

Lean Construction Implementation: Case Study

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Lean construction offers a collaborative approach to traditional construction practices and has the primary goal of increasing value to the client. With the proper use of lean construction tools on projects and the adoption of a lean culture, construction companies have recognized real benefits in terms of cost, productivity, and schedule while increasing customer satisfaction. The construction industry has been slow however in adopting the lean construction practices that have proven to be successful. The research in this study will familiarize the reader with the principles of lean construction, and address why the demand for lean construction is rising. In this case study, participants from two construction companies, a leading lean contractor and a non-lean contractor, were interviewed to evaluate the different lean construction “journeys” taken by each company. The interviews and analysis in this study primarily focus on the lean culture, use of lean construction tools, common barriers, lean education, and industry outlook from each of the companies. Suggestions for the future growth of lean construction were provided based on the interview responses.

Key Words: Lean Construction, Implementation Barriers, Construction Culture, Lean Education

Introduction

One of the first success stories attributed to lean construction is that of the Empire State Building, which was completed more than fifty years before the concepts of lean were even published. By basing the design of the project on the owners’ requirement that the building be completed by a specific date, the Empire State Building was designed, engineered, permitted, had existing buildings demolished, and was constructed in just 20 months (Ghosh & Robson, 2014). The construction industry has been slow in the adoption of lean construction practices however. Some industry professionals estimate that “only a very small minority of firms truly understand what it means to be lean” (Warcup, 2015 p.39). If construction companies operating in the current market climate want to realize the same benefits of lean that successful implementers have reported, then there needs to be a greater emphasis on lean construction and the adoption of lean theory. Lean construction has proven to be a successful business model for construction companies who have been able to implement it successfully. McGraw Hill’s Construction Research and Analytics (2013) surveyed contractors on the benefits of implementing lean construction and found that more than 60% of respondents reported: higher quality (84%), greater customer satisfaction (80%), improved productivity (77%), reduced costs or improved profitability (64%), improved safety performance (77%), and reduced project schedules (74%).

Definition of Lean

According to Paul Akers in his book *2 Second Lean* (2016), lean is a way of thinking which exhibits two foundational principles: eliminating waste and continuous improvement. In Akers’ opinion, “90% of everything we do is waste” and can be categorized into any of the eight categories that he outlines. The eight wastes as defined by Paul Akers are as follows: 1) Overproduction, 2) Over-processing, 3) Excess Inventory, 4) Defects, 5) Transportation, 6) Wasted Motion, 7) Waiting Time, 8) Unuseful Employee Genius. These eight wastes can always

be identified and eliminated at both a company and personal level in an effort to continually improve and add value to the customer, which is another central concept of lean thinking (Akers, 2016 p.25). Before the details of lean construction can be addressed, it is important to first understand these foundational principles.



Figure 1: The 8 Wastes of Lean (Akers, 2016).

Definition of Lean Construction

Lean construction applies these foundational principles of lean to traditional construction methods in order to better meet the industry's growing demand. This is achieved by: optimizing projects as a whole, removing waste, generating value, focusing on process and flow, and continuous improvement (Lean Construction Institute). Previous studies defined a successfully lean construction company as "a company that utilizes lean planning techniques, uses multiple lean tools and concepts, encourages a lean culture, and has completed several lean projects" (Warcup, 2015 p.21). Through the combination of applying lean thinking strategies, lean construction tools, and a focus on continuous improvement, construction companies can fully implement a lean culture which fosters growth, creativity, and success.

Literature Review

Common Tools for Lean Construction

It has been mentioned that the use of "lean tools" is a contributing factor in what determines a lean construction company. To better understand what was meant by this, extensive research was done to pinpoint the most common lean tools that were being used by construction companies. These tools are inspired by lean concepts and have been adapted to deal with the wastes produced by traditional building practices (Jørgensen, 2008). Each of the tools discussed can be applied on almost any construction project, either individually or in combination, without requiring a change to company culture.

Last Planner® System (Pull Planning)

The Last Planner® System is a form of collaborative planning which is achieved through creating a predictable workflow and minimizing waste on a construction project (Ghosh & Robson, 2014). Pull planning is one of the most common aspects of the Last Planner® System that is currently practiced in today's construction industry. Pull planning requires all trades involved on a project to assemble and work backwards from an established milestone in order to clearly define the resources (e.g., time, labor, materials, etc.) that will be required on a project (Ghosh & Robson, 2014). As written by Leong Wong and Mohammed Ahmed (2018) in their research, "This pull type of system ensures that only the necessary resources and work are being delivered, hence reducing the need for physical buffers (e.g., storage space or time)" (p.5). This aligns with lean principles through the process of collaboration, continual improvement, and eliminating wastes.

BIM Technologies

Building Information Modeling (BIM) refers to a 3D model-based process that gives architecture, engineering, and construction professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure (“What is BIM?”). By utilizing a 3D virtual model of a project, construction teams can effectively identify design issues, trade clashes, and resolve conflicts before they arise on the construction site. Furthermore, BIM softwares can incorporate other “dimensions” of a construction project (e.g., cost, schedule, efficiency, and maintenance) directly into the model to provide a single location for project information that is easy for anyone to visualize (Changali, 2015). It is estimated that 51% of contractors are currently using BIM technologies and 82% of BIM users report a positive return-on-investment (Ellis, 2018). BIM technologies comply with lean principles because of the collaboration between owner, architect, engineers, and contractor during the creation of the model.

Modular Construction (Prefabrication)

Modular construction refers to the off-site prefabrication methods of construction elements that would traditionally be performed by tradesmen on-site. Off-site construction allows for factory-controlled conditions that ultimately increase the quality of the product and eliminate the risk of weather conditions that continually plague on-site productivity (Lee & Kim, 2018). The range of prefabricated elements for construction projects is wide and can contain anything from pre-wired lights fixtures to entire bathroom pods that are ready to “plug-and-play” on the project (Bunch, 2017). Other benefits of modular construction can include: lower costs, safer working conditions, shortened schedules, increased collaboration in design, and a reduction in on-site requirements (Bunch, 2017). Modular construction has applied lean manufacturing principles to offer builders an alternative solution to traditional practices by eliminating wastes and increasing the overall value of the project.

Collaborative Contracting

Collaborative contracting is perhaps the most beneficial and least utilized of all of the lean construction tools that have been discussed. Collaborative contracting approaches, such as IPD, encourage a lean culture from the project definition phase all the way through the completion of the project, and sometimes even beyond. In contrast to the traditional design-bid-build contracting - still the most common contracting methodology - collaborative contracting brings in the owner, design team, contractor, and sometimes even subcontractors early on, before the design is finished (Ghosh & Robson, 2014). This allows the various parties to work together and simultaneously establish solutions in design, constructability, and the construction process as a whole before any construction activity is ever performed. Research by Robert Warcup (2015) suggested that this collaboration must continue through the duration of the project for it to be the most successful. The principles behind collaborative contracting approaches are nearly identical to those of lean in that it eliminates waste in projects and stresses the importance of continuous improvement.

Establishing a Lean Culture

The importance of implementing a lean culture, rather than relying solely on lean construction tools, was previously researched by Robert Warcup (2015). Warcup’s study interviewed professionals from leading lean construction companies to suggest a path in becoming a successful lean construction contractor. The researcher concluded that in order to operate as a lean construction company and recognize the full benefits lean construction has to offer, it was imperative to establish a lean culture within the entire company. It was also added that in order to establish a lean culture, it required a complete and full commitment from management (Warcup, 2015). Commonalities between the companies that were interviewed allowed the Warcup to develop a suggested approach for implementing a lean culture and becoming an established lean construction company. Warcup’s suggested approach was used to evaluate and compare the lean approaches used by the construction companies interviewed in this study.

Challenges to Adopting Lean Construction

Extensive research went into Warcup's (2015) previous study to address the common challenges and barriers that prohibit many contractors from transitioning to lean construction. The most prevalent barrier in all cases studied was that there was too much ambiguity with lean construction. A participant in Warcup's study estimated that "only a very small minority of firms truly understand what it means to be lean. There is not a textbook you can open up that [explains] 'Here's how you do [lean]'" (Warcup, 2015 p. 68). By not understanding what is meant to be lean, construction firms are not allowed the benefits of implementing a lean culture. Education was also cited as being a significant barrier as research suggests. Warcup's study stated that academia has been "too slow to change" and is roughly ten to twenty years behind the industry standards of current lean construction practices (2015, p.104). Other common barriers found in the study included: poor commitment from management, overemphasis on lean construction tools, resistance from subcontractors and field staff, and failure to continually improve (Warcup, 2015). The barriers that have been previously identified will be used to compare to those that are discovered from the interviews in this study.

Construction Productivity

Despite the efforts by companies to keep up with the growing demands of the industry, construction productivity has been declining for over fifty years (Changali, 2015). According to Warcup (2015), this declining productivity is partly because "the construction industry is not a whole lot different than it was fifty years ago. It hasn't innovated a great deal" (p.92). This lack in innovation could potentially be stemmed from the failure of more construction companies to adopt lean construction tools and culture. Conversely, the industry demands are currently higher than ever before and if there was ever a time that lean construction would be necessary, it would be now. There is an estimated 85% growth in the volume of construction output by 2030 (Ellis, 2018). In a survey of owners performed by KPMG (2015), 69% claimed that poor contractor performance was the single biggest reason for project underperformance and 58% of owners said they have used or plan to use design-build, moving away from the traditional design-bid-build methodology. The significant increase in industry demand cannot be handled by the traditional construction practices that are still being employed by many of the firms in the industry, especially when underperformance is already an issue. Lean construction offers contractors the opportunity to outperform these demands and thrive in both the current and future construction markets.

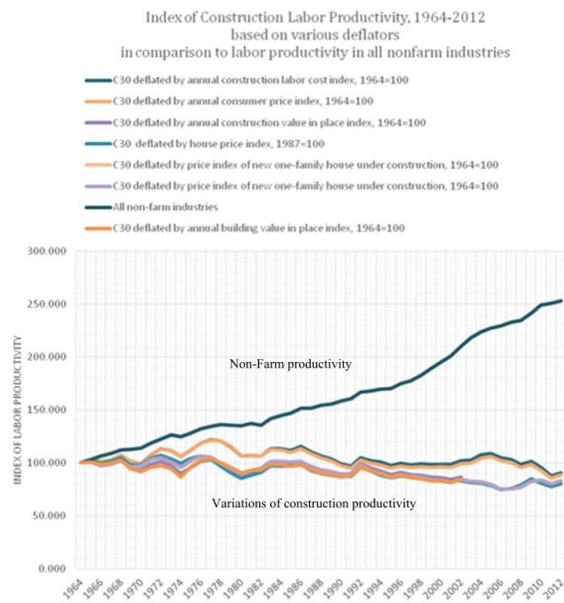


Figure 2: Construction Productivity vs. Non-Farm Productivity from 1964-2012 (Warcup, 2015).

Methodology

The methodology used in this research was primarily qualitative data achieved through a case study approach. In order to perform this case study, a series of exclusive interviews among several industry professionals at two different construction companies was conducted. The decision to explore qualitative rather than quantitative data during this research was made in an effort to better concentrate on the theories and various approaches of lean construction implementation. Quantitative data tends to focus too much on the impacts attributed to lean construction tools rather than the importance of establishing a lean culture. These types of results were not desired for this study. The information received from the interview questions will provide accurate insight from industry professionals regarding the implementation of lean construction within their own companies, as well as highlight the common challenges that are contributing to the slow adoption by the industry.

The purpose of this case study was to:

- Examine the approaches of lean construction implementation used by two construction companies
- Offer suggestions for the future success of lean construction adoption

Case Study

Two construction companies were interviewed, via telephone calls, and evaluated based on their lean construction practices to provide a better insight on the adoption of lean thinking into more construction firms. The selection of the companies was deliberate in the sense that a leading lean contractor and a non-lean contractor were chosen. This was done in effort to easily highlight both the successful and unsuccessful approaches of lean implementation within each company. Both companies selected are general contractors that have over 100 years of construction experience (each), headquarters on the east coast, commercial construction operations nationwide, and are members of the Lean Construction Institute. The interviews focused primarily on examining each firm's: company culture, use of lean construction tools, lean education, barriers, and industry outlook in relation to lean construction adoption.

To encourage full participation from the participants, and to avoid revealing any proprietary information, both the company's and participants' names were kept confidential. The companies will therefore be referred to as "Company A" and "Company B" for the remainder of this study. In addition, the following references will be used for the participant responses (in relation to their current position):

Company A

Participant 1 - Division Vice President
Participant 2 - Project Manager
Participant 3 - Superintendent

Company B

Participant 4 - Director of Field Operations
Participant 5 - Senior Project Manager
Participant 6 - Assistant Project Manager

Results

Company Culture

Company A exhibited a very lean company culture which was to be expected considering their rapport in the lean construction industry. First, a more horizontal business structure has been adopted by the company to "increase employee knowledge" and encourage continual improvement. Participant 1 gave an example of this when they stated:

"An employee may be titled a 'project manager' on their current project, but may have the title of 'project engineer' and tasked with managing a specific trade when they move their next project. Better yet, they may not be placed on a project at all, they may be pulled into the office and become an estimator. Wherever we see the most value; for both the employee and company, that's where they are going to go."

Company A also utilizes lean leaders which was recommended by Warcup's (2015) previous studies. Participant 1 explained that this group of lean leaders constantly evaluates and implements improvements into the company in order to foster innovation and continual improvement of the firm and its employees. They continued that through the complete adoption of lean culture within the company, client satisfaction improved and repeat clients became more common. This allowed Company A to be more selective with their work and participate in more design-build contracts. Participant 2 noted that new employees are taught about lean "from day one" as they are given the book 2 *Second Lean* (also a favored book among successful companies in Warcup's (2015) study) and can be quizzed on its contents at any time or asked to apply the concepts to their own lives.

Company B did not seem to have a lean company culture, but it was not due to the lack of commitment from upper management like many previous firms have experienced. Though a traditional, vertical, business structure was present in the company, it did allow for some horizontal movement and showcased collaboration efforts. Participant 4 stated:

"Employees are encouraged to move horizontally if they feel it will better advance their career and learning opportunities. If we [upper management] agree that it is a good fit, we will pretty much let them move around as they please."

The concept of value was not stressed as importantly in the reassignment of employees by Company B as it was in Company A. Additionally, Company B has no designated estimating department which means that project teams are responsible for bidding on their own future projects. This approach has the benefit of creating incentive for workers to bid projects successfully (unless they want to be stuck in the office), earlier collaboration with designers, greater knowledge of project requirements, and more softwares for employees to get comfortable with according to Participant 5. While collaboration seemed to be a key component of Company B's culture, all participants responded that they did not believe a lean company culture was fully adopted. Participant 5 noted that an "emphasis from upper management on lean could be felt" and more lean tools were being utilized on projects. It has been discovered that the older field crews with traditional methods seem to be the biggest prevention in adopting a lean culture for Company B.

Lean Construction Tools

Company A consistently uses lean construction tools, such as the ones mentioned earlier in this study, on all of its construction projects. Prefabricated construction is used "whenever it makes sense" Participant 2 stated. Participant 1 shared the successes of a recently completed project that saw major benefits from lean construction tools. In this project, 700 prefabricated bathroom pods were used which effectively saved 100 working hours per bathroom, and saved 70,000 in total. It was not only the decision to use prefabrication that saved the company time, money, and stress however. Instead, it was the combination of multiple lean tools (prefabrication, BIM, IPD contract) that were employed on the project as well as [the company's] culture that was able to find the solutions that added the most value, according to Participant 1. Additionally, the company has its own dedicated BIM department and pull planning is used on every project. Company A favors IPD and design-build contracts and wants to move away from the traditional design-bid-build approach. Previous research by Warcup (2015) suggested that daily huddles might be an additional tool for establishing and maintaining a lean culture at the project level, though it was not studied. Company A performs daily huddles with all subcontractors on site before work starts each morning. Participant 3 shared that during the morning huddles, different field workers are provided the chance to lead the stretches, give a short safety presentation, and share any other ideas that might improve the jobsite or employees. The use of daily huddles seem to be an effective lean construction tool which promotes collaboration and enhances a lean culture.

Company B also used lean construction tools such as BIM, modular construction, and pull planning but not with the same successes as Company A. Pull planning was the most common lean construction tool used by Company B, and Participant 4 had the following to say about it:

"I love pull planning and I am trying to get more projects to do it. I have used it on every one of my complex projects, and in my opinion it is the most effective way to continually plan any project."

Participant 6 realizes however that it is challenging to continue using pull planning, and other lean construction tools, when project teams are continually forced to move to a new project and have to start fresh with a new team who may not understand how, or want to use lean construction tools. Company B does not have a designated BIM department which means all project members are required to have some working knowledge of BIM software if they use a model for their project. This can be seen as a top-down approach to lean construction from Company B as management is forcing the use of these programs, or tools, onto the lower project levels.

Education

Innovation and education are some of the top priorities for Company A in terms of lean construction. The company constantly trains employees on the concepts of lean and introduces them to new processes, technologies, and ideas that can be applied to help reduce waste. As mentioned earlier, the company teaches employees how to be lean “from day one” and continually engages them in a collaborative work environment. Company A also holds seminars, summits, and prizes for innovation to continually improve the lean thinking of the company. When participants were asked to judge academia in its role on lean construction implementation in the industry, they were not as excited as they were by their own company’s own efforts. All of the participants responded that they felt higher education, though it encourages collaboration, has not been doing its job in terms of equipping employees with the proper tools and mindsets to be successful with lean construction. Participant 2 exclaimed:

“The new hires that are well-equipped with lean tools or mindsets upon entering the workforce often claim that they learned about the tools or concepts from elective courses or extra-curricular activities such as student competitions.”

Company B made efforts towards the continual learning and improving of its employees as well. Participant 6 mentioned that the company hosts a “tech/innovation” focus group which meets weekly, via Skype, and discusses new tools that can be used to improve the company’s current processes. The group then gives a presentation to the rest of the company, also via Skype, on a monthly basis to share these ideas. Participant 6 is an avid member of this focus group but claims that meeting attendance has been low due to it being loosely enforced, and hosted through a Skype call:

“There are weeks where it is just me and one other person joining the call, and we aren’t really able to discuss anything or get anything done because there aren’t enough people involved to collaborate. Most of the other employees also don’t join the monthly calls to see the new things we are trying to share. It makes makes it really difficult to spread our own employees’ great ideas that everybody can benefit from.”

Additionally, the same concerns were addressed by Company B as were felt by Company A in regards to higher education and its role in lean construction. All of the participants from the interviews felt that higher education was failing to equip students with the adequate skills needed to practice lean construction. Participant 5 mentioned:

“A lot of new hires come in and know what pull planning is, but they don’t know how to do it. They know what lean construction is and they learned about it in school, but they never practiced it and they don’t *understand* lean.”

Barriers

The most significant barrier for Company A’s implementation of lean construction was the resistance from subcontractors and field crews. These hardened veterans are perhaps the best performers on projects because of their abilities to problem solve when issues arise on the job. Lean construction practices often contradict the way in which these veterans have been operating their entire careers. Participant 3 suggested the classic phrase “You can’t teach an old dog new tricks” to further explain. Full commitment from every employee was also noted as being a barrier for Company A, but as the transition to becoming a lean contractor was underway, those who did not want to adapt to the new culture eventually left as Participant 1 noted.

Company B seemed to be facing the same challenges from field crews that Company A faced, but it was also discovered that lean construction tools seemed to be another barrier. Participant 5 said:

“I have no problem investing in technology if employees feel it will better benefit their project or the company. My concern is when technology is wasted. I have an active project which currently has 15 SmartSheet licenses for it, 13 of which are being unused.”

The Company has also recently rolled out a personalized software to help improve employee productivity and allows upper management to easily oversee production rates on a project. The software however is cited as being “clunky, slow, and not user friendly” which has led to frustration and resistance to use the program, specifically from superintendents. Participant 6 noted that it has also been difficult getting subcontractors on board with pull planning sessions and give full commitment:

“It can be encouraged by management and included in a [subcontractor’s] and that’s one thing, but the people in the field don’t deal with contracts. They do not know what’s going on, and they are the people who want to change their ways the least.”

Company B’s top-down approach at implementing lean construction has shown to be challenged at the project-level. This has led to the researcher’s suggestion of a bottom-up approach, starting in the field, which will be discussed later in the analysis.

Industry Outlook

All participants from both companies interviewed shared the same view on the future of lean construction. “The future is going to be lean construction, it has to be,” was the response from Participant 2. All of Company B’s participants stated that though the company may not have already fully implemented lean construction, they felt the company was already making the transition. Both companies have observed that other contractors were beginning to implement lean construction practices more frequently and are seeing positive results from doing so.

Analysis and Discussion

It can be seen that the lack of adopting a lean culture has been the largest contributing factor to Company B’s failure to implement lean construction practices. By instilling a lean company culture that is adopted by every employee, from upper management all the way down to the field (or vice versa), the other barriers that have been addressed can potentially take care of themselves. Troubles at the project-level were experienced by both companies however, with resistance from subcontractors and field crews being the main concern. This appeared to be the most significant barrier for Company B to fully adopting a lean culture with all of its employees. Company B’s lean construction implementation struggles can also be attributed its failure to continually educate and improve their own employees. The low attendance at innovation meetings and lack in employee training (e.g., of learning modules, seminars, innovation awards, etc.) seemed to be a detriment to the advancement of lean construction culture for Company B. In order to establish, maintain, and encourage a lean culture in construction companies, these forms of continued education should be emphasized.

If lean tools are relied upon too heavily, they can become barriers. This was the case for Company B. Paul Akers (2016) states in his book *2 Second Lean* that “using lean as only a tool will leave you disappointed. It is much more than that” (p.37). Technologies should be intensely researched and their value to the company should be evaluated before making the decision to use them. This would counteract the issues that Company B faced with unused software licenses and poor-performing personalized software. Perhaps more input from field crews and project teams would also be beneficial for the development in personalized softwares due to the fact that these are the employees who will be using them the most.

The industry is not completely at fault for the slow transition to lean. It seems as though higher education has also contributed to the slow adaptation. Participant responses from the interviews confirmed the previously discovered challenges regarding academia's role in the slow progression of lean construction. Both companies exhibited concerns that new employees are often not well-equipped with knowledge of lean construction or have ever practiced it. By integrating lean construction into more higher education curriculum and developing practical hands-on applications, perhaps new employees will be ready to employ their lean construction skills upon entering the workforce. Warcup's (2015) previous study suggested that academia is 10-20 years behind the construction industry in terms of its teachings on lean construction. Instead, it is necessary for academia to realize the importance of lean construction and advise students on the most current, and perhaps even emerging, trends in the industry.

Both Company A and Company B exhibited top-down approaches in implementing a lean culture. This type of approach starts with implementing a lean culture at the top level (upper management), then having it trickle down through the company's various departments before finally reaching the bottom, project-level (e.g., project teams, subcontractors, and field crews). Although Company A found great success with this approach, Company B did not have the same results. Because of this, an alternative bottom-up approach may be suggested for future construction companies to test. This type of approach would be the exact opposite of the previously suggested top-down approach, with implementing both lean construction tools and culture at the bottom (project-level), and having it work up through the company's various departments before finally reaching the top (upper management). Akers (2016) also recommended a more bottom-up approach for traditional manufacturing companies, "if it's simple enough for even those at the 'bottom level' to understand, they will get it and it will take off" (p.91) If project teams, including field crews and subcontractors, can visually see the positive results (e.g., shorter schedule, increased productivity, enhanced collaboration, etc.) from using lean construction tools and having a lean culture, they might be more encouraged to continue using these tools on future projects and share their skills with others. Pull planning sessions and daily huddles might be the easiest lean construction tools to implement on projects to begin this approach.

Conclusion and Future Research

Lean construction offers real benefits to contractors, designers, and owners when it is properly implemented and practiced. These benefits (e.g., shorter schedules, reduced costs, enhanced collaboration, increased client satisfaction, etc.) have been proven for nearly 100 years in examples such as the Empire State Building in 1931. Despite these remarkable accomplishments, many construction companies have yet to make the transition to lean construction. It is now evident that establishing a lean culture is a necessary step for becoming a lean construction company. Without fully adopting a lean culture, construction companies may never be able to realize the remarkable benefits that lean construction has proven to offer. Subcontractors and field crews are the largest barriers, to fully adopting a lean culture, that were expressed by the companies in this study. Academia was also cited as an additional barrier in that students have not been sufficiently trained on lean construction principles. With construction productivity steadily declining and owner expectations rising, the time for lean construction is now. In order for lean construction to prosper in the future however, a massive change will need to be performed by the industry.

Implementing a lean culture through a bottom-up approach, starting in the field, can potentially be a solution to the lack in company commitment that has been prevalent in this research. Future research might explore the effect of a bottom-up lean implementation approach within construction companies. This might be able to provide a more clear path for contractors to follow if they want to make the transition to lean construction as well as offer an alternative to the top-down approaches that have been tried and tested with limited success.

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