Production Management and Process Control, Vol. 36, 2022, 161–170
https://doi.org/10.54941/ahfe1001631

Principal Component Analysis of Inhibiting Factors to the Espousal of Lean Construction in Developing Economies

Matthew Ikuabe[1], Clinton Aigbavboa[1], Douglas Aghimien[2], Pretty Ramaru[1], Ayodeji Oke[1], and Opeoluwa Akinradewo[1]

[1]cidb Centre of Excellence & Sustainable Human Settlement and Construction Research Centre, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
[2]Department of Civil Engineering Technology, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa

ABSTRACT

The inefficiencies plaguing construction processes have negatively impacted the delivery of construction projects. The South African construction industry is not exempted from this as it is still characterized with overwhelming ineffectiveness in construction project actualization. Lean construction offers a variety of innovative concepts that aids the optimization of construction activities. Despite the benefits of the implementation of lean construction, its adoption is clearly not evident in developing economies. This study empirically assesses the inhibiting factors to the adoption of lean construction in the South African construction industry. Data was collected from construction professionals and was analysed with Exploratory Factor Analysis which revealed four constructs as the barriers to the implementation of lean construction. Conclusively, the study recommended that lean construction should be inculcated in the curricular of higher institutions of learning offering built environment related courses; also construction professional bodies should encourage the mandatory training of professionals as an area of competence in judging registration of professionals. The findings from this study brings to the fore the hurdles faced in the construction industry in the adoption of lean construction, hence giving a clear direction on how best to abate these challenges for the attainment of the benefits of its espousal.

Keywords: Barriers, Construction industry, Developing economies, Exploratory factor analysis, Lean construction

INTRODUCTION

The importance of the construction industry to the development of the economy of any nation cannot be over emphasized. The industry is considered to be vital due to its influence in the provision of jobs as well as the GDP of any country (Thwala and Mathonsi, 2012). It makes provision for the infrastructural needs which is a viable indicator of the state of the economy to nations. Khan (2008) observed that the construction industry in developing

economies is a dynamic sector that makes provision of new infrastructure which includes roads, airports, railways, housing, schools, health facilities and other infrastructures. In developed economies, the attention is centered on refurbishment and rehabilitation construction as well as providing professional services (Bon and Pietroforte, 1990; Ruddock, 2009). Alinaitwe (2009) noted that the construction industry is typified as an industry with lots of challenges and lack of productivity. Some of the peculiar challenges posed to the construction industry are time and cost overrun, health and safety issues and poor quality delivery (Ikuabe et al. 2020; Mustapha et al. 2016; Sultan et al. 2003). These have greatly inhibited the impacts and benefits of the industry at minute and larger aggregate levels. The need for seeking for alternative methods and approaches in abating some of the perennial issues plaguing the industry has led to the infusion and adoption of more advanced management techniques. One of such approaches is the adoption of lean concepts in construction processes which seeks to mitigate some of the mundane challenges associated with the construction industry.

Ballard and Howell (2004) opined that lean construction (LC) concept is an innovative idea for project management which makes attempt to challenge the conventional concept in the management of construction projects. Mossman (2009) defines LC as a "technique to plan creation frameworks to limit waste of resources, time, and effort, bearing in mind the end goal to yield the greatest imaginable amount of major cost". Moreover, Abdelhamid (2004) outlined LC as an overall decisive design coupled with logic in delivery which possesses an all-inclusive need of enhancing the motivation to all stakeholders in the aspect of proficiency, synergy, and continual modifications of legal acts of binding courses, the outlined structure, the construction processes and strategies as well as network involved in manufacturing. Several studies have outlined how LC has immensely contributed to execution advancements and accomplishing value for the client's money within the construction sector of a few nations (Luo et al. 2005; Womack and Jones, 2003; Vilasini et al. 2011) . Moreover, the reduction of construction project completion period outlines LC as an approach that serves better in comparison with traditional methods of construction project delivery (Erol et al. 2017; Issa, 2013). Mossman (2009) and Salem et al. (2005) noted other benefits in the adoption of LC in project execution to include improved quality, improved reliability, increased productivity, eliminated costs, clean working environment, decrease in chance of accidents and enhancement in designs. However, despite of the potential benefits of LC, little has been reported regarding its execution for performance enhancement and the successful fulfillment of project objectives in the developing countries with particular emphasis on countries in the African continent. Based on the backdrop of the glaring benefits accompanying the adoption of LC in construction processes and management, this study attempts to assess the barriers to the espousal of LC in developing economies, with particular emphasis on the South African CI with a view to presenting ways that will encourage and expedite the rapid adoption of LC.

Bottlenecks to the Implementation of LC

Given the complexities and sizes of construction projects involving many stakeholders, there is usually a level of constraints and uncertainties encountered during the execution of construction projects. This calls for innovative concepts and ideas in striving for the abatements of the numerous challenges encountered in project execution, and LC has been touted to be effective for such purposes. Despite the effectiveness of LC practices, its implementation has been met with a series of barriers. According to Mwarcharo (2013), the most common challenge in LC implementation is that "lean systems are inherently knowledge-intensive", as it requires a shift from the knowledge base of the traditional and conventional systems associated with construction project delivery. Moreover, a complete assimilation and understanding of LC would demand a thorough and dedicated pursuit of the tenets making up the technique. Lean is more than being a tool; it entails a change in flexibility, thinking, discipline, teamwork, assurance, and a comprehensive structure that assures construction project performance at all levels.

Additionally, the CI is used to the traditional practices and the LC system is different. It comes with new concepts and techniques which are distinctly a divergence from the traditional and conventional methods (Sarhan and Fox, 2013). This poses a challenge to its implementation since stakeholders in construction are usually more comfortable with the utilization of traditional systems. Similarly, Sarhan et al. (2017) indicated that due to culture and attitudinal issues, the implementation of LC in construction processes would be a major problem. As earlier posited, the culture and attitudinal disposition of construction stakeholders has continuously been a great challenge to innovative and enterprising concepts, thereby hindering the adoption of new concepts. Furthermore, the top management of construction organizations have a key role to play in achieving a successful implementation of innovative methods (Salem et al. 2005). The achievement of lean practice lies in the commitment of top management in evolving and executing operative plans and satisfactorily giving the desired resources and support to oversee changes emerging from the execution. Common et al. (2000) indicated that the absence of concentration and commitment from top management and difficulties in understanding the idea of LC proves to be barrier to the implementation of lean principles.

The execution of LC may be influenced by technical barriers which have influence on executing certain LC principles and instruments such as consistency, straightforwardness, adaptability and benchmarking (Koskela, 2004). A few of these were recognized by Ballard and Howell (2004), highlighting issues such as inaccurate and inadequate designs, poor performance measurement approaches, nonexistence of approved execution methodology, absence of prefabrication, and uncertainty in supply chain. Moreover, the absence of long term philosophy by organizations has been a barrier to the adoption of lean principles (Shang and Sui Pheng, 2014). It is often experienced that the core philosophical direction of organizations are not positioned to accommodate innovative concepts and ideas. For construction organizations, a direct and purposive mandate in the actualization of the implementation

of LC must be in tandem with the philosophical direction of the organization. Also, the lack of managerial culture and need of information and skills that support collaboration serves as the foremost challenging barriers to LC implementation (Omran and Abdulrahim, 2015).

METHODOLOGY

This study aims at assessing the hindering factors to the espousal of lean construction in developing economies. With the utilisation of quantitative design approach, questionnaire survey was deployed for the study rising from its ability to cover a wide range of respondents in a short time frame coupled with the advantage of objectivity and quantifiability in the research (Ackroyd and Hughes, 1981). Responses were elicited from construction professionals domiciled in Gauteng Province, South Africa. The choice of Gauteng province emanates from the fact that the province is a host to a large pool of construction projects and construction professionals in the country. The professionals making the respondents comprised of Architects, Quantity Surveyors, Construction Managers, Engineers and Project Managers; while convenience sampling technique used for the study due to constraints such as cost and time. With the administration of two hundred (200) questionnaires, a total of one hundred and fifty-two (152) were retrieved, while one hundred and fifty-one were deemed suitable for analysis. Cronbach's alpha was used in ascertaining the reliability of the research instrument, and gave a value of 0.910; thus, indicating a high reliability value (Tavakol and Dennick, 2011). The method of data analysis deployed for the study is factor analysis using principal component analysis which aids in the conversion of identified similar related variables possessing features that are liner correlated and forming constructs which are attributed with variation shown in the original variable (Jollife, 2002).

RESULT AND DISCUSSION

Exploratory Factor Analysis

With the purpose of trying to establish the variables measuring similar underlying dimensions, exploratory factor analysis (EFA) was employed. This helped in the identification of clusters having related variables, thereby bringing about the reduction in the number of variables into simpler and seemingly understood framework. An evaluation of the suitability of the information for factor analysis was carried out. An optimum range for the inter-item correlation of 0.15 to 0.50 is deemed appropriate (Phelan and Wren, 2007). The correlated values of all the variables have co-efficient above 0.3, thus proving the suitability for factor analysis.

The Kaiser–Meyer–Olkin (KMO) extent of sampling suitability and Bartlett's test of sphericity was utilized in ascertaining the factorability of the information collected. Pallant (2005) recommended that the Bartlett's test of sphericity has to be significant ($P < 0.05$) for FA to be considered suitable. Findings in Table 1 shows a KMO value of 0.847 and a significant level of 0.000 for the Bartlett's test. These findings combined with the 0.910 result acquired

Table 1. KMO and bartlett's test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.847
Bartlett's test of sphericity	**Approx. chi-square**	1474.624
	Df	190
	Sig.	0.000

Table 2. Rotated factor matrix.

Factors	1	2	3	4	Comm. Extract
Lack of lean understanding	0.827				0.786
Lack of adequate lean awareness	0.807				0.706
Absence of a lean culture	0.606				0.584
Lack of appropriate lean training	0.604				0.611
Lack of lean specialists and expertise	0.567				0.533
Lack of adequate time for innovation	0.563				0.412
Poor communication among stakeholders		0.749			0.705
Lack of top management commitment		0.717			0.733
Inaccurate and incomplete designs		0.661			0.545
Inadequate pre-planning		0.623			0.543
Lack of interest from clients		0.453			0.509
Poor standardize procurement strategies			0.654		0.498
Lack of prefabrication techniques			0.645		0.469
Uncertainty in supply chain			0.632		0.555
Lack of agreed implementation methodology			0.562		0.367
Insufficient financial resources				0.533	0.432
Lack of organisational culture that supports lean				0.507	0.531
High cost of lean training				0.502	0.429
Lack of government support				0.418	0.380
Human resistance to change				0.408	0.448

Extraction Method: principal component analysis.
a 4 components extracted.

from the reliability test carried out using Cronbach's alpha test indicate that the use of EFA for the data collected is suitable.

As the information collected met all the fundamental necessity, EFA was carried out utilizing Principal Component Analysis (PCA) with varimax rotation. Findings in Table 2 revealed that four factors with eigenvalues greater than 1 were extracted utilizing the factor loading of 1.0 as the cut-off point. The total variance described by each factor extracted is as follows: factor 1 (Inadequate knowledge and understanding) with 36.5%; factor 2 (Stakeholders and construction process barriers) with 9.2 per cent, factor 3 (Procurement and technical barriers) with 4.6 per cent and factor 4 (Lack of government support and organizational barriers) with 3.6 per cent. The final statistics of the PCA and the factors extracted accounted for almost 53.89 per cent of the total cumulative variance. This accomplishes the requirements of components explaining at least 50 per cent of the variation (Stern, 2010).

Discussion of Extracted Components

Cluster One Inadequate Knowledge and Understanding

The variables in this cluster are Lack of lean understanding returns (0.827), Lack of adequate lean awareness (0.807), Absence of a lean culture (0.606), Lack of appropriate lean training (0.604), Lack of lean specialists and expertise (0.567), and Lack of adequate time for innovation (0.563) with a total variance of 36.5 %. This outcome supports the study of Common et al. (2000) which indicates that the lack of concentration and commitment from top management, troubles in understanding the idea of LC and absence of training are obstacles hindering the adoption of lean concepts in the CI. This also affirms the findings of the study by Mwacharo (2013) and Adegbembo et al. (2016) who stated that the need for LC knowledge and consciousness amongst professionals is the main obstruction to its usage. Furthermore, Bicheno and Howleg (2009) asserts that the greatest barriers of implementing LC are lack of understanding lean construction process and going back to the traditional ways of doing things. This gives credence to the notion that a significant number of stakeholders in the construction industry are not familiar with the idea of LC, hence, bringing about a hindrance in its adoption for construction processes. Sarhan and Fox (2013) and Kim (2002) opined that LC can be a complex and complicated system and that understanding the application of lean tools and principles coupled with the support of top management of organizations would go a long way in aiding its adoption.

Cluster Two Stakeholders and Construction Process Barriers

The variables in this cluster are Poor communication among stakeholders (0.749), Lack of top management commitment (0.717), Inadequate preplanning (0.623), Inaccurate and incomplete designs (0.661) and Lack of interest from clients (0.453) with a total variance of 9.2 per cent. This finding is corroborated by Aigbavboa et al. (2016), noting that there are numerous boundaries to the implementation of LC in the South African CI. These include poor communication, lack of interest from clients, and lack of long-term commitment. The findings are in conformity with Salem et al. (2005), stating that top management of each organization plays a major role in accomplishing a fruitful application of advanced approaches and further showed that the achievement of lean practice lies in their commitment in evolving and executing an operative plan. Furthermore, Sarhan et al. (2017) affirms that the absence of concentration and commitment from top management and lack of interest from clients are some of the key barriers to the adoption of lean concepts in the construction industry. All these portray the inadequacies of the part of stakeholders in the construction industry which has great impact on the adoption of LC in the construction industry.

Cluster Three Procurement and Technical Barriers

The variables in this cluster are Poor standardize procurement strategies (0.654), Lack of prefabrication techniques (0.645), Uncertainty in supply chain (0.632), and Lack of agreed implementation methodology (0.562), with a total variance of 4.6 per cent. This outcome is in consonance with

the study of Ballard and Howell (2004), which asserts that methodological inadequacies in implementation hugely hinders the adoption of LC; also the uncertainties in supply chain serves as a major contributor to the non-implementation of LC. Furthermore, the findings of the study agrees with Alinaitwe (2009) which revealed that a lack of standardized procurement strategy coupled with the lack of control over factors influencing the management of supply chain is in tandem with the findings of the study.

Cluster Four: Lack of Government Support and Organizational Barriers
The variables in this cluster are Insufficient financial resources (0.533), Lack of organizational culture that supports lean (0.507), High cost of lean training (0.502), Lack of government support (0.418) and Human resistance to change (0.408), with a total variance of 3.6 per cent. Koskela (2004) and Al-Aomar (2012) highlighted that government's indifference in the advocacy of LC coupled with inadequate training and its high cost are the main hindering factors to the adoption of LC in the construction industry. This is affirmed by the findings of this study. Government's participation in the advancement of construction process cannot be overemphasized. The enactment of policies and regulations coupled with strict enforcement would go a long a way in making advocacies for the adoption of unique project management concepts like LC.

CONCLUSION AND RECOMMENDATIONS

Lean concepts have been heralded to be a significant innovation for the optimization of processes and activities in the delivery of construction projects, hence the advocacy for its adoption by stakeholders in the construction industry. However, its level of adoption in developing countries, with particular emphasis on South Africa has not been a success. This study carried out an empirical assessment of the inhibiting factors to the adoption of LC in the South African construction industry. Through the holistic review of extant literature, the study identified the hindering factors to the implementation of LC, and then analysis was carried out with appropriate statistical tools. Findings derived from the study shows that the hindering factors to the adoption of LC are Inadequate knowledge and understanding, Stakeholders and construction process barriers, Procurement and technical barriers and Lack of government support and organizational barriers. Based on the backdrop of these findings, this study recommends that requisite fundamental knowledge on LC should be highly encouraged and supported. A good step in achieving this is the infusion of the rudiments and tenets of LC in the curricular of higher institutions of learning, as this would serve as a springboard in launching the right quality of construction professionals that would eventually be saddled with the duties of synergizing LC concepts in construction processes; hence, it wouldn't be strange practice during the process of engaging in on field practice. Likewise, the implications of the study for the South African CI further expands the discussion on construction organizations and professional bodies being mandated to encourage the training of stakeholders in this area, since it has been established that the lack of technical knowledge is

a huge hindrance for its adoption. Also, the role of the government agencies in South Africa such as Construction Industry Development Board (CIDB) in the advancement of the construction industry is never overemphasized. Such agencies can help propagate the espousal of LC in the South African CI. Furthermore, through the enactment of policies and regulations, the innovative concepts such as LC will be highly encouraged, thereby leading to high drive for its adoption. Generally, due to the importance of the construction industry to the economy of any nation, it is advocated that special focus should be placed on propelling concepts that would bring about the growth of the industry particularly on the optimization of the processes in construction projects; as clearly stated in the body of this study, LC is not an exception to this.

REFERENCES

Abdelhamid, T.S. (2004). "The self-destruction and renewal of lean construction theory: A prediction from Boyd's Theory", In: Proceedings of the 12th Annual Conference of the International Group of Lean Construction, Helsinga, Denmark, 3–5 August 2004, pp. 1–19.

Ackroyd, S., Hughes, J.A. (1981). Data Collection in Context. Longman, London, UK.

Adegbembo, T. F., Bamisaye, O., Aghimien, D. O. (2016). Assessment of Lean Construction Practice in the Nigerian Construction Industry. Proceedings of the Joint International Conference (JIC) on 21st Century Human Habitat: Issues, Sustainability and Development, 21-24 March 2016, Akure, Nigeria, pp. 756–764

Aigbavboa, C., Oke, A., Momoti, T., (2016). Drivers and barriers of lean construction practice in South African construction industry. International Conference on Innovative Production and Construction in Perth, Australia, 29–30th September, pp. 195–201.

Al-Aomar, R. (2012). Analysis of lean construction practices at Abu Dhabi construction industry, LEAN CONSTRUCTION JOURNAL Volume 13 No. 1 pp. 105–121.

Alinaitwe, H.M. (2009). Prioritizing lean construction barriers in Uganda's construction industry, JOURNAL OF CONSTRUCTION IN DEVELOPING COUNTRIES Volume 14 No.1, pp. 15–30.

Ballard, G., Howell, G. (2004). Competing construction management paradigms, LEAN CONSTRUCTION JOURNAL, Volume 1 No.1, pp. 38–45.

Bicheno, J., Holweg, M. (2009) The lean toolbox: The essential guide to lean transformation. 4th edn. Buckingham: PICSIE Books.

Bon, R., Pietroforte, R. (1990). Historical comparison of construction sectors in the United States, Japan, Italy, and Finland using input-output tables, CONSTRUCTION MANAGEMENT AND ECONOMICS Volume 8, pp. 233–247.

Common, G., Johansen, E., Greenwood, D. (2000). "A survey of the take-up of lean concepts among UK construction companies", In: Proceedings of the 8th Annual IGLC Conference. Brighton, UK, 17th – 19th July 2000. pp. 1–10.

Erol, H., Dikmen, I., Birgonul, T. (2017). Measuring the impact of lean construction practices on project duration and variability: A simulation-based study on residential buildings, JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT Volume 23 No. 2, pp. 241–251.

Ikuabe, M., Aghimien, D., Aigbavboa, C., Oke, A. (2020). "Exploring the Adoption of Digital Technology at the Different Phases of Construction Projects in South Africa", International Conference on Industrial Engineering and Operations Management, Dubai, UAE, March 10-12, pp. 1553–1561.

Issa, U.H. (2013). Implementation of lean construction techniques for minimizing the risks effect on project construction time, ALEXANDRIA ENGINEERING JOURNAL Volume 52 No.4, pp. 697–704.

Jollife, I.T. (2002). Principal Component Analysis. 2nd Ed. New York Springer Publishing.

Khan, R.A. (2008). "Role of construction sector in economic growth: empirical evidence from Pakistan economy", 1st international conference on construction in developing countries (ICCIDC–I) Advancing and Integrating Construction Education, Research & Practice, Karachi, Pakistan 4-5 August 2008, pp. 1–12.

Kim, D. (2002). Exploratory study of lean construction: Assessment of lean implementation. Ph.D. thesis, University of Texas at Austin, Austin, TX, USA.

Koskela, L. (2004). Moving-on – Beyond lean thinking. Lean Construction Journal. 1,1, pp. 24–37.

Luo, Y., Riley, D.R., Horman, M.J. (2005). "Group for Lean Construction Conference", Conference proceedings of the 13th conference held in China, 29-31 July, pp. 501–509.

Mossman, A. (2009). Why isn't the UK construction industry going lean with gusto?, LEAN CONSTRUCTION JOURNAL. Vol. 5 No. 1, pp. 24–36.

Mustapha, Z., Aigbavboa, C., Thwala, W. (2016). "Small and Medium-Sized Enterprises Contractors' Health and Safety Performance", International Conference of Socio-economic Researchers Johannesburg, South Africa.

Mwacharo, F. (2013). Challenges of lean management: Investigating the challenges and developing a recommendation for implementing lean management techniques. Bachelor's thesis submitted to the HAMK Univerisity of Applied science.

Omran, A., Abdulrahim, A. (2015). Barriers to Prioritizing Lean Construction in the Libyan Construction Industry, ACTA TECHNICA CORVINIENSIS-BULLETIN OF ENGINEERING Volume 8 No.1, pp. 53–56.

Pallant, J. (2005). SPSS survival manual: A step-by-step guide to data analysis using SPSS for Windows (Version 12). Crow's Nest: Allen & Unwin.

Phelan, C., Wren, J. (2007). Exploring Reliability in Academic Assessment. Retrieved from https://chfasoa.uni.edu/reliabilityandvalidity.htm [Accessed 5 December 2020].

Ruddock, S. (2009). Reassessing productivity in the construction sector to reflect hidden innovation and the knowledge economy, CONSTRUCTION MANAGEMENT AND ECONOMICS Volume 27 No. 9, pp. 871–879.

Salem, O., Solomon, J., Genaidy, A., Luegring, M. (2005). Site implementation and assessment of lean construction techniques, Lean Construction Journal. 2,2, pp. 1–21 (2005).

Sarhan, J.G., Xia, B., Fawzia, S., Karim, A.: 2017. Lean construction implementation in the Saudi Arabian construction industry. Construction Economics and Building, Volume 17 No.1, pp. 46–69.

Sarhan, S., Fox, A. (2013). Barriers to implementing lean construction in the UK construction industry, THE BUILT AND HUMAN ENVIRONMENT REVIEW Volume 6 No. 1, pp. 1–17.

Shang, G., Sui Pheng, L. (2014). Lean construction management. New York: Springer.

Stern, L. (2010). A visual approach to SPSS for Windows: A Guide to SPSS 17.0. 2nd ed. Boston, MA.: Allyn & Bacon.

Sultan, M., and Kajewski, S. (2003). "The Yemen construction industry: Readying the industry for the successful implementation of sustainability", Proceedings of the International Conference on Smart and Sustainable Built Environment, Brisbane, Australia, 19–21 November.

Tavakol, M., Dennick, R. (2011). Making sense of Cronbach's Alpha. INTERNATIONAL JOURNAL OF MEDICAL EDUCATION Volume 2, pp. 53–55.

Thwala, W. D., Mathonsi, M. (2012). Selection of procurement systems in the South African construction industry: An exploratory study, ACTA COMMERCII Volume 12 No. 1.

Vilasini, N., Neitzert, T.R., Rotimi, J.O. (2011). Correlation between construction procurement methods and lean principles, INTERNATIONAL JOURNAL OF CONSTRUCTION MANAGEMENT Volume 11 No.4, pp. 65–78.

Womack, J., Jones, D. (2003). Banish waste and create wealth in your corporation. 2nd Ed. United Kingdom: Simon and Schuster.