STRATEGIC ISSUES IN LEAN CONSTRUCTION

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ABSTRACT

This paper reviews the basic components of lean construction, with references to the development of lean production systems by manufacturing organizations and the advances of lean construction research. The paper also presents the key concepts on strategic management and industry structure analysis. It discusses the implications on the implementation of lean construction with regard to a firm's strategic planning as well as to the conditions for the industry to lesser the barriers for lean construction implementation. Finally, the paper describes the objectives and anticipated contributions of current research conducted at the Worcester Polytechnic Institute involving strategic issues in lean construction.

KEY WORDS

Lean construction, strategic management, competitive strategy

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INTRODUCTION

A typical Architecture/Engineering/Construction (AEC) firm often operates in a quite competitive environment and, therefore, there is continuous interest in the industry to develop new methods to improve organizational effectiveness. In the past few years, AEC researchers have studied key successful improving methodologies developed within the manufacturing sector and one of the most promising approaches is perhaps the adoption of lean production principles to construction projects. Through this learning process, several groups of researchers understood not only how the lean production system redefined the way a manufacturing organization manages its production operations, but also how lean production enabled firms to produce quality products at lower costs. Based on those premises, AEC research has focused on applying the key aspects of lean production that are suitable for the AEC industry's environment.

The research agenda has indicated that, mainly because of some peculiarities of construction (Koskela 1992), adapting principles and methodologies initiated in industries other than the AEC industry is a particularly challenging endeavor. Nevertheless, in the case of adapting lean principles to construction, it is imperative to first consider and to understand the underlying motivation for lean thinking development. Early literature on the subject – especially the introduction of the Toyota Production System (Ohno 1988) - indicated two important issues. First, the main goal of the lean production philosophy was to increase the competitiveness of the firm by making the production process more cost effective through the elimination of non-value added activities (initial plans included a better definition of the value chain, as well as an improved flow of resources). Second, the effort to create this innovative production system was part of a long-term plan, a competitive strategy that would allow under-capacitated post-WWII Japanese manufacturers to gain market share internationally.

The objective of this paper is to review the contributions of current research on both lean construction and strategic planning, and to explore strategic implementation issues. The paper presents the basic assumptions of a current research being conducted by the authors at the Worcester Polytechnic Institute that aims to better understand the proposed areas of concern and to study lean construction implementation from a strategic management perspective.

ASSUMPTIONS

It is largely accepted that the new production philosophy provided manufacturing and services organizations with competitive advantage, mainly because of improved efficiency, cost reduction, and value generation. On the other hand, the implementation process does require a major commitment from the corporation, in both capital and human resources, and success is not certain. In this context, it would be interesting to determine whether a similar tradeoff exists for an AEC firm implementing lean construction. The first area of concern relates to the reasons why major manufacturing companies have abandoned the traditional methods of production and implemented the lean philosophy and whether those reasons are similar for an AEC firm – with limited gains from economies of scale - to adopt lean

construction (LC). The question that addresses this area comprises the motivation for an AEC firm to commit to lean construction.

Another area of concern relates to how does the lean philosophy apply to the AEC competitive environment. An additional question aims to determine which competitive strategy an AEC firm should pursue in implementing lean construction. Should the firm position itself as being different from competitors by applying lean construction or, contrarily, should the firm stress its projects' cost reduction due to lean principles implementation?

Strategic management theory identifies different frameworks to analyze competitive strategies. In 1980, Michael Porter proposed one of the most widely used classifications for competitive strategies (Porter 1998) that includes three main aspects: (1) *Cost leadership*, which emphasizes production cost reduction, (2) *Differentiation*, where firms strive to offer a perceived unique product/service, and (3) *Focus*, which targets a selected segment in the market. According to Porter's classification, the firm's effort/ability to lower production costs – e.g., lean production - is part of a "cost leadership" competitive strategy. Do AEC firms necessarily need to embrace cost leadership strategies? What is the gain? To answer these questions one must consider that the AEC industry operates under a fluctuating demand and within an environment where opportunities for mass production are few. Consequently, the implementation of lean construction at a corporate level requires a thorough understanding of the competitive forces that led the manufacturing organizations to change from mass production to the lean enterprise.

BRIEF OVERVIEW OF LEAN CONSTRUCTION

One of the most significant business phenomenons of the 1980s was the development of the lean production system. Pioneered by Toyota – through the work of Eng. Taiichi Ohno – and presented to American managers by the book "The Machine that Changed the World" (Womack et al. 1991), lean production defines a new production philosophy for any manufacturing organization. Lean production involves the continuous effort to eliminate "waste," i.e. any activity that does not add value, doing more with less and still delivering value to customers.

Following the dissemination of lean production principles in Europe and in the United States, AEC researchers were interested in whether or not those principles and results would apply to construction. Koskela (1992) presented one of the initial investigations involving lean construction in the format of a technical report. He conducted a vast literature review and field research to assess whether or not lean concepts have implications for the AEC industry.

Koskela concluded that lean principles should be adapted to construction and he stressed, as a main reason for the transformation, the improved competitiveness lean manufacturers encountered by eliminating waste. He pointed out that the traditional controlling methods in construction (Critical Path Models, for example) do not address "waste-source" activities in construction (such as waiting, storing, moving, inspecting) and proposed that actual construction should be broadly perceived as flow processes instead of conversion processes only.

Following Koskela's technical report, several academic papers and reports exposed the growing interest in the subject. Associations such as the Lean Construction Institute and the International Group for Lean Construction developed research agendas in the mid-1990s. As a result, international literature and research are presently addressing the most important aspects of this field.

A major concern in adapting the lean production philosophy to the AEC industry is the set of singular characteristics found in construction, which are different, in nature and extent, to the manufacturing or services sectors. Often called peculiarities of construction, those characteristics represent barriers to implementing innovative manufacturing methods or systems in the AEC industry. Koskela identified four key peculiarities of construction that affect the implementation of lean principles:

1. **One-of-a-Kind Product**: owner and/or designer preferences are the most common reasons for this construction characteristic, followed by specific site attributes. The major problems with one-of-a-kind products are the lack of repetitive cycles for feedback within a specific project and restricted means for comparison with finished products.
2. **Site Production**: the construction product is "assembled" in the same site it will be delivered. The problems with the site production relate to uncertainty with weather, local labor and materials, problems with coordination of crews around the production site, and that the "product" is always evolving, which restricts the ability to improve planning.
3. **Temporary Multi-organization**: construction is an organization created specifically for a particular project and several problems surface, such as poor communication among participating organizations, lack of stimulus for long-term improvement, liability issues, and inability to accumulate knowledge.
4. **Regulatory Authorities:** construction projects are subject to approval from authorities, which brings uncertainties in schedule and design solutions.

In addition to those items above however, and from a broader perspective, there are several other characteristics of the AEC industry related to its structure. For example, the AEC is a mature industry –with slower growth rate - presenting the following main characteristics:

1. **Fragmented industry**: in economic terms, fragmentation implies an industry where there is not a single firm with significant market share and/or in conditions to influence the industry's outcome (Porter 1989).
2. **Lower barriers to entry**: in general, entering in the industry requires neither substantial capital requirements - equipment may be rented in an as-needed basis- nor advanced technical expertise.
3. **Lack of economies of scale**: which means no reduced per-unit cost by increasing volume and consequently limited gains from economies of scale.

In general terms, lean construction studies focus on production control rather than on project control. It is known that the traditional project management approach to construction places

control over schedules, budgets, and contract management. The consequence is the tendency to "push" the schedule to project completion and thus insufficient attention is devoted to the physical circumstances of the site work and to the coordination of tasks, which are crucial sources of "waste."

Current lean construction research focuses on adapting the basic principles of the lean thinking and on studying implementation issues, vis-à-vis the AEC industry's complex characteristics and uncertainties. Much of the LC research addresses the issues of both the variables and the uncertainties that negatively affect the continuous production in construction. For example, pioneer studies show the validity of shielding production to reduce workflow uncertainty (Ballard et al. 1998) and the concept of "commitment planning" introduces the ideas of both *quality assignments* (e.g., weekly work plans) and *percent plan complete (PPC)*. In addition, Tommelein (1998) demonstrated the advantages of using a "pull-driven" approach to production systems in construction through computer simulation analysis of a pipe-spool installation. Furthermore, researchers are presenting papers and studies in international lean construction conferences, covering subjects such as concurrent design of product and process, supply-chain management, teamwork, and construction safety, among others (IGLC Proceedings – 1994/2001). Similarly to the automobile manufacturing of the 1980s, the AEC industry seeks improvement and lean construction plays a major role in this effort.

STRATEGIC MANAGEMENT

According to Michael Porter's definition, "competitive strategy is about being different" (Porter 1996). This simple statement could be a helpful starting point to an ample field of study known as strategic management. Although the concept of strategy extends back to ancient army, the theory of strategic management did not emerge until the late 1970s, associated with the oil crisis and the changing competitive circumstances (Grant 1995). Since then, rival organizations apply strategic management to constantly search for a favorable competitive position in their industries.

Strategy analysis outlines how an organization relates to its environment. There are valuable frameworks to analyze a firm's internal factors (strengths and weaknesses) and external factors (opportunities and threats). Those situation analysis tools, along with the organization's own mission statement, allow the firm to formulate a competitive strategy, and therefore to make long-term commitment and investment decisions (Warszawski 1996).

As mentioned above, Michael Porter (1998) in his book Competitive Strategy proposed a classification for business strategies encompassing three generic groups: cost leadership, differentiation, and focus. The author stresses that a firm should emphasize one of these three generic strategies; simultaneous use of generic groups is incompatible for the long run.

Cost leadership is the organization's ability to offer similar products/services at a price lower than the competition; other firms with equivalent offers would not compete without losing money in the long term. Cost leadership emphasizes the management of cost drivers, such as economies of scale, learning curves, capacity utilization, and improved processes technology, among others. It is imperative, however, that the firm keeps the optimum level of customer satisfaction by means of quality, service, etc.

Differentiation strategy applies the organization's efforts to continuously offer products/services that present unique characteristics. Customers are willing to pay a premium (or slightly higher) price in exchange for a specific, more valuable feature. In this case, the company does not ignore costs but the effort is toward offering uniqueness, from the customer's perspective. Examples of differentiation are design, image, technology, customer services, post-sale assistance, and so on.

Focus (niche) strategy employs the firm's ability to serve a specific customer group, or/and a specific geographical market. The strategy is to offer products/services to a particular segment more efficiently than competitors that operate in a broader market do. A company that operates according to the focus strategy may emphasize either cost or differentiation. In general, focus strategy suits smaller firms, which operate locally to serve specific customers (Warszawski 1996).

There are risks involved with the use of any particular competitive strategy; nevertheless, the appropriate match of firm's mission and resources with its environment will define the basis for a sustained competitive advantage.

STRATEGIC ISSUES

The terms competition and value are key to the lean production system (Womack et al. 1991). In applying lean principles, Japanese car manufacturers were able to compete against European and American corporations that, since the early 1900s, had been employing mass production techniques in their production lines. The revolutionary production philosophy represented a powerful advantage in reducing production costs, primarily by eliminating most of the waste in the system (Koskela 1992) and delivering value.

Although the basic concepts of lean thinking were developed aiming the corporations as a whole, i.e. as an organization's competitive strategy, few researchers in lean construction address the core motives for manufacturing organizations to go from mass to lean production (Featherston 2000). A preliminary review of the lean construction literature shows that the research advances toward improving construction processes at the project level but this paper is concerned with the level of understanding on organizational issues in the implementation of lean construction (Barros Neto 2002). To develop a broader view, lean construction researchers ought to explore other important aspects of the AEC industry. More specifically, literature should include the AEC competitive environment, competitive strategies, industry's structure, and the effects of the power of suppliers and buyers, among others.

In addition, the authors are interested in current customers' profile. For example, questions such as what owners perceive as "value" in the actual construction market, whether they are willing to pay a premium price in exchange for innovative design, and would owners decide on a contract based on the new – lean – production system.

CURRENT RESEARCH

The authors at the Department of Civil and Environmental Engineering of the Worcester Polytechnic Institute (WPI) are conducting a research study that seeks a better understanding on what constitutes value from the owner's point of view and how do the principles of LC could be applied as a competitive strategy within a project driven industry. More

specifically, the objectives of the research encompass short- and long-term perspectives. Short-term goals include a review of literature on lean construction and strategic management - with focus on implementation issues - and the collection of empirical evidence regarding:

- Customer's awareness of lean construction
- Results of using lean principles
- Customer's perception on "value" in construction
- Lean construction as a criterion in contractor selection
- Low initial cost versus life-cycle project costs
- Owner's involvement in all phases of the project

It is expected that the results of the empirical test will support future analysis and recommendations on the implementation of lean construction, and the establishment of the relationships between lean construction and firm's competitive strategy.

As for long-term goals, the research will concentrate on specific issues that are inherent to innovation. Among other important outputs, the research will seek additional veins to better understand the changes and impact within the construction industry due not only to the development of lean construction, but also to the technology the industry is embracing. More specifically, the research will address topics such as what type of AEC organization will lead the LC era and what are, if any, the pre-requisites for a LC/AEC firm to be competitively successful.

CONCLUSION

The philosophy of lean construction extends across several boundaries that traditionally molded the AEC industry's structure and therefore lean construction implementation requires considerable changes in the way people work (new roles and responsibilities). In addition, lean construction implementation requires top-to-bottom change in both culture and attitude, with emphasis on multi-organizational effort to sharing a common purpose. Nevertheless, an interesting question would be: Is it possible to break AEC's traditional boundaries and reshape the structure of the industry? The authors would like to assess that question taking into consideration both the developments in technology and innovative methods of production (lean construction).

The use of technology in the AEC industry –especially computer related technologies – is increasingly being noticed. Recent large, real-world experiences, such as Chicago's Soldier Field (Post 2003) for example, have shown the applicability of 3D Parametric Building Modeling (3DPBM) and the successful delivery of a "paperless" project. Moreover, recent introduction of relatively affordable 3DPBM software -such as Autodesk's Revit– and the consolidation of several Internet portals for both project management and procurement, provides the AEC professionals and/or organizations with efficiency and integration. In addition, several other technologies, such as user-friendly AEC software applications (i.e.

Timberline, Primavera, etc.), Computer Numerically Controlled (CNC) fabrication, and bar-code control, are expending their usage.

As for innovative method of production, the increasing interest by industry's members on lean principles (construction as flow) applied to construction constitutes a major shift towards the adaptation/implementation of lean production method to construction and therefore a "breakthrough" change for the traditionalist, conservative AEC industry.

In conclusion, the authors believe that the AEC industry's reaction to such technologies and methodologies will translate into a structural change that consequently will affect the industry's forces of competition. Future venues for research include the definition of a new form of construction organization that will assure a top-to-bottom lean thinking philosophy, place the costumer as the most important player, and integrate the several participants of a construction project with the ideals of teamwork, continuous improvement, and waste reduction (Garnett et al. 1998), among others.

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