Enablers and Barriers of Lean Implementation in Construction Projects

Hasan Gokberk Bayhan ¹, Sevilay Demirkesen ¹, Eshan Jayamanne ²

¹ Faculty of Technology, Sakarya University, Sakarya, Turkey
² Webcor Builders, 450 Harrison Street, Suite 375, San Francisco, CA 94105 USA
sevilaydemirkesen@aydin.edu.tr

Abstract. Lean aims to maximize customer satisfaction while minimizing waste. However, Lean philosophy has not been well understood yet in the construction industry for the fact that the complexity and dynamic nature of construction projects bring up uncertainties that may be hardly handled by construction practitioners. Moreover, project-based nature of construction business makes Lean implementation even more challenging for construction people. Even though Lean efforts in construction have recently increased, there are problems with the implementation processes. It is undeniable that successful Lean implementation strongly affects project performance. Therefore, it is essential to reveal enablers and barriers in Lean implementation so that the construction industry practitioners might conduct projects more effectively and satisfy project requirements (i.e. schedule, budget, safety). This study aims to provide a set of core enablers and barriers of Lean implementation in construction projects and guide construction professionals to better satisfy project requirements. Within this context, the study proposes seven major enabler and barrier groups, namely the financial, managerial, technical, workforce, culture, government, and communication and twenty-seven components for each group. Moreover, a survey was designed and administered to Lean practitioners to rank the enablers and barriers based on importance level. Clear understanding of technical requirements in Lean practices was ranked as the most important enabler of Lean implementation whereas lack of top management support was ranked as the most important barrier in the Lean implementation. However, the average rankings were not found to be diverging indicating that selected components of enabler and barrier groups are properly chosen. The study is expected to lead Lean practitioners with creating value to customers while preventing them from experiencing waste.

1. Introduction
Construction is one of the leading industries generating 35% of net value growth ranging from 7.4 trillion-dollar worth in 2010 to 10.0 trillion dollars in 2020 [1]. Even though the industry has a tremendous raise in its net value, fragmented nature of the industry might sometimes result in low profit in regards to competitive structure of the construction business. Considering the project constrains such as scope, time, cost or quality, environmental constraints are also of paramount importance in terms of reducing or eliminating waste. According to Meadows (2011), the construction industry produces more waste than any other industry in the world [2]. Eliminating non-value adding activities is not only a concern for manufacturing but also a must for the construction industry to stay competitive. According to Construction Industry Institute (CII), the percentage of value-adding activities cover 62%, support
activities cover 12% and only 26% of the work is the waste in the manufacturing industry whereas the percentages are 10%, 33%, and 57%, respectively in the construction [3, 4].

Hence, it is essential to implement effective strategies in the construction industry to reduce the amount of waste and promote the level of competitiveness [5]. As one of these strategies, introducing Lean thinking to the construction industry is undoubtedly beneficial for project practitioners. As a mastermind in Lean research, Koskela (1992) translates Lean principles into the context of construction research and proposes methods to execute construction projects more efficiently [6, 7, 8, 9]. However, it is still challenging for the construction professionals to conceive and implement Lean concepts. Therefore, various firms are in lack of information in terms of benefiting from Lean practices. Apart from the lack of knowledge, another misconception is that firms find Lean practices costly and are unfamiliar with long term benefits or overall profit that the practices bring up. This clearly requires a better understanding of Lean practices and a clear identification of drivers and barriers of Lean implementation. This study aims to fill this gap by first identifying enablers of Lean and introducing barriers for the fact that construction professionals execute projects with success and without waste. Moreover, the study proposes seven factor groups for the enablers and barriers under which twenty-seven components are presented. The factor groups are namely the financial, managerial, technical, workforce, culture, government, and communication. The study also presents enablers and barriers rankings according to the order of importance based on the results of a survey sent out to construction professionals.

2. Lean Construction and Implementation

The construction industry is very dynamic and open to various opportunities. This dynamic nature and openness to change makes the industry feasible for adopting new concepts. Within this context, application of Lean systems into manufacturing might be also applied in the construction industry to experience higher productivity rates [10].

Lean production is first coined with Taiichi Ohno, a master mind in Lean Production, in the 1950s. Lean production kept Toyota profitable every year from 1950 to 2008 until the global recession and the oil price spike [11]. However, Lean production was offered as a term by Krafck in 1988, who is a member of the research team working on the International Motor Vehicle Programme at Massachusetts Institute of Technology (MIT) [12]. The Lean Construction concept further studied by Womack et al. (1990) in their book “The Machine That Changed the World”.

Koskela (1992) was one of the first pioneers of Lean, who came up Lean principles with the aim of maximizing value for customers while minimizing waste [6, 13]. The transformation-flow-value generation model of production is the key to Lean construction for facilitating the flow in the steps with the elimination of non-value adding activities [7, 14, 15]. Experience in just in time (JIT) planning, effective use of pull-driven scheduling, reduced variability in labour productivity and improvement in flow reliability are part of Lean construction practices. Lean production and construction introduce eight types of waste, namely the transportation, inventory, motion, waiting, over-production, over-processing, defects, skills misuse [13, 16].

Furthermore, Womack and Jones (1996) established the five principles of Lean production, namely the value, value stream, flow, pull and perfection. This theoretical foundation is called ‘Lean Thinking’ and it differentiates production activities [7, 13, 16].

Over the years, several researchers have focused on the Lean implementation in construction in different countries [17, 18, 19] and many of them concluded that Lean implementation is challenging for the construction industry [13, 20]. Therefore, it is essential to identify enablers and barriers of Lean implementation to conduct successful Lean operations.

3. Enablers of Lean Implementation

This study identifies twenty-seven enablers for the successful Lean implementation. Table 1 shows the enablers identified specific to Lean implementation under seven factor groups and present relevant sources for each enabler.
### Table 1. Enablers for Lean Implementation

| Category | Code | Enablers | Description |
|----------|------|----------|-------------|
| **Financial** | FE1 | Existence of a clear marketing strategy [21][23][25][29] | A visionary market strategy enhances Lean implementation |
| | FE2 | Long term profit of implementing Lean tools [23][24][27] | Implementing Lean tools brings profit for the companies in long term |
| | FE3 | Willingness to invest in Lean practices [21][29] | Investing in Lean tools and practices facilitate the implementation of Lean |
| | FE4 | Market share [21][23][29] | Growth and increase in market share lead to improvement in Lean implementation |
| **Managerial** | ME1 | Management commitment [22][29] | Commitment by top and middle management in Lean practices facilitate Lean implementation |
| | ME2 | Incentive mechanisms [22][26][29] | Incentive mechanisms are the catalysts for Lean Implementation and improves process efficiency |
| | ME3 | Creating awareness for Lean [14][22][29] | Enhancing awareness for Lean leads to a collaborative and effective structure in Lean implementation processes |
| | ME4 | Customer satisfaction [21][23][24][34] | Adopting customer satisfaction as the firm policy ensures the success of Lean implementation |
| **Technical** | TE1 | Lean training [23][27][28] | Lean training leads to a more definite scheme of Lean implementation process resulting in desired success |
| | TE2 | Availability of Lean tools and techniques [23][28][29] | Available resources in Lean and familiarity with Lean techniques facilitate Lean implementation |
| | TE3 | Clear understanding of technical requirements in Lean practices [28][34] | Clarity in Lean terms definition and identification of best practices are of paramount importance to Lean implementation success |
| | TE4 | Morning huddles for Lean [9][24][28] | Daily meetings and morning huddles reinforce Lean learning and improve technical skills in Lean implementation |
| | TE5 | Effectiveness of Value Stream Mapping [21][29][34] | Value Stream Mapping helps visualize Lean implementation process and provides a graphical representation of steps to be used |
| **Workforce** | WE1 | Supportive environment for workforce efficiency [13][21][27][32] | Workforce efficiency reduces waste in Lean practices leading to successful Lean implementation |
| | WE2 | Existence of certified and qualified Lean personnel [14][21][23][29] | Lean certified personnel are more able to come up with better implementation strategies knowing the terms to be applied |
| | WE3 | Efficiency of human resource management activities [4][21][29] | Effectiveness of human resource management activities including selecting best fitting personnel for the projects promotes Lean practices and affects Lean implementation positively |
| | WE4 | Availability of consulting team members in Lean [13][21][22] | Lean consultancy and an available consulting team matter for the success of Lean implementation for resolving conflicts in processes |
| **Culture** | CUE1 | Adopting a Lean culture [13][29] | Adopting a Lean culture helps people conceive the importance of Lean practices leading potentially to safer practices in the workplaces |
| | CUE2 | Lean as a firm strategy [21][29] | Making Lean part of firm culture increases the familiarity with Lean practices leading employees with the practices along with shorter application durations in Lean implementation |
4. Barriers of Lean Implementation

This study identifies twenty-seven barriers, which make Lean implementation difficult in the construction industry. Table 2 presents the barriers identified specific to Lean implementation under seven factor groups.

Table 2. Barriers for Lean Implementation

| Category     | Code | Barriers                                      | Description                                                                 |
|--------------|------|-----------------------------------------------|----------------------------------------------------------------------------|
| Financial    | FB1  | Inventory costs [21][22][23]                  | Cost of storing the inventory negate Lean activities and leads to slower actions in Lean implementation processes |
|              | FB2  | Dimensional variation costs of Lean tools [14][21][22] | Design variations of Lean tools might bring an extra cost to Lean tools resulting in reluctance to implement Lean processes |
|              | FB3  | Consulting costs in Lean [13][24]             | Lean practitioners might be concerned with the consulting costs of Lean practices, which might reduce the efficiency of Lean processes |
|              | FB4  | Market conditions [4][13][22][25][26]        | Fluctuations in market conditions have potential to negatively impact firms in terms of achieving best practices in Lean resulting in lower customer satisfaction |
| Managerial   | MB1  | Misperception about Lean practices [22][23][26] | Firms may have pre-judges about the application of Lean practices for the fact that they seem to be costly and require special expertise |
|              | MB2  | Risk aversion in Lean implementation [13][15][22][23] | Firms might develop concerns for investing in Lean thinking that Lean implementation might create uncertainties for the project |
| Category | Code  | Barriers                                                                 | Descriptions                                                                                                                                 |
|----------|-------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
|          |       | **MB3** Lack of top management support [13][15][21][22][23][24][25][26] | Top management actions and reluctance to apply Lean practices may create deficiencies in Lean implementation                                      |
|          |       | **MB4** Inefficiency in resource planning [14][22][27]                  | Inefficient planning of resources has potential to generate waste and to impact Lean implementation steps                                       |
| Technical|       | **TB1** Complexity of Lean philosophy and terms [13][15][21][22][24][26][28][29] | Lean construction has not yet been understood well by construction firms and there still needs to develop a common understanding of concepts in order to practice Lean implementation considering the most efficient manner and in regards to the project based nature of the construction industry |
|          |       | **TB2** Complexity in design [4][13][14][26]                            | Designing Leaner and safer is more challenging than traditional design since Lean implementation has potential to create complexity in projects |
|          |       | **TB3** Inefficiency in Takt time planning [10][30]                      | Inefficiency in Takt time planning due to multiple stakeholders in the project might generate negative outputs for firms in Lean practices   |
|          |       | **TB4** Failure in operational excellence [13][26][28]                  | Lack of understanding in operational excellence might lead construction firms not to adopt Lean culture leading to failure in Lean implementation processes |
|          |       | **TB5** Lack of understanding in Last Planner Implementation [4][28]     | Last planner system (LPS) implementation is among the key techniques of Lean but firms having limited knowledge of using LPS are more likely to fail in Lean implementation on a timely manner |
| Workforce|       | **WB1** Problems in teamwork and diverging aims in Lean [4][13][15][22][26][31] | Diverging aims in applying Lean practices and lack of coordination and collaboration among team members lead to inefficient processes in Lean applications |
|          |       | **WB2** Lack of understanding – Non-native speakers [14][22]             | Language and level of education are among the most important barriers of Lean learning and have potential to result in slower Lean implementation |
|          |       | **WB3** Employees' resistance to Lean [4][22][29]                       | There may be a resistance towards applying Lean practices for the fact that employees might feel they are not performing as efficient as Lean tools (i.e. poka yoke devices, Kanban cards) |
|          |       | **WB4** Stress and pressure in deadlines [4][13][32]                    | Efforts in meeting the deadlines in construction projects might create stress and pressure on firm employees leading to wrong or missing practices of Lean |
| Culture  |       | **CUB1** Resistance to change [13][14][15][21][22][23][24][29][33]      | Lean is a relatively new concept in the construction industry and some construction practitioners are concerned about using Lean practices for the fact that they are either unfamiliar with the benefits that Lean proposes or are satisfied with the current applications |
|          |       | **CUB2** Diversity in adopting Lean culture [22][23][33]                | Lean offers applications in various industries depending on the needs of the specific industry to which it refers. However, diverging backgrounds of users of Lean practices might create different learning curves for varying groups |
| Category | Code | Barriers | Descriptions |
|----------|------|----------|--------------|
| CUB3     | [15][24][33] | Lack of long-term philosophy | Lean is still not adopted as a long-term philosophy due to dynamic nature of construction industry leading to pressures in getting short-term profits to sustain the projects, which makes the Lean implementation challenging in the construction industry |
| CUB4     | [26][27] | Insistence on mass manufacturing | Lean is still compared with the mass manufacturing and continuing interest in mass manufacturing make Lean practices less attractive with the opportunity to apply traditional thinking and to get discounts on mass orders |
| GB1      | [14][15][23] | Stringent requirement and approvals | Procedural documents might lead to deficiencies in information flow, which in turn slows down the Lean process implementation |
| GB2      | [13][31][33] | Lack of knowledge in Lean | Lean understanding has not yet conceived well by most government authorities as well as benefits of using Lean techniques, which negatively affect investment decisions in Lean |
| GB3      | [15][33] | Lack of government support for research and collaboration in Lean | Limited funding opportunities for research and collaboration in Lean practices lead to a narrower spectrum of Lean activities and scarcity of project specific applications of Lean |
| COB1     | [13][15][22][25][31] | Stakeholder issues in communication | Failure to engage stakeholders in project processes leads to ineffective communication creating problems in decision making and Lean processes |
| COB2     | [21][22][24][25][28][32] | Lack of organizational communication | Lack of organizational communication is a key barrier in terms of project success and willingness to apply Lean practices |
| COB3     | [25][26][31][32] | Lack of information sharing and integrated change control | Managing uncertainties and changes in the project are only possible with effective communication channels and lack of information sharing can break the Lean learning chain resulting in defective processes |

5. Discussion

The study conducted a survey to rank the enablers according to the order of importance. Out of 50 surveys sent out, 23 responses were collected resulting in a response rate of 46%. The respondents were asked to score the enablers based on Likert scale, where 1 represents “not important” and 5 represents “most important”. Figure 1 presents the enablers along with the average ratings of importance level.

According to Figure 2, it is found that “Lack of top management support” was rated as the top barrier (rating: 4.61) in terms of importance level as ranked by the Lean practitioners. Secondly, “Misperception about Lean practices” and “Lack of information sharing and integrated change control” were rated as the following top barriers with average ratings of “4.14” and “4.09”, respectively. “Lack of government support for research and collaboration in Lean” (rating: 3.04) and “Lack of understanding – Non-native speakers” (rating: 3.30) were rated as moderately important in terms of affecting Lean implementation.
According to Figure 1, it is found that “Clear understanding of technical requirements in Lean practices” was ranked as the most important enabler of Lean implementation with an average rating of “4,32”. Secondly, “Adopting a Lean culture” and “Management commitment” were rated as the most important elements of Lean implementation with average ratings of “4,26” and “4,23” respectively. “Market share” and “Supportive nature of governmental regulations in Lean” were rated as moderately important with average ratings of “3,14” and “3,17”, respectively.

Figure 2 presents the barriers along with the average ratings of importance level.

6. Conclusion
The construction industry is fragmented and dynamic. Therefore, the industry is dealing with several uncertainties and claims as well as safety, quality and productivity problems. To prevent these problems or to reduce and control their effects, Lean construction is introduced to the construction industry in order to best manage construction processes. However, Lean implementation is still a challenge for the most practitioners in the construction industry due to varying reasons such as lack of understanding in
Lean, misperception of Lean practices or lack of expertise to apply the Lean practices. Hence, this paper focuses on developing a set of Lean enablers and barriers for the successful Lean implementation in the construction industry. Within this context, the paper derived twenty-seven components of enablers and barriers investigated under seven factor groups. The paper also ranked these components based on their level of importance through a survey addressed to the Lean practitioners. The study showed that Lean practitioners point out to clear understanding of technical requirements in Lean to best manage Lean implementation process whereas they highlight that the lack of top management support as the most important barrier for the Lean implementation.

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