

Lean Techniques Approaches to Managing Ghanaian Contractor Supply Chains

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Abstract Evidence from past research demonstrates a high potential for significant improvements in overall construction performance through the incorporation of Lean techniques into construction supply chains. Amongst Ghanaian contractors however, there is a low level of awareness and poor uptake of Lean techniques and principles. The current material supply processes used by Ghanaian contractors lead to waste and inefficiency. In this multiple-case study, the level of awareness and the uptake of Lean techniques and principles in the management of contractor supply chains in the Ghanaian construction industry are investigated. Using three selected cases, in-depth interviews were conducted with twenty (20) professional project participants from the selected construction firms. The findings showed a low awareness of Lean techniques amongst the contractors surveyed. Long-term relationships are not a major priority for most of the respondents. Contractors surveyed faced challenges relating to material deliveries such as quality, quantity and bad sequence of deliveries and problems with communication between contractors and their suppliers. The paper concludes that education will help improve the knowledge and understanding of Ghanaian contractors on Lean techniques and principles. This will improve the uptake of these techniques and integration into the management of their supply chains leading to overall performance improvements.

Keywords Construction, Ghana, Supply Chain Management, Lean Construction

1. Introduction

There is a growing awareness in the construction industry of the importance of the Supply Chain Management (SCM) concept [11]. Leading industries such as the automobile and manufacturing sectors have integrated Lean principles into the supply chains to great effect. Unlike the manufacturing and automobile sectors, the construction industry has been slow in employing the concept of SCM [27] and Lean principles due in part to the one-of-a-kind nature of the industry's products [12]. This is a problem in the Ghanaian construction industry too where the knowledge, awareness and the uptake of both SCM and Lean principles is low. The problem is worsened by the lack of documented evidence of the levels of awareness and the uptake of Lean Principles in the Ghanaian construction industry. This study aims to address this gap by exploring the potential for integration of Lean principles into the management of supply chains of Ghanaian contractors. The key objectives of this paper are to explore the level of awareness of Lean principles amongst Ghanaian contractors, to identify the extent of implementation of Lean principles and to outline some of the

benefits that will accrue from the implementation of Lean by contractors.

The objectives of the paper are addressed in the following research questions: "how much knowledge of Lean principles do Ghanaian contractors have?", "to what extent do Ghanaian contractors incorporate Lean techniques in their management of their supply chains?" and "what benefits will Ghanaian contractors achieve by incorporating Lean techniques into the management of their supply chains". Using the case study approach, experienced professionals from the Ghanaian construction industry are interviewed about their awareness of these principles and the extent to which these are used in the Ghanaian construction industry. This paper is divided into 5 sections. The introduction gives a background to the paper, the main aim of the study and the key research questions addressed in the paper. In the literature review section, the concept of Supply Chain Management is defined and the application to construction management discussed. The review also explores the concept of Lean thinking including its broad application and its application to construction supply chain management. Lastly literature on the Ghanaian construction industry further develops the background and context within which the paper has been developed. In the next section, a background to the methods selected is provided as well as a general description of the approaches used in developing this paper. Next, the key findings from review for this paper and

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the interviews conducted are presented and discussed. The approach to validating the results are also discussed. In the last section, the main conclusions of this paper are presented. This presents the implications of this paper to the management of construction firms, the limitations of the study for this paper as well suggestions for future research.

2. Literature Review

2.1. Overview of Supply Chain Management

The concept of Supply Chain Management (SCM) is the “coordination of independent enterprises in order to improve the performance of the whole supply chain.” [25]. This usually involves a group of companies working collaboratively to satisfy customer needs [12]. Contemporary supply chain practices consider the supply chain as an integrated value generating flow rather than only as a set of independent activities [38]. [9] identified trust, commitment, and willingness to share information among supply chain participants as pre-requisites for efficient supply chains.

2.1.1. Construction Supply Chain Management

The construction industry has been slower to employ the concept of supply chain management which has been embraced in other industries such as manufacturing [27]. This is due to the short-term supplier-contractor relations that are subject to vulnerability due to the temporary nature of construction projects and the one-of-a-kind nature of the product [1]. Due to the complexity of the sector and the number of suppliers in a single project, [3] proposes a strategy to improve the management of supply systems in construction using Lean principles and techniques. The application of Lean principles and solutions facilitates supply chain management and helps reach significant reduction of time, costs and stocks [40]. In construction, it can help improve the accuracy of site demand (increase workflow reliability) by enabling better planning and production control [4]. Waste and associated problems in construction supply chains as extensively present and persistent [31].

In construction, relationships with third parties have traditionally been managed through adversarial approaches causing detrimental effects on project performance [32]. [24] highlights some of the industry problems such as the sector’s reliance on competitive tendering and the adversarial attitudes that commonly exist between contractors and their suppliers. Current and popular thinking in construction however is that the best practices to manage relationships should always foster highly collaborative approaches based on high levels of trust and transparency other than typical opportunistic and adversarial approaches [10]. There is a need to move away from adversarial attitudes towards enlightened cooperative relations [16]. Based on the success of other industries, several reports have encouraged this

approach in order to overcome a situation of low profitability and poor performance [21]. If the construction industry is to move from an adversarial environment to one founded on collaboration, it should openly embrace the concepts of Lean supply chain management [28].

[33] advocates effective SCM through the early involvement of both contractors and subcontractors as a means to effectively reduce overall construction costs. [34] studied construction material flows and established that in the delivering of the physical flow of materials between elements of the supply chain, only 0.3% to 0.6% of the total time is value being added. Only for the interface between the main contractor and the supplier has an average cost reduction potential of 10% (of material costs) through improved logistical procedures been shown. The waste can be even higher when taking the whole supply chain into consideration.

2.2. Lean Thinking

The term “Lean” was coined to reflect the waste reduction nature of the Toyota production system and to contrast it with craft and mass forms of production [42]. Lean philosophy is a common sense approach that strives for the systematic elimination of waste in the production process [43]. A production system design is said to be “Lean” when it is done in pursuit of Transformation-Flow-Value (TFV) goals [7]. Since its introduction, Lean thinking has been applied to many aspects of the manufacturing industry including their supply chain. The Lean Production system is the most efficient production system in the world. Many world-class companies have improved their operations significantly through the application of Lean techniques to minimise waste in the supply chain and maximise value to clients [12]. The use of Lean principles in the supply chain which involved a redesigning of the way materials were purchased, transported and stored made Toyota one of the best auto manufacturing companies in the world [13].

The primary goal of Lean supply chain management is to accomplish supply management with the minimum possible waste in construction. Lean supply chain management emphasizes and focuses on improving relationships among project participants and improving the total flow of material [44]. [2] proposed a solution for the delivery of material without a build-up of unnecessary inventory on site based on the Last planner system. This is described as a tool that uses the overall project plan as the general framework, but suggests that the day to day activities should be managed by a more flexible approach with regard to the actual progress of the project [2]. Concepts such as pulling production, reducing variability and increasing flow reliability integrated in the Last planner system help reduce waste [37]. Using this system assignments are clearly defined, in the right sequence, with the right amount of resources and within the capacity of the crew supposed to do the work [20]. It can be used to improve the flow of work on construction sites by reducing constraints such as shortages in the supply of materials [12].

2.2.1. Applying Lean Techniques to Construction SCM

Lean construction is derived from Lean manufacturing which is based on the elimination of waste such as the time spent waiting for material supplies which are delayed or missed, unnecessary stocks and inventory, value tied up in excess stocks or waiting for assembly. These problems can be addressed using the Just-in-time philosophy which is an integral part of Lean Manufacturing. Lean production is the generic form of the Toyota Production System easily recognised as the most efficient system of production in the world [5].

Whilst the construction industry is inherently different from the auto industry where the Toyota Production System has achieved such remarkable success, lessons can be learnt from the automobile sector and applied to the construction industry. Significant improvements have been achieved in the automobile industry using Lean techniques over the space of ten to fifteen years. Supply Chain Management principles and the use of Lean techniques principles if successfully adapted to construction from other industries can lead to significant improvements in standards across the Construction Industry, deliver sustained Continuous Improvements [23], create value and minimise cost through the elimination of waste [19].

2.3. Overview of the Ghanaian Construction Industry

The problems relating to poor performance and widespread underperformance in the Ghanaian construction industry are well documented [29]. Many of the larger indigenous Ghanaian contractors are mostly owned by proprietors who have little or no formal knowledge of the construction, project or organisational management. Such owners do not see the need to employ personnel with the technical know-how to manage their firms towards sustainable growth. Management of firms' resources is undertaken haphazardly with little or no knowledge of current developments. This does not promote growth in the construction industry [39]. [22] argues that a significant proportion of time and effort is spent on waste activities. Many of proprietors who head even the larger Ghanaian owned construction firms have no formal training in construction management [39].

Over-production, defective products, waiting, multiple handling, inventory and over-processing are some of the common forms of waste in the production systems employed by Ghanaian firms. These non-value adding activities – or waste – must, therefore, be targeted for removal while value-adding activities are identified for change or improvement. Lean systems strive to achieve “continuous flow,” i.e., get raw materials to proceed through all production steps without undue inventory or other waste [22]. [30] identified “the implementation of Lean Principles as one of the main critical success factors (CSFs) which could lead to improvements in the Ghanaian construction industry. Despite significant improvements delivered through the use of Lean Principles and Techniques in many industries, these

techniques and principles appear to have rather limited application resulting from an apparent lack of awareness. There is a gap in the knowledge of the extent of use and application in the Ghanaian construction industry. This paper will address this gap by providing evidence of the extent of awareness and the usage of Lean Techniques in the Ghanaian construction industry.

3. Method

This paper is based on the case study research approach. The approach was necessary to gain a deeper appreciation of the problems and issues involved in the management of the Ghanaian construction supply chain. The strategy of inquiry involved using different methods of collecting and analysing empirical material. The case study approach was employed for this study as the strategy of inquiry. Case study is an ideal methodology when a qualitative, in-depth investigation is needed [14]. Case selection is one of the most important aspects of conducting case study research as the appropriate selection of the case(s) can determine the extent to which the phenomenon under study can be understood [35].

The number of cases included is however only one aspect as the depth and richness of the cases is also another critical component of case study research. Three cases were selected for the purpose of this study. The primary data consisted of in-depth interviews, direct observations, documentation and archival records. The in-depth interviews were conducted with project participants on three (3) different cases in Accra and Kumasi. The unit of analysis for the three cases comprised of large construction firms selected from the largest of four financial categories, D1K1 from the Ghanaian construction industry. The 3 firms are all national building and road construction firms whose activities require significant logistics and supply chain management. The decision to use the largest group of contractors was because given perceived novelty of the Lean System of Production in the Ghanaian construction industry, it was felt that these would most likely to have some experience if any of Lean principles. To make the analysis more comprehensive, a total of twenty (20) project professionals were interviewed. The respondents interviewed were three (3) project managers, one (1) works superintendent, four (4) Quantity Surveyors, four (4) Site Supervisors, three (3) Stores Managers, one (1) Logistics Manager, one (1) Site Engineer and three (3) General foremen.

The interviews were based on semi-structured questionnaires divided into two parts. The first part of the questionnaire focused on the background, experience and other details of respondents to enable the suitability of respondents to be assessed. There were also questions on the respondents' experience on the use of Lean techniques in the management. The second part presented questions on three thematic areas with questions focused on the application of Lean principles and techniques in these three areas. The three themes focused on the relationships between suppliers and

contractors, the level of communication with suppliers and material supply. Data collected was analysed using descriptive statistics. The outcomes from the interviews were validated using direct observations and content analysis of archival records.

4. Research Results

The review for this paper identified some of the potential benefits which can accrue to construction firms from the integration of Lean principles into the management of construction supply chains. These include improvements in overall standards, creating value for the end customer and minimising costs through waste reductions.

Respondents had different educational backgrounds and qualifications ranging from Construction Technician Course II (CTC II) to Masters' Degree holders. Majority of the respondents representing 50% held a Bachelor's Degree and 45% the respondents representing 45% had industrial experience from 11 years and above, 30% between 6-10 years, whilst 25% had less than 6 years of industrial experience. There were Findings from the second part of the questionnaire are grouped under three thematic areas explored. There were similar patterns from the answers given by respondents drawn from the three selected cases.

On their familiarity with the concept of Lean supply chain management, 90% were not familiar with the concept and associated tools such as Kanban, Kaizen, Last Planner and 5S. On the extent of implementation of Lean principles, none of the cases studied had either current or past programmes of implementing Lean principles in their supply chains or other aspects of management.

Questions on the theme "relationships between contractors and suppliers" focused on how respondent contractors managed the relationships with their suppliers. All the respondents indicated that there was some form of collaboration between them contractor and their suppliers. This form of collaboration was mainly based on the needs of the current project. Respondents recognized the need for cooperation with the suppliers in order to cut down cost, achieve quality delivery and time improvements. Furthermore, all the respondents indicated that the way suppliers are managed is significant in their overall performance and on the project performance. About 75% of respondents claimed price was not the main focus of the relationship stressing that other factors such as ability to deliver on time, availability of credit facilities, quality of product or service and ability to deliver the needed quantity at a given point were key considerations.

Seventeen (17) out of the twenty (20) respondents representing 85% stated that suppliers are only involved in the chain during the construction stage when their services are needed. It was also clear from the interviews held with the respondents that suppliers are usually not informed on the progress of work. The mode of communicating with suppliers is via phone calls, e-mails and occasionally meeting with suppliers. Ninety percent (90%) of the

respondents indicated that information is accurately transmitted with only ten percent (10%) saying otherwise. Sixty percent (60%) of the respondents indicated that the amount of information sharing with suppliers was limited to the needs of current projects. On communication with suppliers, all respondents said that their suppliers were not usually informed of the progress of work so they could prepare for future deliveries.

Internal operation refers to inventory management, systems for checking incoming supplies, systems for rating suppliers' performance, storage and handling of materials. When the respondents were asked about the procedure being used for the delivery of materials, two different alternatives were proposed: building up inventory or Just-in-Time delivery. From the results of the survey, both approaches seemed to be utilized on construction sites. However, seventy percent (70%) of the respondents' preferred the build-up of inventory. According to these respondents, saving in transportation cost, avoiding shortage of materials leading to work being brought to a halt, and increasing your bargaining power for discounts were some of the reasons for ordering material in large amounts.

On the systems in place for checking incoming supplies, visual inspection and testing were the main methods used to ensure that the right quality and quantity of materials were delivered according to all respondents across the cases studied, before they are received into stores. One interviewee said sometimes you might order for example 6 inches blocks only for 5 inches blocks to turn up on site. To avoid double handling, there was always a professional to check and re-check before offloading deliveries to site as evidenced in the direct site observations for all three cases. Checking involved inspection to confirm the material being delivered however these visual inspections cannot be passed off as adequate tests for quality of the delivered materials.

All respondents agreed that to avoid project delays due to late deliveries of materials, additional time was added to project completion dates. Whilst all respondents had regular experiences of supply chain delays. On the amount of inventory kept for projects, 80% of respondents distributed fairly amongst the three cases studied.

The results showed that suppliers' performance was measured basically on their ability to deliver on time, right place and to the right specifications. More so, credit facilities offered by the supplier were also considered in rating suppliers' performance. These factors have an effect on the continuous relationship between contractors and suppliers. In addition, respondents stated that time buffers were added to avoid disruptions in the supply of materials.

Respondents were asked to identify the main problems which affected their supply chain and for which could be potentially addressed using Lean techniques. From a list of 18 supply chain problems identified from literature, respondents were asked to tick whichever was applicable. From the results, all the respondents identified the following as problems: Information not accurately transmitted among contractors and suppliers, suppliers not usually informed of

the progress of work so they can be prepared for future deliveries, late deliveries, problems with quality and quantity of Unnecessary processing of materials, poor communication between the respective parties, bad relationships between contractors and suppliers, bad handling leading to materials waste, transportation problems, lack of trust between contractors and suppliers and unnecessary processing of materials.

90% of all respondents respectively identified the following as problems: bad sequence of orders, unnecessary transport of goods and time waste in the delivery and management of materials.

80% respectively of the respondents from across the 3 cases studied opined that too much materials are stored on site, that there was frequent shortages of material, that materials needed to be regularly moved around to make space for new incoming materials or to give access to other materials and that there were high inventory levels whilst 70% of respondents saw unnecessary movement of people as a problem.

On how Lean practices could be promoted in the management of supply chains by contractors, respondents were asked which of the following three steps were needed in their companies: training of employees at all levels on Lean supply chain management, engagement of managers with some awareness and experience of Lean and making changes to organisational and management practices to systems which promote Lean principles. All respondents agreed that these measures would help. In addition, all respondents agreed that professional bodies and major stakeholders in the Ghanaian construction industry should organise and fund training programmes for their members which would introduce them to Lean principles as well as sponsoring workshops and research conferences to promote transfer of knowledge on Lean supply chain management.

4.1. Discussion of Findings

Cross analysis of the outcomes of the interviews showed similar patterns in the responses from the respondents drawn from the three cases studied. This could be due to the similar backgrounds of the construction firms selected for the case studies who were all chosen from the DIK1 category of contractors in Ghana. Contractors from this category have no limit on the value of projects they can undertake and in the view of the authors these were most likely to have Lean systems in place. Given the similarities in the trends of responses for this exploratory work, descriptive statistics was used as the main method of analysis.

The purpose of the case studies was to investigate the different challenges related to material delivery and site management and suggest ways of improving these through a Lean supply chain management. Whilst the review of existing literature shows challenges with construction supply chains generally, it was seen that improving the management of the parties in the chain will improve overall performance. Given the practical benefits associated with the implementation of Lean Production Techniques, it has been

inferred in this paper that the integration of Lean techniques into the management of construction supply chains held significant potential benefits.

From the review of literature, it was realized that contractor- supplier relationships had moved from being transactional to collaborative. These parties increasingly see each other as partners in business. Such partnership relationships are perceived as win-win situations for all parties involved. This is in line with existing research such as [11] and [16] where generally buyer-supplier relationships have evolved from being transactional to collaborative then to alliance based. The main difference between a collaborative and alliance relationship is the existence of institutional trust. The trust in alliance relationships should be carefully designed, planned and mutually agreed upon. This can be challenging given the uniqueness of every project and the numerous parties involved in construction projects. This can be improved if all parties work to promote a win-win situation for all parties involved. There must also be a commitment to avoid creating a culture which compromises on quality and engenders mediocrity.

Evidence from existing literature indicates that for project success, deliveries should be properly sequenced to be consistent with the work plan. In addition, contractors should make sure the delivery rate from the supplier is compatible with the installation rate of the workers on site. By using *Transport Kanban* to signal the need for more material, Just-in-Time delivery can be achieved. One of the rationales behind ordering material in bulk is the savings in transportation cost. From literature it has been realised that in some situations the costs saved in transportation can be offset by the labour cost of double handling. To avoid the construction site being cluttered which hampers productivity and delays projects, continuous care should be taken to reduce inventory levels. Written procedures to handle these issues are important. Lean theory suggests the 5S methodology to keep the construction site clean and tidy. By using the 5S procedures, the construction site will be free of clutter. Again, it is important that the material is delivered directly to the area of work to avoid double handling, by doing so, a significant amount of labour cost and schedule time can be saved for the contractors.

The study showed that long-term relationships are not a major priority for most of the respondents. It is hoped that adapting such long term relationships through the formation of alliances with their suppliers as recommended by [12] will help engender institutional trust and lead to improved performance.

From the interviews conducted, there was a consensus on communication and information flow as well as coordination as an essential element for completing projects. With the main medium for communicating with suppliers is via phone calls and e-mails, there are opportunities to introduce contemporary methods of communication such as those presented by short message service (SMS) and other related technologies in the Ghanaian construction industry. The industry can also benefit from methods and technologies

which enable collaborative working which enables project teams to communicate in real time from different locations. However the level of satisfaction amongst contractors with the accuracy of communication with suppliers is commendable with some ninety percent of the respondents indicating that information is accurately transmitted with only 10% saying otherwise. Concerning this issue, an important point noticed in the findings was that a large percentage of respondents agreed that information was accurately transmitted between themselves and the supplier off site. However, at the same time they face challenges related to material deliveries such as quality, quantity and bad sequence of deliveries. This situation shows that there are communication problems. It was also clear from the interviews held with the respondents that suppliers are usually not informed on the progress of work.

The study showed a low awareness and uptake of the concept of Kaizen amongst the respondents. The concept of Kaizen which promotes standardization of procedures should be applied at this level to construction supply chains in Ghana. Information should be transmitted in the same format through similar channels to assure its accuracy, consistency and also improve its readability. Integrated information systems for all participants of the project will help achieve standardization. Through this common information system, new plans and information about material delivery can flow immediately to the parties involved and quicker and more efficient document transfer can be obtained. Variations occur quite often on the supplier side as stated by the respondents; contractors need to be prepared to deal with this situation. The Last planner system addresses this by dealing with variations without the build-up of unnecessary inventory.

4.2. Validation

To confirm the main outcomes of the literature review and the interviews, direct observations were undertaken of employees from the selected cases studies in addition to a review of their archival records. The direct observations were to ascertain if there was any evidence of the practice of Lean principles in the daily operations of the construction firms selected for the case studies.

The review of archival records involved prospective for evidence of policies, training and other documentation to see if there was any evidence relating to Lean principles which may not have been captured in the interview responses.

The outcomes of the direct observations and the review of company records did not provide any evidence to show the awareness or practice of Lean principles in the management of the supply chains within the cases studied as had been gathered from the interviews. This approach to confirm research outcomes is similar to the concept of triangulation described in [35].

5. Conclusions and Future Research

5.1. Conclusions

The study has shown a gap in knowledge, awareness and the extent of uptake of Lean principles amongst Ghanaian contractors. The study also shows the potential for integrating Lean approaches into the supply chains of Ghanaian contractors as a means to improving overall performance.

Literature abounds with examples of the benefits achieved through Lean techniques in industries such as the auto industry. These techniques have been integrated in the supply chains of industries where they are used. Despite the documented benefits arising from the integration of these principles into supply chains, the knowledge and uptake of Lean techniques in the Ghanaian construction industry is low. The study identified challenges related to material delivery and site management on the selected cases studied.

5.2. Managerial Implications

Whilst there is some form of collaboration between the main contractors and suppliers' in many cases the relationships and communication were mainly need-based and dependent on the exigencies of particular projects. Because of the poor relationships between the parties, contractors are forced to keep large inventories. The contractors also usually experience supply and delivery problems such as late deliveries, problems with quantity and quality of supplies, and bad sequence of orders.

The low level of awareness and low uptake of Lean principles amongst Ghanaian contractors as evidenced in this study shows significant opportunities to improve overall construction performance through the integration of Lean approaches into the supply chains of Ghanaian contractors as a means to minimizing waste, enhancing communication and eliminating non value-adding activities. However to achieve this, Ghanaian contractors need to invest in training and other development programmes which will educate about Lean concepts and their potential to improve construction supply chains and overall construction performance. The industry has to invest in research on Lean techniques and the challenges which affect their deployment in construction supply chains. The industry should promote the dissemination of the benefits of implementing Lean techniques in the management of construction supply chains.

5.3. Limitations of the Study

The study covered only three construction firms used in the case study. Also only twenty professionals were interviewed. These should be taken into account in making generalisations from the outcomes of this research.

5.4. Future Research

As a means to improving the knowledge and awareness of

the concept of Lean in the context of the Supply Chain, it is proposed that structured training be provided for employees at all levels in the Ghanaian construction industry. This can be done through workshops, seminars and conferences funded by key industry stakeholders. It is also proposed that construction firms in Ghana employ people with skills, competencies and experience of the implementation of Lean techniques on projects to improve their capacities to successfully incorporate Lean Thinking into their projects.

Following this exploratory study, three workshops will be conducted for selected contractors and construction professionals. The first workshop will focus on helping participants understand what Lean Construction is and the main techniques used. The second workshop will help participants to develop an implementation plan for introducing Lean techniques into their supply chains. The last session will be a monitoring session to identify any inherent problems with the introduction of Lean techniques into their supply chains and to assist them undertake correction action.

Most of the documented examples of the benefits of the application of Lean techniques in the supply chain are of companies outside the construction industry. Further research will also be conducted to identify construction industry examples of the benefits accruing from the use of Lean techniques in construction supply chains.

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