and Crew compatibility at 8%. These metrics assess labour input, resource allocation, and team efficiency in construction projects.

Time category includes metrics such as Schedule Performance Index (SPI) and Cycle time (days), each appearing in 15% of the studies, while Total time is used in 7%. These indicators help measure project scheduling efficiency and time performance. In the Cost/Profit category, metrics such as Total Project Cost ($), used in 50% of the studies, assess the overall financial expenditure of a project. Other metrics, like Returns and Construction Cost Growth, focus on profitability and cost growth over time. The Quality category focuses on compliance and defect tracking. Enumeration of RFIs is the most cited metric, used in 29% of the studies, followed by Enumeration of punch-list items and Percentage of Rework, each appearing in 14%. These metrics are critical for assessing construction quality and identifying areas of non-compliance.

Finally, in the Process category, Flow efficiency appears in 22% of the studies, followed by Reduction of waste and Lean Workflow Index (LWI), 11% each. These process-related metrics aim to enhance workflow efficiency and minimise construction waste. The wide variety of metrics across these categories highlights a lack of consistency in measuring construction performance. While specific metrics like Production Rate and PPC are more commonly used, there is no standardised approach, which may hinder the ability to compare and integrate findings across studies and projects. Moreover, Nguyen and Waikar (2018) emphasised that relying solely on PPC is not ideal. They identified two main drawbacks of existing plan reliability metrics as they concentrate only on short-term or are based on a static master plan.

Table 1: List of performance measurement metrics in construction.

Category	Metrics	Nos	%
Production/Progress (n=36)	Productivity (Output/worker-hour)	10	38%
	Production Rate (Output/area/day)	9	35%
	Percent Plan Complete (PPC)	8	31%
Resources/ Crew (n=12)	Total worker-hours	4	33%
	Capacity to Load Ratio (CLR)	3	25%
	Crew compatibility	1	8%
Time (n=27)	Schedule Performance Index (SPI)	4	15%
	Cycle time (days)	4	15%
	Total time	2	7%
Cost/Profit (n=6)	Total Project Cost ($)	3	50%
	Returns	2	33%
	Construction Cost Growth	1	17%
Quality (n=7)	Enumeration of RFIs	2	29%
	Enumeration of punch-list items	1	14%
	Percentage of Rework	1	14%
Process (n=9)	Flow efficiency	2	22%
	Reduction of waste	1	11%
	Lean Workflow Index (LWI)	1	11%

DISCUSSION

The findings of this study highlight a salient challenge. That there are no consistent measurement of project performance from an outcomes-based perspective. Existing literature presents various approaches, but these methods lack standardisation, making cross-project comparisons difficult. For a long time, the importance of identifying common elements between project activities to form a basis for objective comparison has been advocated (Marosszeky and Karim, 1997). However, our analysis shows that while some efforts have been made to define these common elements, there is still no universally accepted methodology that allows for a reliable comparison of project performance across different lean construction implementations.

One major challenge is the reliance on conventional metrics, such as cost and schedule deviation, but only in a supportive role rather than as standalone indicators of performance. España et al. (2012) argue that these metrics should be used to improve system performance rather than as isolated indicators requiring direct responses. While cost and schedule provide important insights into project execution, their use in lean construction has been largely reactive rather than predictive, limiting their effectiveness in measuring overall project success.

We have made an alarming observation based on our interactions with project team members from over 50 construction projects worldwide. Most project teams do not have a clear understanding of how well or poorly they are performing compared to similar projects in the industry, sometimes even within the same company. Therefore, the only benchmarking tools available to them are construction schedules and budgets, which themselves were not developed using the most up-to-date data.

Furthermore, existing benchmarking initiatives in the construction industry present additional limitations. Elfving and Seppänen (2022) highlighted that benchmarking efforts often rely on voluntary participation, meaning that they do not provide a comprehensive industry-wide perspective. Additionally, data collection can be time-consuming and inconsistent, leading to potential biases in the reported metrics. This aligns with our findings, which show that many industry benchmarks are either company-specific or financial in nature, making it difficult to compare performance across different firms or sectors. To overcome this, we propose to focus on comparing historical and real project benchmarks, which can offer a more stable and objective reference for assessing performance trends. Cross-project comparisons is already a difficult task due to the unique nature of each construction project. The lack of standardised metrics means that comparisons across projects are not straightforward and often unreliable, limiting the usefulness of benchmarking as a tool for performance improvement. In addition, the absence of uniform data collection practices across projects makes it difficult to establish consistent benchmarks, as data quality and interpretation variations can skew results. This inconsistency in both metrics and data collection practices underscore the need for a more standardised approach to performance measurement. Such an approach would allow for better comparisons across projects and the broader construction industry, ultimately improving the effectiveness of performance evaluations and fostering more reliable comparisons across different projects. Standardising metrics and establishing consistent data collection practices are essential steps toward overcoming these challenges and enabling more effective benchmarking in construction.

Another observation from our research is the institutionalised practice of using activity count, schedule performance index (SPI), and Gantt Charts despite some awareness of lean construction practices (and their benefits), such as LBMS. Some contractors struggle to adopt flowlines for planning and control due to a lack of readily available software, data, metrics, and benchmarks, making production management not a priority in their innovation agendas (Rathnayake et al., 2024a). This begs the question; what data should we measure to show the full picture of performance improvement?

We share the lean community's view that performance metrics should not be used for production control (Howell & Ballard, 1996), as such an approach is reactive and does not identify underlying workflow issues. However, there is value in understanding whether a particular project is performing better than others in the industry to identify best practices that could be applied to future projects. Lagos et al. (2024) states the value of past project information for proactive planning and uses historical data. However, data on reasons for non-compliance/blockers to productivity is indeed very limited in literature, alarmingly so, even in projects with a collaborative/LPS culture. While we recognise that blockers to productivity/flow should be anticipated and removed before activities commence, as outlined in the Last Planner System (LPS), post-facto learning remains valuable provided that rapid feedback loops are in place.

On the other hand, tool time and direct work is of increasing interest for construction productivity. However, recent work shows that this can be as low as 10-20% for superstructure works (Rathnayake et al., 2024b), and between 19-24% for MEP works (Görsch et al., 2024). Tool time sits at the foundation of lean construction, however, research has generally decreased as observed in the results of this paper, as evidenced by its apparent omission from Table 1.

MEASURING PERFORMANCE CONSISTENTLY

We believe that measuring real historical metrics allows for more consistent and objective evaluation of project performance. A multilevel productivity measurement framework has been developed to allow comparisons of productivity among similar projects, work packages (i.e. groups of complementary activities) and individual activities (Murguia et al., 2024), based on research conducted over the past five years. In this section, we present examples from this work on deploying consistent performance metrics in construction projects. We believe similar instruments can help overcome the issues discussed in earlier sections of this paper.

Two of the productivity metrics we use in this multi-level measurement framework are production rate (output per unit of time), which indicates speed, and labour productivity (output per worker-hour), which measures labour efficiency. Figure 3 compares two key metrics for a 14-level reinforced concrete structural frame with substantial precast components. Each dot on the graph represents a building level. The results indicate that the best performance was achieved on levels 3 to 8 (highlighted in the green box), whereas levels 1, 2, and 9 to 12 (highlighted in the red box) exhibited lower performance, on average, by a factor of two. This location-based analysis provides industry stakeholders with significantly greater transparency into actual project outcomes that often goes unnoticed, compared to traditional metrics such as activity count and SPI. The observed variability in performance is primarily influenced by factors such as batching, cycle times, crane availability, the reliability of precast component deliveries, and weather conditions, among others. While a detailed analysis of these factors is beyond the scope of this paper, understanding performance variability and its underlying causes is essential for improving production planning.

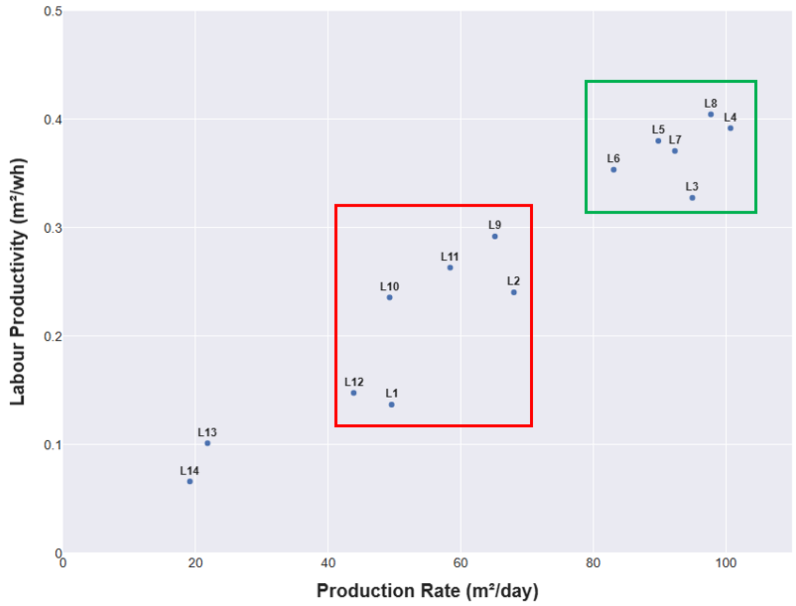

Figure 3: Labour productivity v production rate of the structural frame of a 14-level building

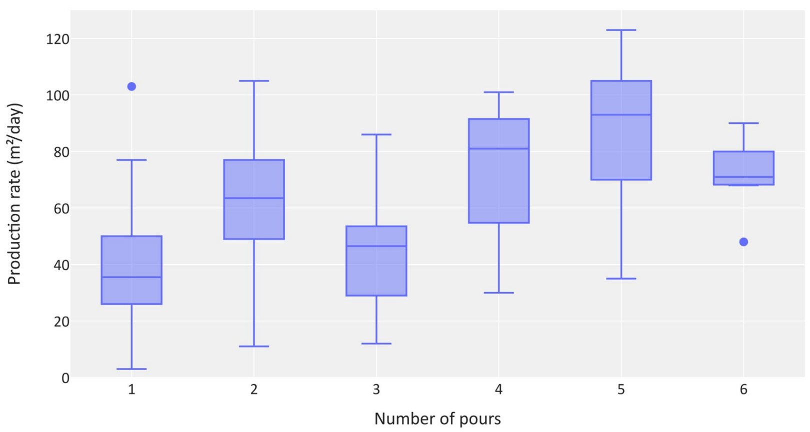

Figure 4: Production variability based on number of pours per level (data from 15 buildings)

Another example is the evaluation of production rates according to the number of batches per level in structural frame construction (see Figure 4). The number of slab concrete pours represents the number of locations available for work. It is generally known in the lean construction community that increasing the number of available work locations can reduce worker idling time (Maturana et al., 2003). This figure illustrates how that can lead to improved performance. There is a general upward trend in production rate (i.e. speed) as the number of concrete pours increases. In summary, performance measurement can benefit lean construction research by demonstrating how lean construction initiatives contribute to overall performance improvements.

We believe that the unavailability of large-scale quantitative studies linking the benefits of lean construction to performance improvement hinders efforts to bridge the gap between lean construction and traditional construction management, as well as those practising it (both researchers and practitioners). Most studies attempting to establish this link have been limited to case studies or hypothetical examples. In some cases, performance improvement was not even observable. For example, Liu et al. (2011) analysed the relationship between percent plan complete and labour productivity using 134 weeks of production data from 10 work areas on a pipe installation project. The authors found only a very weak correlation of 0.181 between the two metrics. When they reduced the sample size to seven areas with similar types of work, complexity and worker skills, the correlation coefficient increased slightly to a weak 0.318. Similarly, in their study Lagos and Alarcón (2021) could only observe a weak correlation between PPC and SPI, when attempted to link lean principles with project performance in 69 construction projects. Such results would not be convincing to anyone practising traditional construction management to implement lean techniques. Ergo, we believe that efforts should be focused on finding robust quantitative evidence of the effect of lean construction techniques on project performance if the field is to develop into a mainstream discipline.

CONCLUSIONS

In this paper we explore the position of performance measurement in lean construction, and we contend for a more structured and industry-wide approach to benchmarking and performance evaluation. To drive meaningful performance improvement in lean construction, the industry must establish a consistent and comprehensive performance measurement framework. However, existing measurement systems must evolve beyond short-term planning metrics to capture and document process-based metrics of actual performance. By integrating lean metrics that align actions with performance objectives, construction projects can enhance transparency, accountability, and continuous improvement.

Ultimately, our study underscores the need for a more standardised and transparent approach to measuring project performance in lean construction. By incorporating historical benchmarking and objective productivity comparisons, we propose a methodology that moves beyond the current fragmented landscape and provides a more reliable framework for evaluating project outcomes. Benchmarking, when applied systematically, can provide valuable insights into best practices and areas for improvement. This approach not only addresses the inconsistencies in existing literature but also provides practitioners with actionable insights to enhance project planning and execution. We contend that a structured approach to performance measurement is essential for realising the full benefits of lean construction and ensuring sustained industry-wide adoption.

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