Lidelöw, H. and Simu K. 2015. Lean Construction as an Operations Strategy. In: *Proc. 23rd Ann. Conf. of the Int'l. Group for Lean Construction*, Perth, Australia, 28-31 July, pp. 486-495, available at www.iglc.net

LEAN CONSTRUCTION AS AN OPERATIONS STRATEGY

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ABSTRACT

All companies have an operations strategy; a pattern of decisions made in operations with the purpose to support the business strategy. Lean Construction can be seen as an operations strategy. The aim of this research is to present the generic decision categories in an operations strategy and discuss their characteristics in contrast to the Lean Construction framework. A literature study identified ten decision categories: process technology, capacity, facilities, vertical integration, human resources, organization, quality, production control, product development, and performance measurement.

Data was collected through in-depth interviews with managers on the tactical level at three construction companies with a Lean implementation. The results indicate that Lean construction companies emphasize quality, production planning, and vertical integration in their operations strategy. Facilities, process technology, capacity, and organization receive less attention. Quality, production planning, and vertical integration are keywords also in Lean Construction, while it is intriguing that organization receives little attention. Facilities, process technology, and capacity are ever changing between construction projects and are candidates for decision categories that could be less relevant for formulating an operations strategy in construction.

KEYWORDS

Operations, process, production, production system design, strategy.

INTRODUCTION

Construction projects are executed by temporary organizations assembled to deliver a specific artifact to the client, while the contractor firm is a permanent organization designed to organize projects (Winch, 2014). The contractor firm and the projects have an overlapping interest in the firm resources. Like every firm, a contractor must have a business strategy and an operations strategy, Figure 1. The business strategy frames *what* products and on what market (*where*) this will be offered. An operations strategy is a long-range plan for the operations function (Anderson, Cleveland and

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Schroeder 1989). The operations strategy, (Skinner, 1969), frames *how* operations should be conducted to support the business strategy (Boyer and McDermott, 1999). It is the guiding idea on the tactical firm level, and is often emergent; traceable as a pattern of decisions (Slack and Lewis, 2011).

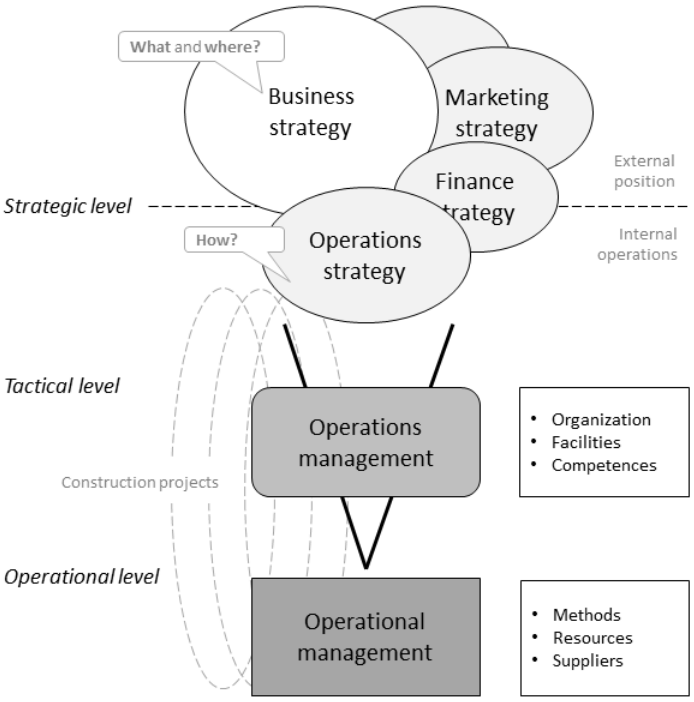

Figure 1: Links between business and operations strategies in a single-business firm.

Lean Construction, (Koskela, 1992), can be perceived as an operations strategy (Slack and Lewis, 2011). Hayes (1985) stated that operations capabilities can even determine the business strategy, especially in environments that are difficult to forecast. Porter (1996) contends that operational effectiveness is necessary but does not suffice as a business strategy. Successful operations interact with the business strategy and the business model of the firm (Brege, Stehn and Nord 2014; Pekuri, Pekuri and Haapasalo 2014). The situation in construction is often highly changeable and difficult to forecast, thus analysis of contractor firms' operations strategies should provide interesting indications about how they balance engagement in temporary projects with permanent survival.

The aim of this research is to identify published characteristics of typical operations strategies (in terms of decision categories) and compare them to emergent decision categories in Lean Construction. A literature study displays the elements of operations strategy and Lean Construction. Furthermore, the operations strategy at three Lean construction contractor firms was explored by investigating the types of decisions prioritized by tactical level managers.

FRAME OF REFERENCE

OPERATIONS STRATEGY

The idea that manufacturing affects business strategies was first put forward by (Skinner, 1969). In strategy literature a similar concept is labeled the resource-based

view, advocated by Barney (1991). While the resource-based view addresses capabilities on a firm's strategic level, an operations strategy formulates how resources are to be used on the tactical level. When forming an operations strategy, aspects of firms' resources and their environment related to several decision categories should be considered. Rudberg and Olhager (2003) compiled a list of decision categories mentioned by various authors, as summarized in Table 1.

Table 1: Decision categories condensed by Rudberg and Olhager (2003)

Structural categories	**Infrastructural categories**
Process technology – *the choice of production method*	Human resources – *availability and competence of human workforce*
Capacity – *amount of work that can be completed in an operation*	Organization - *the relations among staff, functions, responsibilities and processes within a firm.*
Facilities – *in construction most often the building site*	Quality - *the degree to which customer requirements are fulfilled. In construction, there is a sequence of customers in the supply chain.*
Vertical integration – *long term relations with subcontractors*	Production planning and control - *the methods applied to manage production*.
	Product development - *the development of new solutions that renew client offers.*
	Performance measurement - *methods to evaluate if an organization is performing as intended (coupled to the business strategy).*

Decisions in each category are made when starting a new business unit or changing the direction of an existing unit. For an operations strategy to yield good performance there must be consensus among the individuals in a firm, (Boyer and McDermott, 1999). Consistency between the operations strategy and business strategy is essential, (Wheelwright and Hayes, 1985). As new decisions are made to enhance the operations strategy, its relation to the business strategy can be strengthened.

The decisions made in daily operations are handled through operations and operational management, Slack and Lewis (2011), focusing planning, execution and quality control of work tasks, Figure 1. Hjelmbrekke and Klakegg (2013) claim that many contractors use the productivity gained through efficient operational management as part of their business strategy, while they should focus customer value (c.f. (Koskela, 1992)). Aligning each construction project's strategy with the overall business strategy is an action to ensure project success both for the client and the contractor (Cooke-Davies, 2002). The operations strategy must serve multiple concurrent projects, while operations and operational management can focus a single construction project. The operations strategy is an important mediator to unite operational (project) and strategic levels, supporting (Haugbolle and Forman, 2011).

LEAN CONSTRUCTION

The ideas of lean production were brought to construction by (Koskela, 1992) through noting the peculiarities of construction: one-of-a-kind site production realized by temporary multi-organizations. The basic concept to grasp for leaders in a Lean

construction firm is that production consists of flow and conversions of material and information, gradually adding value delivered by the supply chain, (Koskela, 1997). The guiding principles in Lean construction describe how to improve production performance e.g. reduce variability, increase process transparency or simplify (ibid). The principles are realized through methods as JIT, concurrent engineering, or Last Planner (Ballard and Howell, 1998). Howell and Ballard (1997) pointed out that there is great uncertainty at the beginning of construction projects, which distinguishes construction from manufacturing. They even claimed that 'construction is essentially a design process', which is explained by the engineer-to-order supply chain structure of construction, (Johnsson, 2013). The design process is: 1) A production process (of information) with a flow, which can be improved using Lean Design Management (Koskela, Ballard and Tanhuanpää, 1997) and 2) A product development process improvable and decomposable through the application of e.g. the Design Structure Matrix and derivatives (Furtmeier and Tommelein, 2010).

Howell and Koskela (2000) summarised the development during the first 8 years: 'lean construction is a development where lean production has been taken to the project environment'. Several methods have been developed, useful to successfully manage construction projects, where the foremost is the Last Planner system (Ballard, 1994); a method that is robust in the turbulent flow of construction (Bertelsen and Koskela, 2004). Stability in the supply chain flow was sought by e.g. proposing logistics centres (Arbulu and Ballard, 2004) as an answer to the call 'construction must develop supply chain management in its context' (Vrijhoef and Koskela, 1999).

Site production calls for workplace planning (Pennanen, Whelton and Ballard, 2004). Breaking down the workplace in several zones and allocating resources to them, supports the search for 'takt' in the construction project (Frandson, Berghede and Tommelein, 2014). Human resources in construction are very important as they constitute much of the production capacity due to little automation in construction. Humans are carriers of knowledge in an organization and also between projects. A hindrance for knowledge transfer and joint learning through experience feedback is the construction trades (Bertelsen, 2001). Allocating resources between projects is a typical work task for a construction manager on the tactical level (O'Brien, 2000).

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Etges et al., (2012) categorized the practices in the IGLC community, Table 2. A comparison was made with Table 1 to check for topics that overlap and the result is shown in Table 2 (with reservation for different interpretations). Table 1 mentions a few categories that are not part of Table 2: process technology, capacity, and organization. Furthermore, Table 2 reports some categories that are not part of Table 1 as continuous improvement and flow. These categories concern running of the business, not redirection.

Slack and Lewis (2011) explained Lean production principles in relation to some of the decision categories:

- Capacity means sacrificing high resource utilisation for fast and dependable output
- Supply network means synchronising flow with suppliers and expecting them to improve continuously

- Process technology should be small, flexible technology that reduces process variability
- Development and organisation should rely on continuous improvement through waste reduction where a smooth flow exposes the waste

What Slack and Lewis (2011) did with this exercise was to identify not what the operations should do, but how operations shall be conducted i.e. they concluded that Lean is an operations strategy.

Table 2: Identification of decision categories in Lean Construction

Topics at IGLC	[%]	In Table 1	Comment
Production planning and control	18%	√	
Design and product development	16%	√	
Supply Chain Management	10%	√	Vertical integration
Human Resources	9%	√	
Information technology	9%		
Continuous improvement	8%		
Workplace layout	6%	√	Facilities
Standardised work	4%		
Visualization and performance	4%	√	Perf. measurement
Safety and sustainability	3%		
Pull	3%		
Continuous flow	3%		
Cost	3%		
Quality	2%	√	

Researchers have identified the need for consistent leadership for Lean Construction to be successfully implemented e.g. (Keiser, 2012). For construction it is important to distinguish between the leadership tasks in projects, which can benefit fully from methods and approaches developed for projects (e.g. Last Planner) and the leadership tasks on the tactical level, which encompasses how to manage several projects while aligning with the business strategy and how to manage cultural change during Lean implementation. On this level, Lean Construction provides less support as it is mainly a strategy for operating projects (Howell, Ballard and Tommelein, 2011).

METHODOLOGY

As the operations strategy is frequently implicit, in-depth interviews focused on decision categories and their prioritization were conducted. The research does not attempt to formulate an operations strategy for the construction industry; rather the intention is to elucidate possible constituents and priorities of operations strategies. The limited number of interviews renders indicative conclusions.

DATA COLLECTION

Empirical data was collected through interviews with a tactical level manager at each of three different Lean construction contractors in Sweden, Table 3. The selection of respondents was based on their position in the contractor firm and their long-term experience of enacting their respective firms' operations strategy. Respondents were selected from different contractors to increase the external validity of the results.

Table 3: Respondents.

Respondent	Position at firm
D	Lean manager, reporting directly to top management, liable for process improvements of 10 M€
E	CEO, liable for a turnover of 3.5 M€
F	Platform manager, part of top management, joint liable for a turnover of 1300 M€

The interviews were semi-structured and about one hour long. All interviews were recorded, fully transcribed and the texts were used as the basis for the analysis. The respondents received transcripts of the interviews for approval. Both authors are active professionals in both academia and the construction industry. This was advantageous for understanding the language and expressions used for naming and attributing objects when interpreting the interviews. A disadvantage with being socialized in construction is the risk of regarding an issue as being settled before it is actually fully understood. Another risk lies in interpreting statements as they appear in our own, rather than the respondents', frames of reference.

ANALYSIS METHOD

All the transcripts were read by both authors, and meanings of decision categories (Lidelöw and Simu, 2015) were defined in terms of the construction context. The statements in the interviews were coded according to 10 defined decision categories, Table 1. The authors conducted this analysis separately to increase the internal validity of the findings. The results of the coding are presented in Figure 2, where the size of the squares indicates the proportion of time spent by each respondent talking about a certain decision category (taking due care that the respondents were actually discussing the decision category, not trying to understand or question it).

INTERVIEW RESULTS AND ANALYSIS

Illustrative comments from the interviews are presented in Appendix A1. Although the Appendix contains many comments in almost all decision categories, it does not provide a fair overview of the actual emphasis put by the interviewees on them. In Figure 2, the emphasis is visually displayed.

From Figure 2 it is evident that *Quality* is a major concern in operations for the respondents at the Lean construction firms. Standardization and strive to repeat processes were reoccurring topics. 'We try to focus on the 90% that we can standardize, not the 10% that we cannot', Lean manager, company D. Standardised work and quality sum up to 6% of the topics in IGLC papers (Table 2), which does

not reflect the emphasis in the interviews. This can be due to differing interpretations of the definition of quality.

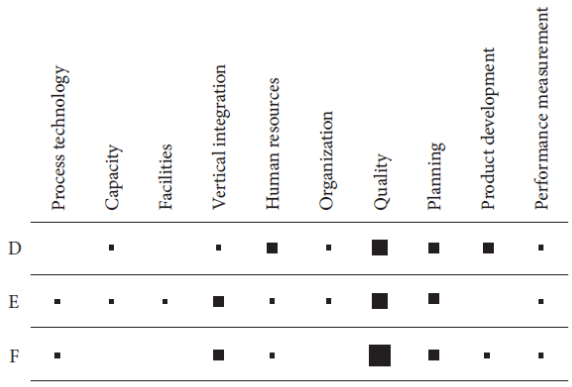

Figure 2: Graphical representation of interview results. Larger squares indicate larger emphasis by respondents.

Planning is another category that attracts great interest from the respondents. Arranging meeting arenas (daily meetings, rooms) and making schedules with varying level of detail are two activities that are used. In Table 2, planning is the largest category (18%) where developments around the Last Planner system dominate. Firms D and F both have variants of the Last Planner system in place. 'We use time sheets, running 5 week schedule, weekly schedules and daily control', Platform manager, company F.

Vertical integration concerns the supplier network and the relation to subcontractors. Supply chain management is addressed in 10% of all IGLC papers (Table 2) and is identified by Slack and Lewis (2011) as one of their four decision categories for an operations strategy. 'When we started with Lean, we brought in our subcontractors from the onset', CEO, company E.

Managing *Human Resources* entails the pedagogic challenge to show people how they should act and respond to actions around them. The respondents identify leadership as an important factor along with the actions leaders take. Human resources are brought up in 9% of IGLC papers, even though leadership is not explicitly mentioned in Table 2.

Product development is a decision category that attracts much attention in the IGLC community (16%). It is not mentioned by the respondents very often, but is seen as a way to enhance the client offer. Product development is linked to continuous improvement through sharing the PDCA-cycle. *Performance measurement* is mentioned by all respondents, mostly in terms of takt time. Table 2 labels categories differently: performance measurement could be part of visualization and performance, but also continuous flow and production control.

Process Technology, *Capacity* and *Organization* attract the same (quite low) level of interest from the respondents. Neither of these decision categories is mentioned in Table 2 as strongly represented in the IGLC community. However, they are all put forward by Slack and Lewis (2011) as three of the four decision categories to consider (the last one being *Supply Network*). One should note that Slack and Lewis (2011) developed their framework for the manufacturing industry in general.

Facilities attract the least attention of all the decision categories from the respondents. Workplace layout is addressed in 6% of the IGLC papers. Rudberg and Olhager (2003) put forward facilities and the physical planning of them as decisive for the formation of an operations strategy in manufacturing.

CONCLUSIONS

As an operations strategy is the pattern of decisions made on the tactical level, using decision categories can help identify the decision topics. The decision categories presented by Rudberg and Olhager (2003) all emerged from the three interviews with construction managers. *Quality*, *Planning*, *Vertical Integration*, and *Human Resources* are prioritized by Lean Construction firms. *Capacity*, *Organization*, and *Process Technology* attracted much less interest from the respondents. The topics hitherto covered in the IGLC community overlap with 7 of the decision categories suggested by Rudberg and Olhager (2003): *Process Technology*, *Capacity*, and *Organization* are missing in Table 2. *Process Technology* and *Capacity* could be logically explained since construction is realised through subcontracting to a large extent. *Organization* is more surprising not to find – perhaps this is a reflection of the topics in the IGLC community revolving around improving the project (Figure 1 lower part) and has yet to address the firms that manages the projects (Figure 1 upper part). This research will continue with a search for decision categories relevant to construction.

ACKNOWLEDGMENTS

The authors would like to gratefully acknowledge the Swedish Construction Federation for financial support and the respondents for their time and effort.

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