CIB TASK GROUP
TG74 - NEW PRODUCTION AND BUSINESS MODELS IN CONSTRUCTION

PAPERS AND POSTGRADUATE PAPERS FROM THE SPECIAL TRACK
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CIB Publication 362
TG74 - NEW PRODUCTION AND BUSINESS MODELS IN CONSTRUCTION

PAPERS AND POSTGRADUATE PAPERS FROM THE SPECIAL TRACK

If offsite production and manufacture is to make a positive contribution to society, research is needed to identify the issues associated with related cultural, societal, economic and business models. Against this background the Task Group will focus on the necessity for a strong, coherent international research strategy to address theories as related to production and business models within the built environment disciplines and will develop a comprehensive built environment innovative offsite research roadmap.
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A Comparative Analysis of User Satisfaction with Enterprise Resource Planning

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Abstract

An Enterprise Resource Planning system (ERP) is a packaged business software system that integrates a series of modular software applications to serve all functions of an “Enterprise”, including work flow and document management, scheduling, cost control, human resource management, procurement, quality control and reporting. It is used by many industries to support company business processes. This study identified and analyzed the factors that are associated with the implementation of enterprise resource planning (ERP) in the construction industry. It also attempted to conduct a comparative analysis of user satisfaction with ERP between construction and non-construction industries. A questionnaire was developed to collect the data through case studies from both construction and non-construction industries. Companies that used ERP systems in the United States were identified. Forty companies were randomly selected for case studies—20 from the construction industry and 20 from the non-construction industries. The results of the study indicate a statistically significant difference between the groups in terms of user satisfaction with ERP as a product, vendor service for the systems, and knowledge of the users and their involvement with the systems.

Key words: construction industry, enterprise resource planning, user satisfaction
1. Statement of the problem

1.1 Enterprise Resource Planning System

An Enterprise Resource Planning system (ERP) is a packaged business software system that integrates a series of modular software applications to serve all functions of an “Enterprise”, including work flow and document management, scheduling, cost control, human resource management, procurement, quality control, and reporting.

Initially developed as a manufacturing resource, an ERP system includes a set of software modules linked to a common database can handle basic corporate functions such as manufacturing, finance, human resources, materials management, sales, and distribution (Slater, 1998). ERP systems focus on integrating all internal enterprise transactions processing to balance demand and supply (Wallace and Kremzar, 2001).

In short ERP helps to integrate the numerous data in an organization under one common platform. The purpose behind is not only to ensure transparency but also to facilitate tracking down information regarding the status of a particular order or its dispatch and so on. ERP benefits result from successful achievement of these objectives.

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![Figure 1: A schematic representation of an ERP system](image-url)

Figure 1 shows a graphic representation of an ERP system. At the core of an enterprise system is a single comprehensive database. When new information is entered in one place, related information is automatically updated. Despite its capacity to integrate, an enterprise system is not flexible. It is a
generic solution that does not always fit with each enterprise’s individual characteristics (Davenport, 1998).

1.2 Use of ERP in non-construction industry

The ERP market is reported to be the fastest growing sector in information technology (Razmi et al., 2009). Many companies around the globe have implemented ERP and many more are in the process of implementing it. One of the major objectives for introducing the systems is an increase in revenue earnings through cost reductions.

There are various functions of ERP that may lead to achieve this objective. Some of these functions are measurable, but many of them are very difficult to measure. These can only be realized with thorough knowledge of the ERP system. A few of the functions are as follows:

1.2.1 Accessibility of information

There used to be fixed procedures and formalities to view or acquire the information from different departments within the company. Approvals of the senior executives had to be taken and it consumed a lot of time of the company. With the advent of ERP, a person can easily and readily access the information from all over the company according to the person’s position in the organization. The level of information accessible varies according to the position and authority of the person in the company and, hence, confidentiality can be maintained at all levels.

1.2.2 Improvement in productivity

When all departments in an organization have their own computer systems, data, and database, it is unlikely that they would be able to communicate with one another or need to store or rewrite data. In other words, it is not possible to make cross computer system communications. For instance, if finance department of a company were on a separate computer system than the human resources, it would more intensive and complicated to process pay checks.

Once an ERP system is in place, all aspects of a company can work in harmony instead of every single system needing to be compatible with each other. For most organizations, it means maximizing productivity and minimizing software costs.

1.2.3 Economy of resources

ERP systems help to identify the areas within an organization where resources are not appropriately or efficiently used. The systems, therefore, facilitate significant saving on resources such as time, money, and labor. This improper allocation of resources would not be identified without the ERP implementation.
1.2.4 Enhancement of decision making

The purpose of the ERP system is reducing the communication time within an organization. ERP does this by automation of the business processes. Due to the automation, the various procedure of getting approvals from different level authorities is taken out of the picture. This helps in easing out the decision making process.

Every organization in the industry has different style of working. Hence the above mentioned functions are not standard and it varies at least by a small amount as it depends on the nature of the organization.

1.3 Use of ERP in construction industry

The efficiency and productivity of the construction industry is crucial for the whole economy and for the organization itself to progress in this competitive era (Razmi et al., 2009). The construction industry needs to communicate on a large scale with other related businesses such as material and equipment suppliers, vendors, subcontractors and clients. ERP can be used by construction companies to improve responsiveness in relation to customers, strengthen supply chain partnerships, enhance organizational flexibility, improve decision making capabilities and reduce project completion time and lower costs.

Also construction industry has a history of having huge amount business failures and low amount of profits. Introduction of ERP can be useful in changing this scenario similar to what it has done in other commercial and industrial sectors (Sheikh, 2003). There are very few studies conducted about the implementation of ERP systems in the construction industry. Recently, several practitioners have stated that ERP implementations have so far yielded more failures than successes in large construction firms (Voordijk et al., 2003). When implemented to solve the right problems, these ERP systems can be a powerful tool for business improvement as witnessed by the manufacturing industry.

2. Measures of user satisfaction in an ERP environment

User satisfaction on information systems is defined as the sum of one’s feelings and attitudes toward a variety of factors related to the delivery of information products and services (Ives et al., 1983). Literature indicates that valid measures for user satisfaction with ERP include the factors of (1) product quality, (2) service provided by the ERP vendor or contractor, and (3) user knowledge of and involvement in the use of ERP (Ives et al., 1983; Sengupta and Zviran, 1997; Wu and Wang, 2007).

ERP systems are installed to integrate and synchronize all the activities of a company, provide accurate and timely data, facilitate efficient information flows, and reduce operational costs. Higher the usefulness of the product, more will be the user satisfaction.

Organizations seldom develop their own ERP systems; typically they employ contractors or vendors to provide the services. The contractors install the system according to standard operating procedures of the organization and provide training to key users. They are also responsible for ongoing support
services to keep the program running efficiently. The quality of contractor service, therefore, is a key factor in measuring user satisfaction.

Last but not the least important measure of user satisfaction of ERP is knowledge and involvement of the users themselves. This satisfaction is affected by the degree to which the users perceive their usefulness in the involvement with the program and the extent of their comprehension of the system.

3. Hypothesis

This paper attempts to find the differences in user satisfaction, if any, among construction and non-construction industry users of ERP. It is hypothesized that there is a statistically significant difference in user satisfaction between these two sectors in terms of (1) ERP as a product, (2) contractor or vendor service provided for ERP, and (3) knowledge of and involvement in the use of ERP.

4. Methodology

4.1 Data collection procedure and sample size

Data was collected from 40 randomly selected companies, 20 construction and 20 non-construction, from different regions of the United States. The companies selected were either small or medium enterprises. A questionnaire was developed to collect user satisfaction data on (1) ERP as a product, (2) vendor service for the systems, and (3) user knowledge of and involvement with the systems. Data collection was done through telephonic interviews with the CEOs of the companies.

4.2 Variables and their operationalization

Category (CATEGORY): It is the category of the company. It was treated as a class variable consisting of two classes: (1) construction company (CONST) and (2) non-construction company (NONCONST).

ERP as a Product (PRODUCT): It is the user satisfaction with ERP. The variable was operationalized by measuring satisfaction with accuracy, completeness, and reliability of the product on a likert scale ranging from 1 (extremely dissatisfied) to 5 (extremely satisfied) for each of these constructs. The sum of the values of these constructs measured the user satisfaction with ERP as a Product. The range of satisfaction values for the variable could range from a minimum of 3 to maximum of 15.

Vendor Service for the Systems (VENDOR): It is the user satisfaction related to vendor or contractor service for the systems. The variable was operationalized by measuring satisfaction with the competency, domain knowledge, reliability of the vendor or contractor on a likert scale ranging from 1 (extremely dissatisfied) to 5 (extremely satisfied) for each of these constructs. The sum of the values of these constructs measured the user satisfaction with Vendor Service for the Systems. The range of satisfaction values for the variable could range from a minimum of 3 to maximum of 15.
Knowledge of and Involvement with the Systems (KI): It is the satisfaction related to user knowledge and involvement. The variable was operationalized by measuring satisfaction with the knowledge of the program, comprehension of the program, involvement with the program, and perceived benefits of the system on a likert scale ranging from 1 (extremely dissatisfied) to 5 (extremely satisfied) for each of these constructs. The sum of the values of these constructs measured the user satisfaction on knowledge of and involvement with the systems. The range of satisfaction values for the variable could range from a minimum of 4 to maximum of 20.

5. Analysis and results

A chi-square test was performed to test the hypothesis there is a statistically significant difference in user satisfaction between these two sectors in terms of (1) ERP as a product, (2) contractor or vendor service provided for ERP, and (3) knowledge of and involvement in the use of ERP. It is a non-parametric test of statistical significance for bivariate tabular analysis. A hypothesis tested with chi-square is whether or not two different samples are different enough in some characteristic or aspect of their behavior that we can generalize from our samples that the populations from which our samples are drawn are also different in the behavior or characteristic. If the chi-square value is found to be larger than the critical value at a chosen probability of error threshold, then the data present a statistically significant relationship between variables used in the test.

The formula for calculating chi-square is:

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$  
Eqn. (1)

Where, o = observed data and e = expected data.

The results of the test are shown in Tables 1 and 2.

Table 1: Chi-square analysis of user satisfaction

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>Chi-square value</th>
<th>p-value</th>
<th>Critical Value of Chi-square @ p-value of 0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATEGORY vs. PRODUCT</td>
<td>32</td>
<td>&lt;0.0001</td>
<td>16.92</td>
</tr>
<tr>
<td>CATEGORY vs. VENDOR</td>
<td>40</td>
<td>&lt;0.0001</td>
<td>16.92</td>
</tr>
<tr>
<td>CATEGORY vs. KI</td>
<td>40</td>
<td>&lt;0.0001</td>
<td>14.07</td>
</tr>
</tbody>
</table>

Table 2: Mean values of user satisfaction

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>PRODUCT</th>
<th>VENDOR</th>
<th>PROVIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST</td>
<td>9.40</td>
<td>7.60</td>
<td>10.20</td>
</tr>
<tr>
<td>NONCONST</td>
<td>11.80</td>
<td>11.20</td>
<td>15.40</td>
</tr>
</tbody>
</table>
The chi-square values of pairwise comparisons were found to be quite high at levels of significance lower than 0.0001. The results clearly indicate that the user satisfaction levels on three dimensions related to ERP measured in the study were significantly different between non-construction industry and construction industry, at least for the sample population. In fact, the mean levels of user satisfaction were found to be higher for non-construction than the construction industry. However, the difference was found to be the least for ERP as a product.

6. Conclusions

The study shows that domain knowledge, related experience and the technical competence of the ERP vendors is much better in the non construction industry as compared to that in the construction industry. There have not been many implementations in the construction industry and more over not even many studies have been conducted over the implementations in the construction industry.

The ERP system is fairly accurate and reliable in both construction and non-construction industries. But the biggest problem in the construction industry is the completeness of the system in terms of functionality. This is probably because of the reason that the ERP systems have not developed keeping the construction industry in mind. Construction industry is unique in terms of the work setting and diversity of stakeholders. The projects constructed are diverse in nature. Due to this project-based nature of the sector, the system is not able to give the much required flexibility needed to serve the construction industry. Even though there are some systems available to meet these demands, they are still a long way being completely successful (Tatari et al., 2008).

The non-construction industry is using ERP for a longer time the construction industry. This is probably the reason why the systems have not yet been properly customized to meet all the requirements of the construction industry. When it comes to the training and the education of the end user it is a very crucial factor in both the type of industries. Construction industry being a new comer is lagging behind in this respect. It is reflected by low user satisfaction scores in issues related to user knowledge and involvement.

The relatively low difference in user satisfaction scores on ERP as a product is worth mentioning. It suggests that the construction industry underscores the importance of using ERP as a product. They probably realize the advantages of using the systems, despite some reported failures of such implementations. When implemented to solve the right problems, the ERP systems can be a powerful tool for business improvement as witnessed by the manufacturing industry.

References


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Abstract

The background involves the pioneering review of a population of construction-related business-management (BM) concepts published in English between the years 1990-2009. Construction involves herein the design, implementation, servicing, and life-cycle aspects of capital investments in natural resources usage, energy supply, telecommunications, transportation, infrastructure, manufacturing, and general building concerns. The purpose is to overview the updated 62-concept platform for (i) advancing BM research and concepts in the six overlapping fields of building economics, construction management (CM), real estate development, facility management (FM), project management (PM), and industrial management as well as (ii) enhancing global and local BM practices among firms. The same original limitations are adopted to maintain the validity and to expose major developments. The 20-year search for BM concepts has been conducted comprehensively within 20 construction-related journals and 42 management journals. Otherwise, the degrees of the search comprehensiveness vary markedly across the six other publication channels. Overall, the platform reveals that no established tradition in BM exists as part of construction-related management research in the OECD countries. The temporal pattern is emerging and fragmented. Only 10 (16%) new BM concepts have been published via the journals between the years 2006-2009. 32 (52%) concepts are related to CM, 11 (18%) concepts to PM, 11 (18%) concepts to corporate real estate services, and 8 (13%) concepts to industrial management and international marketing. Clearly, construction is outside the interests of generic management researchers vis-à-vis alternative contexts and application areas. The relatedness of the 62 concepts to the eight schools of thought on generic BM is as follows: 15 (24%) Porterian concepts, 14 (23%) organization-based concepts, 10 (16%) knowledge-based concepts, 10 (16%) dynamism-based concepts, 7 (11%) process-based concepts, 5 (8%) competence-based concepts, and 1 (2%) resource-based concept. None of the concepts is related to the evolutionary school. Nevertheless, it is posited that the updated platform enables practitioners to choose and to enhance their ways of managing a business in global and local construction, real estate, and project-based markets. Future research is needed to advance BM concepts within the six disciplinary fields, to enhance BM practices, and to increase collaboration between researchers and practitioners.

Keywords: business management, construction, global markets, literature review, real estate
1. Introduction

The background involves the long-term, pioneering identification and review of a population of construction-related business-management (BM) concepts published in English between the years 1990-2009. The overviews of the two prior review rounds have been presented at the CIB W55 and W65’s joint symposiums in Toronto (Huovinen 2004) and Rome (Huovinen 2006b-c) as well as at the LEAD Conference on Bahamas (Huovinen 2006a).

Construction (or capital investing) involves herein the design, implementation, servicing, and life-cycle aspects of investments in natural resources usage, energy supply, telecommunications, transportation, infrastructure, manufacturing, and general building concerns. Dynamism includes a spectrum of static, dynamic, even chaotic, global and local markets and businesses. A firm population consists of seven business scope groups: (i) technology-intensive contracting, (ii) construction-related contracting, (iii) process engineering, design, and consulting, (iv) construction-related design and consulting, (v) the supply of building products and construction materials, (vi) real estate ownership and development, and (vii) life-cycle (including real estate/facilities management) services.

The purpose of this paper is to introduce the updated platform, i.e. 62 concepts published between the years 1990-2009, for enhancing BM practices for a better construction world and advancing BM research in the six overlapping fields of building economics, construction management (CM), real estate development, facilities management (FM), project management (PM), and industrial management. The conduct of the three sub-reviews is reported upon in Section 2. The 62-concept population is overviewed in Section 3. Some conclusions are put forth for the future advancement in Section 4. A complete list of the 58 references containing the 62 concepts is included in the paper.

2. Comprehensive concept search within 62 journals

The pioneering review consists of the three review rounds in the years 2003, 2006, and 2010. The same limitations have been adopted to maintain the validity and to expose any major developments. The method for the reviewing of conceptual literature, i.e. the replicable ways of searching, browsing, in-/excluding, retrieving, inferring, moderate coding, describing, and analyzing the construction-related conceptual data is introduced in Huovinen (2006b).

The volumes of the 20 construction-related journals (1990-2009) and those of the 42 management journals (1990-2008) have been browsed comprehensively. This is so because peer reviewers apply the most rigorous criteria when pre-reviewing manuscripts for the publishing in scientific journals. Otherwise, the degrees of the comprehensiveness of the search vary markedly among the eight formal publication channels (Table 1).

A list of the 20 construction-related journals browsed in January 2010 is compiled in Tables 2a and 2b. The reviewer will submit the itemized lists of all the eight publication channels by request.
Table 1: Distribution of 58 references containing 62 construction-related business management concepts published via the eight channels. The degrees of comprehensiveness of the search vary during the three rounds in the year 2003, 2006, and 2010 (see the 2nd column).

<table>
<thead>
<tr>
<th>Channel</th>
<th>Comprehensiveness of three search rounds</th>
<th>No. of references</th>
<th>No. of construction-related BM concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.   (%)</td>
<td>No.   (%)</td>
</tr>
<tr>
<td>Construction-related books and reports</td>
<td>1990-2002: 9 inter-national publishers</td>
<td>6      (10%)</td>
<td>9      (15%)</td>
</tr>
<tr>
<td></td>
<td>2003-2009: No search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other management books and reports</td>
<td>1990-2002: 18 inter-national publishers</td>
<td>1      (2%)</td>
<td>1      (2%)</td>
</tr>
<tr>
<td></td>
<td>2003-2009: No search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapters in edited, construction-related books</td>
<td>1990-2002: 9 inter-national publishers</td>
<td>2      (3%)</td>
<td>2      (3%)</td>
</tr>
<tr>
<td></td>
<td>2003-2009: No search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapters in other edited management books</td>
<td>1990-2002: 9 inter-national publishers</td>
<td>1      (2%)</td>
<td>1      (2%)</td>
</tr>
<tr>
<td></td>
<td>2003-2009: No search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction-related journals</td>
<td>1990-2005: 25 journals</td>
<td>30     (52%)</td>
<td>30     (48%)</td>
</tr>
<tr>
<td></td>
<td>2006-2009: 20 journals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other management journals</td>
<td>1990-2008: 42 journals</td>
<td>7      (12%)</td>
<td>8      (13%)</td>
</tr>
<tr>
<td></td>
<td>2009: No search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction-related conference proceedings</td>
<td>1990-2005: 22 inter-national conferences</td>
<td>11     (19%)</td>
<td>11     (18%)</td>
</tr>
<tr>
<td></td>
<td>2006-2009: No search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other management conference proceedings</td>
<td>No search</td>
<td>0      (0%)</td>
<td>0      (0%)</td>
</tr>
<tr>
<td>Construction-related databases</td>
<td>No search</td>
<td>0      (0%)</td>
<td>0      (0%)</td>
</tr>
<tr>
<td>Other management databases</td>
<td>No search</td>
<td>0      (0%)</td>
<td>0      (0%)</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td>58     (100%)</td>
<td>62     (100%)</td>
</tr>
</tbody>
</table>
Table 2a: List of 13 journals on construction-related management, the volumes published and browsed during 1990-2009, and the coverage (Nos. of issues) of the latest volume of 2009

<table>
<thead>
<tr>
<th>Journal, volumes published and browsed during 1990-2009</th>
<th>Publisher, Internet address (Web database) used in January 2010</th>
<th>Volume in 2009</th>
<th>Nos. included (Nos. excluded)</th>
</tr>
</thead>
</table>
Table 2b: List of 7 journals on construction-related management, the volumes published and browsed during 1990-2009, and the coverage (Nos. of issues) of the latest volume of 2009

<table>
<thead>
<tr>
<th>Journal, volumes published and browsed during 1990-2009</th>
<th>Publisher, Internet address (Web database) used in January 2010</th>
<th>Volume in 2009</th>
<th>Nos. included (Nos. excluded)</th>
</tr>
</thead>
</table>

3. Overview of 62 construction-related BM concepts published between the years 1990-2009

The third search round resulted in the updated 62-concept population published between the years 1990-2009. This platform is overviewed by replying to six questions as follows. **Question 1. What are the frequencies of the publishing of the 62 concepts via the eight formal channels between the years 1990-2009?** 30 (48%) concepts have been published via the 14 construction-related journals, 11 (19%) concepts in the nine construction-related conference proceedings, 7 (12%) concepts in the three management journals, 6 (10%) concepts within the six construction-related
books and reports, 2 (3%) concepts in one edited, construction-related book, 1 (2%) concept in one management book, and 1 (2%) in one edited management book.

**Question 2. What is the relatedness of the 62 concepts to one or several scientific fields?** 32 (52%) concepts are primarily related to CM, 11 (18%) concepts are related to PM, 11 (18%) concepts are related to corporate real estate services, and 8 (13%) concepts are related to industrial management and international marketing. Overall, no established research traditions or groups exist in the area of construction-related BM. Only 7 (11%) concepts have been designed by the authors who are affiliated with the business schools. Clearly, construction is outside the interests of generic management researchers vis-à-vis alternative contexts and application areas.

**Question 3. What is the relatedness of the 62 concepts to one or several of eight schools of thought on BM?** Generic BM research involves the eight schools of thought: (1) Porterian school, (2) resource-based school, (3) competence-based school, (4) knowledge-based school, (5) organization-based school, (6) process-based school, (7) dynamism-based school, and (8) evolutionary school (Huovinen 2008). During the three review rounds, each of the identified BM concepts has been assigned to one of the eight schools based on the authors’ (in)direct replies to the question “What is the primary way (element) of managing that will enable managers to set challenging business goals and also to attain them?”, besides the theoretical root references. The combined share of 15 Porterian concepts, 14 organization-based concepts, 10 knowledge-based concepts, and 10 dynamism-based concepts is 79%. Overall, none of the eight schools (and their key generic concepts) has triggered a coherent flow of construction-related BM concepts or applications. The temporal pattern is emerging and fragmented. Only the 10 (16%) new concepts have been published via the journals between the years 2006-2009 (Table 3).

**Table 3: Relatedness of 62 construction-related business management concepts (published between the years 1990-2009) to the eight school of thought on business management**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Porterian school</td>
<td>11 (29%)</td>
<td>0 (0%)</td>
<td>4 (40%)</td>
<td>15 (24%)</td>
</tr>
<tr>
<td>2 Resource-based school</td>
<td>1 (3%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>3 Competence-based school</td>
<td>3 (8%)</td>
<td>0 (0%)</td>
<td>2 (20%)</td>
<td>5 (8%)</td>
</tr>
<tr>
<td>4 Knowledge-based school</td>
<td>7 (18%)</td>
<td>3 (21%)</td>
<td>0 (0%)</td>
<td>10 (16%)</td>
</tr>
<tr>
<td>5 Organization-based school</td>
<td>9 (24%)</td>
<td>4 (29%)</td>
<td>1 (10%)</td>
<td>14 (23%)</td>
</tr>
<tr>
<td>6 Process-based school</td>
<td>0 (0%)</td>
<td>4 (29%)</td>
<td>3 (30%)</td>
<td>7 (11%)</td>
</tr>
<tr>
<td>7 Dynamism-based school</td>
<td>7 (18%)</td>
<td>3 (21%)</td>
<td>0 (0%)</td>
<td>10 (16%)</td>
</tr>
<tr>
<td>8 Evolutionary school</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Sum</td>
<td>38 (100%)</td>
<td>14 (100%)</td>
<td>10 (100%)</td>
<td>62 (100%)</td>
</tr>
</tbody>
</table>
Question 4. For what primary industries, businesses, or sectors have the authors designed their 62 concepts, respectively? 21 (34%) concepts address construction or building, 21 (34%) project-based business, contracting, complex product systems, or combined engineering, purchasing, and construction (EPC) projects, 10 (16%) real estate development and services, and 5 (8%) capital investments-based businesses, 4 (6%) design and consulting services, and 1 (2%) building products supply.

Question 5. What degrees of business dynamism have the authors assumed to be prevailing or emerging in their focal contexts? Most authors have not given any specific degree(s). It is herein interpreted that each author(ship) has considered high or at least moderate dynamism. This perception is supported by the industry or business contexts (see Question 4) and the home-base contexts of the focal firms. The range of 64 home-base contexts includes 19 (30%) worldwide or global contexts, 15 (23%) UK contexts, 11 (17%) US contexts, 7 (11%) Finnish contexts, 3 (5%) generic contexts, 3 (5%) Swedish contexts, and 2 (3%) Australian context, 1 (2%) Dutch context, 1 (2%) German context, 1 (2%) Swiss context, and 1 (2%) Hong Kong-based context.

Question 6. To what extent have the authors of the 62 concepts reported on empirical evidence? 29 (47%) authors have conceptualized the management of a construction-related business without presenting readily any new empirical evidence to validate their concepts. 22 (35%) of the authors demonstrate their arguments or support the concepts by presenting one or more cases (and some examples, too). Most case researchers report on the conduct of the studies only briefly. 7 (11%) authors present the results of the interviews. 4 (6%) authors present the results of the mail questionnaire survey.

4. Conclusions

The updated platform consists of the 62 construction-related BM concepts published in English between the years 1990-2009. The basic overview reveals that BM is still a neglected area within the six construction-related fields of applied research in the OECD countries. The same applies to the research agendas among generic management scholars. It is herein assumed that this ‘white area’ is a fact even after the concept search would have been intensified and enlarged to cover all the eight publication channels as comprehensively as in the case of the 20 construction-related journals and 42 management journals.

Indeed, it is suggested that applied research programs across construction-related contexts be launched in order to advance BM concepts within the six disciplinary fields, to enhance BM practices among firms, and to increase collaboration between researchers and practitioners. In turn, this reviewer will follow up and report on the published relevant outcomes of scientific research also in the future (in part under CIB’s umbrella).

Nevertheless, it is posited that the updated 62-concept platform help firms, i.e. practicing managers to choose and to enhance their ways of managing a business in targeted construction, real estate, and project-based markets, respectively, for ‘a better construction world’.
References


List of 62 concepts published in 58 references in 1990-2009


Viable Concepts for Managing Global Businesses in a Better Construction World

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Abstract

Managing of a single business (un)successfully in any context is herein perceived to be the most challenging and enduring level of strategic management. In the same vein, generic business management (BM) research is posited as the most important sub-field within strategic management research. BM concepts are seen as abstractions representing objects or phenomena. Concepts are building blocks in theory building. Contextually, it is utmost disappointing that construction-related and other capital investments-related business managers cannot find any BM concepts that would have been designed primarily for their global contexts, e.g. telecommunications networking contracting. Only a few candidates can be sorted out from among a 62-concept population published between the years 1990-2009. The purpose of the paper is to define the systemic criteria for the attributes of a set of viable concepts for managing a business successfully in global capital investment markets. The sub-aims are as follows: (i) to define a global business based on capital investment markets, (ii) to define the systemic criteria for the attributes of viable concepts that can be exploited in managing a global business successfully, and (iii) to justify a research agenda for advancing global BM concepts. A viable global BM concept is defined as a semi-Beerian system with its four subsystems (actions, plans, models, and boundaries) and eight modes. In global contexts, managers are facing evolving challenges across developing countries (e.g. multi-cultural, mixed financing, environmental protection, energy saving, and localization issues) as well as across advanced industrialized countries (e.g. aging societies, personnel shortages, and the transformative effects of digitalization). The proactive meeting of challenges is exemplified with the solutions of HOCHTIEF AG of Germany, the most internationalized contractor and services provider, which has ranked No. 1 in the years 2007-2008 in the lists of ENR Top 225 International Contractors. It is concluded that there is no research tradition to advance (global) BM within the six disciplines of building economics, construction management, project management, real estate investing, facilities management, and industrial management. Thus, a collaborative research agenda should be planned and implemented for the advancement of global BM in the contexts of a better capital investments-based world.

Keywords: business management, capital investments, construction, global markets, systems
1. Introduction

Managing of a single business (un)succesfully in any context is herein perceived to be the most challenging and enduring level of strategic management. In the same vein, generic and applied business management (BM) research is posited as the most important sub-field within strategic management research. In part, Rumelt (1991) enabled this priority by revealing that business-specific effects are the most important factor explaining performance differentials among firms. Rumelt et al. (1994) recognized business success and its problematic origins as one of fundamental issues in strategic management. In turn, Porter (1994) has stressed that a basic unit of analysis in a theory of strategy must ultimately be a strategically distinct business.

BM concepts are herein seen as abstractions representing objects or phenomena. Concepts are also building blocks in theory building (Ghauri and Gronhaug, 2005). Overall, conceptual management research is taking place within 20-30 disciplines that belong to business administration, other social sciences, and engineering sciences (e.g. construction management).

In the context of global capital investments-based businesses (e.g. ENR’s Top 10 international contractors and Top 10 international design firms), focal managers are facing new and evolving challenges, e.g. multi-cultural, mixed financing, environmental protection, energy saving, and localization issues across China, India, Brazil, and Russia (CIBR countries) and other developing countries. There are also severe challenges, e.g. aging societies, personnel shortages, and the transformative effects of digitalization across advanced industrialized countries. Typically, this is witnessed by the key managers of HOCHTIEF AG (of Germany), the most internationalized contractor and construction services specialist, which has ranked No. 1 in the years 2007-2008 in the lists of ENR Top 225 International Contractors (Reina and Tulacz, 2009). In the year 2008, the total work done of HOCHTIEF was EUR 21.64 billion. Thereof, the dominant share of the international work done was EUR 18.82 billion (87.0 %) and the remaining share of the German or domestic sales was only EUR 2.82 billion (13.0 %) (HOCHTIEF, 2009).

Nevertheless, it is utmost disappointing that global business managers cannot find any applied BM concepts that the author in question would have designed primarily for their capital investments-based contexts (e.g. telecommunications networking contracting, plant and system contracting, and environmental engineering & design services business). Only a few candidates could be sorted out from among a population of 62 construction-related BM concepts published between the years 1990-2009 (Huovinen, 2006a-b and 2010). In short, there are no research traditions to advance (global) BM within the six interrelated disciplines of building economics, construction management (CM), project management (PM), real estate investing, facilities management (FM), and industrial management – not to talk about research groups belonging to any of the eight schools of generic thought on BM (Huovinen, 2005 and 2008).

Thus, the purpose of this paper is to define the systemic criteria for the attributes of a set of viable concepts for managing a business successfully in global capital investment markets. The three sub-aims are (and the paper is structured) as follows:
to define businesses based on global capital investment markets (Section 2)

to define the systemic criteria for the attributes of a set of viable concepts that can be exploited in managing a firm’s business successfully in targeted, global capital investment markets (Section 3)

to suggest the planning of a collaborative research agenda for advancing global BM concepts in particular in various contexts of capital investing in the future (Section 4).

It is herein assumed that **a high degree of systemic advancement** is one of the necessary attributes of any concept that will be proven to be highly viable to actually manage a business across global capital investment markets.

### 2. Businesses based on global capital investment markets

**Global capital investment markets** deal with the design, implementation, services, and life-cycle aspects of investments in the utilization of natural resources, energy supply, telecommunications, transportation, other infrastructure, manufacturing, housing, and general building concerns (Huovinen, 2002). In the long-term, all economies develop through three main stages and belong to less developed (LDCs), newly industrialized (NICs), or advanced industrialized countries (AICs) across the globe. Capital investing is intimately related to industrialization and urbanization. Capital investment markets grow and decline concomitantly with manufacturing. An S-shaped process of urbanization is consistent with an inverted U-shaped profile of capital (including construction) investments: the share of capital investments in the gross national product (GNP) first grows and then declines as the GNP per capita increases. Moreover, there is growing evidence that the inverted U-shaped relationship does hold also for the volume of capital investments in any one country over time (applying Bon, 1992).

**The generic, technical scope of a given capital (industrial) investment or a project** includes sector and feasibility studies, engineering and design, the supply of a production line with its installations and start-up, the construction of buildings, facilities, and infrastructure as well as after-investment services. Particular investment needs, i.e. project types, contract scopes, and task contents vary markedly within this generic scope.

**Global business** is herein defined to have the following common features in various contexts of capital investment markets (applying Huovinen, 2002). **Market fluctuations** are associated with short-term business cycles and public sector developments. Recessions inevitably occur in any given market. Thus, a firm’s very existence may be endangered if its owners and top managers choose to focus on one market only. It seems that firms can better ensure profitability when their portfolios of businesses, investment sectors, core competences and products, countries, and/or client groups are in balance. **The locations** of capital investments are to be found across the globe. In each location or market, project stakeholders may be nationals and/or foreigners. In typical competitive settings, firms (or alliances or networks) submit bids and one or several of them are chosen by investors to carry out all or only specified tasks of a total scope of their particular capital investments, respectively.
Core businesses involve contracting and real estate investing/ownership because contractors, investors, and developers take responsibility for the development, engineering, design, and implementation of capital investments up to their total values. Clients include versatile owners of and diversified investors in capital investments. Contracting businesses can be differentiated into six major groups as follows: natural resources contracting, power utilities contracting, industrial plants contracting, telecommunications networks contracting, general building contracting, and infrastructure contracting.

Procurement methods, contracting modes, delivery methods, or contract forms determine (i) the number of project stakeholders, (ii) the contractual roles and responsibilities between investors (owners), developers, contractors, financiers, designers, and suppliers as well as (iii) the nature of such competition by capital project. Each investor applies a specific procurement method to achieve the best possible results in terms of functionality, buildability, environmental impacts, quality, money, time, and other investment criteria. Contractors assume various roles as system, turnkey, design-to-build, general, CM, plant, engineering, main, and specialty contractors. As a rule, leading contractors possess core technologies, systems, investment solutions, products, and/or services that focal investors (clients) prefer both in private and public sectors.

International operations are typically systems selling, project exports, joint ventures and consortiums, subcontracting, technology transfer, licensing, management contracts, and various services contracts. So far, longer term partnerships and networking among project stakeholders have increased only gradually both at the global level and the local ones. Financing propositions for capital investments play often decisive roles. Investors may require that contractors arrange the financing of their capital projects as a whole or in part. Contractors may also assume the role of minor shareholders for a limited period of say 3–10 years. In AICs, most recent solutions combine private and public financing sources. In LDCs, public investors have adopted various build-operate-transfer (BOT) strategies in order to enable the realization of major infrastructure projects.

The population of firms operating in global capital investment markets belongs primarily to the eight business-scope groups or sectors, differentiated in the ways each group typically leverages its adding value to the design, implementation, and servicing of capital investments in their targeted markets as follows:

1. technology-intensive contracting
2. construction-related contracting
3. process engineering, design, and consulting services
4. construction-related design and consulting services
5. the supply of building products, systems, and materials
6. the supply of construction machinery, equipment, and tools
7. real estate ownership, investing, and development
8. life-cycle, real estate and facilities management, maintenance, and operation services.
3. Criteria for designing viable business management concepts and succeeding in global capital investment markets

3.1 Systemic frame of reference

A systemic semi-Beerian frame of reference is herein defined as Subsystems 1, 2, 3, and 4 as well as eight modes, see Figure 1). It is proposed that this scope of the four subsystems and eight modes serves as the necessary criteria for designing any set of viable BM concepts and succeeding in global capital investment markets. A business unit is seen as a system which is interacting with global offering and resource markets (applying Huovinen, 2008). The eight principles of Beer’s (1985) viable system model (VSM) are incorporated into this frame of reference as follows. (i) Within each focal corporation, a viable global business unit is an entity that is capable of maintaining an existence independent of other competing or collaborating units and interacting both with clients in offering markets and with suppliers in resource markets. A global business unit operates in its own right, in agreement with a corporation’s goals. (ii) A global business unit and its two principal markets are interdependent and evolving through interactions and adjustments. A unit influences its markets and vice versa. (iii) The eight roles of systemic, organizational competences underlie and connect respective subsystems and modes, internally and externally. A competence includes an ability to orient towards and, when logical, to connect a unit with its markets. It can absorb, attenuate, and amplify. It guides and re-specifies all technology, knowledge (embedded in individuals, teams, and IT systems), capabilities, and other resources that, taken together, enable a business unit to think and interact in pre-defined, emerging, or innovative ways needed for goal attainment.

(iv) The four subsystems and eight modes of a global business unit are defined along a bottom-up view as follows (Figure 1). Subsystem 1 involves the setting of goals for global business performance, competitiveness development activities, and the planning and implementation of interactions as well as the attainment of these goals by actually releveraging projects (Mode O1) and redeveloping competitiveness (Mode R1). Goal attainment is enabled by the two 1st-order competences in offering releveraging and competitiveness redevelopment. Subsystem 2 involves the setting of strategic plan-specific goals for the remaking of two sets of viable strategic plans for global business operations and competitiveness, the programming of strategic planning activities, and the making of the plans as well as the goals-attainment by remaking plans for both offering leveraging (Mode O2) and competitiveness development (Mode R2). Goals-attainment is enabled by the two 2nd-order roles of plan remaking competences. Subsystem 2 accommodates Subsystem 1. Subsystem 3 involves the setting of model-specific goals for a global business unit and the goals-attainment by redefining business-unit boundaries for interactions with global offering markets (Mode O4) and global resource markets.
Figure 1: Eight criteria (modes) of viable competence-based concepts for managing a business across global capital investment markets (applying Huovinen, 2008)

(Mode R4). Goals-attainment is enabled by the two 4th-order roles of boundaries redefinition competences. Subsystem 4 is an existential, governing frame for Subsystems 3, 2, and 1.

(v) **Real-time management** involves managerial and operational processes that link internally the four subsystems and externally a business unit with its stakeholders in global offering markets and global resource markets. (vi) **Organizationally**, each of the subsystems and the modes is coupled with the corresponding competence internally or a subsystem addresses an external competence via subcontracting, partnerships, or networking. (vii) **Autonomy** is nurtured so that a business unit copes well with global market dynamism. Each subsystem takes a responsibility for co-evolving with its submarket. Each subsystem is empowered for the attainment of (sub-)goals. Each competence mode enables a subsystem to self-reflect, improve its state, or renew its attributes. Development needs are mapped onto each mode. (viii) **Global complexity** is managed within a business unit. Each subsystem or each mode is competent in solving problems as close as possible to points where they occur by re-exploiting its competences. Each systemic mode enables to carry out a mix of adjustments to global dynamism.

In the next four subsections (3.2-3.5), the eight systemic criteria (requirements) for designing viable, global BM concepts and, thus, succeeding in global capital investment markets are stipulated in some detail and related global, complex challenges are exemplified with the perceptions and solutions of HOCHTIEF AG of Germany, the most globalized corporation in the entire construction industry across the globe.
3.2 Releveraging global offerings and redeveloping competitiveness

This subsystem involves the setting of goals for global business performance, competitiveness development activities, and the planning and implementation of interactions as well as goals-attainment by projects releveraging (Mode O1) and competitiveness redevelopment (Mode R1). When a business unit is actually leveraging its offerings (Mode O1) and interacting in global offering markets, a unit’s systemic competences enable it to (re)leverage its offerings in a variety of flexible (non-)specified ways. Real offering leveraging solutions are exemplified by the high global business performance of HOCHTIEF AG, which is based on its ViCon’s (Virtual Design and Construction) internal support (Figure 2, right side).

When a unit is actually developing the areas of its global competitiveness (mode R1) and interacting in internal and external, global resource markets, a unit’s systemic competences enable it to (re)develop the targeted areas of the competitiveness such as new offering development or global procurement and logistics processes. In the case of HOCHTIEF, the development of ViCon as the innovative presentation forum is emphasized (Figure 2, left side).

<table>
<thead>
<tr>
<th>RM</th>
<th>Global competitiveness redevelopment performance (R1)</th>
<th>OM</th>
<th>Global business performance (O1)</th>
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<tr>
<td>HOCHTIEF ViCon GmbH was established on January 1, 2007. ViCon processes and technologies has been developed especially for the real estate industry. The 4th info dimension of ViCon can capture and integrate in a digital building model every parameter, e.g. technology, costs, time planning, and space utilization. All project participants can work with synchronized know-how and the very latest information. This covers the entire life cycle of the project including project marketing and FM, to optimize processes and interfaces (to minimize risks). This innovative presentation platform provides HOCHTIEF with a further means of effectively marketing projects. Its model managers serve as advisors when clients work with ViCon.</td>
<td>HOCHTIEF issues tenders for entire service packages and intelligent, end-to-end solutions whenever possible. Internally, HOCHTIEF ViCon (Virtual Design and Construction in 4D) has already offered innovative life-cycle services in over 300 projects. Externally, ViCon’s expert services are available to international clients. E.g. “virtual inspection” enables to visualize rooms etc. in the design phase. “Building configurator” enables to experience interactively planned apartments or offices in an online 3D model and video animations. A 4D model is used for precise determination of quantities. Various options are tested and their effects are observed. Only the very best solutions are realized, respectively.</td>
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Figure 2: Contractor’s global performance solutions exemplified by HOCHTIEF AG of Germany (HOCHTIEF, 2009). Key: OM/RM refers to offering/resource markets

The attainment of performance goals is enabled by the two 1st-order competences in offering releveraging and competitiveness redevelopment. Over time, these systemic competences need to be redefined, recreated, and redeveloped, too. (i) Competences in global competitiveness redevelopment are enhanced in ways that integrate them with the globalization and localization of a business unit as a learning organization and with its tacit and explicit knowledge, embedded in individuals, teams, and their competencies. (ii) Competences in global offering releveraging are conceptualized and developed in ways that integrate them with the overall advancement of a unit’s global effectiveness such as the selected management tools, the management of a value chain or a network, time-based competition, demand/supply chain management, and IS/IT-enabled solutions.
### 3.3 Remaking global business plans and global competitiveness development plans

This subsystem involves the setting of goals for the making of two sets of viable strategic plans for global business operations and global competitiveness, the programming of strategic planning activities, the making of the first plans, and the remaking of these plans in order to ensure goal-attainment in both offering leveraging (Mode O2) and competitiveness development (Mode R2). When a unit is remaking its global business plans (Mode O2) and interacting in offering markets, a unit’s systemic competences enable it to make a set of effective plans that underlie actual offering releveraging (Mode O1). Real business planning solutions are exemplified by HOCHTIEF AG’s strategy of global service spanning whole project life-cycles (Figure 3, right side).

When a unit is remaking its global competitiveness development plans (Mode R2) and interacting in internal and external, global resource markets, a unit’s systemic competences enable it to make a set of redevelopment programs that underlie actual development (Mode R1). In the case of HOCHTIEF Americas Division, the green building development is emphasized (Figure 3, left side).

<table>
<thead>
<tr>
<th>RM</th>
<th>Global competence redevelopment program (Mode R2)</th>
<th>OM</th>
<th>Global business plan (Mode O2)</th>
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</thead>
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<tr>
<td>In the case of HOCHTIEF Americas Division, green building is becoming steadily more important in the USA, and Turner, the market leader in this segment with more than 1000 LEED Accredited Professionals, is well prepared (no other company employs as many professionals). These professionals are being specially trained to manage construction projects in accordance with the US Green Building Council’s certification guidelines. The two subsidiaries, Turner and Flatiron also show their strength when working together. They just secured the second airport project as a team. Along with a partner, they expand Terminal 2 at San Diego International Airport and are targeting LEED Silver certification.</td>
<td>HOCHTIEF’s strategy of global service spanning the whole project life-cycles delivers results. Providing a full range of capabilities from a single source is a key element. The durability of HOCHTIEF’s client relationships are built on sound contracting models and partnership. HOCHTIEF is also profiting from economic stimulus packages in the key countries and sectors. A positive trend can be seen also in HOCHTIEF’s concessions portfolio, which is geared to generate a steady income stream for the long term. In 2009, HOCHTIEF aims at generating a pretax profit and consolidated net profit at the previous year’s level.</td>
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Figure 3: Contractor’s global planning solutions exemplified by HOCHTIEF AG of Germany (HOCHTIEF, 2009). Key: OM/RM refers to offering/resource markets

The attainment of planning goals is enabled by the two 2nd-order plan remaking competences in terms of revising, updating, modifying, or adjusting strategic plans whenever such strategic needs arise. Over time, the two systemic competences need to be redefined, recreated, and redeveloped, too. The ultimate purpose is to enable practicing managers to identify and to specify their units’ existing or new competences that enable them to redevelop the areas of their competitiveness as anticipated and to releverage units’ offerings successfully in the future. Thus, offering releveraging plans and competitiveness redevelopment programs are tailored around applicable competences.
3.4 Redesigning global business models and global competitiveness models

This subsystem 3 involves the setting of model-specific goals for the design of a global business model coupled with a global competitiveness model, the planning of the conceptualization activities, the design of the models-to-be-used, and the redesign of the same in order to ensure goals-attainment in business modeling (Mode O3) and competitiveness modeling (Mode R3). When a unit is redesigning its global business model (Mode O3) and interacting in global offering markets, a unit’s systemic competences enable it to redesign this business model in ways that sustain its viability. Real business modeling solutions are exemplified by HOCHTIEF AG’s vision, business portfolio, and models (Figure 4, right side).

When a unit is redesigning its global competitiveness model (Mode R3) and interacting in internal and external, global resource markets, a unit’s systemic competences enable it to redesign this competitiveness model in ways that sustain its viability. In the case of HOCHTIEF, its core competency, networking, synergies, and guiding principles are emphasized (Figure 4, left side).

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<thead>
<tr>
<th>RM</th>
<th>Global competitiveness model (Mode R3)</th>
<th>Global business model (Mode O3)</th>
<th>OM</th>
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<tr>
<td>HOCHTIEF’s core competency is construction. Building on this, the Group is systematically expanding its spectrum of services to include multifaceted innovative solutions, concessions business, and specialist services. HOCHTIEF’s business is shaped by innovative thinking, vast competence, working in a spirit of partnership and maintaining transparency. The global network covers all the world’s major markets. Offering all services from one source requires intense cooperation among operational units. Such synergies are especially effective in public-private partnerships (PPP). HOCHTIEF’s guiding principles are divided into (1) client-oriented service spectrum, (2) successful employees, (3) sustainability, and (4) value-oriented strategy. The highly qualified workforce creates value.</td>
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<tr>
<td>“HOCHTIEF is building the future – along with our partners, we expand horizons, link people and organizations, create new ways to think and act, and enhance the values entrusted to our care”. This vision is fulfilled through all the modules of HOCHTIEF’s product and service portfolio. The four modules, i.e. development, construction, services plus concessions and operation are closely interrelated. Services like FM and insurance create a stable, long term income streams. E.g. PreFair is a collaborative business model for clients, architects, and engineers. The concessions business is a value driver for their stock with the applications like airport investment partnership and management as well as underground and open pit contract mining. Sustainability drives business activities.</td>
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Figure 4: Contractor’s global modeling solutions exemplified by HOCHTIEF AG of Germany (HOCHTIEF, 2009). Key: OM/RM refers to offering/resource markets

The attainment of modeling goals is enabled by the two 3rd-order competences in model redesign in terms of performing modeling tasks such as to test a viability, to reveal a robustness against a set of (ir)rational scenarios, and to allocate a minimum number of years (months) for building up the new targeted areas of a unit’s business-specific competitiveness. Over time, the two systemic competences need to be redefined, recreated, and redeveloped, too. The ultimate purpose is to enable practicing managers to create, to comprehend, to assess, and to realize the alternative twin models of business and competitiveness. Thus, the viable realization of a particular pair of these models implies that the business-specific competence platforms or pools are identified, defined, and modeled concurrently.
3.5 Redefining global business boundaries and global competitiveness boundaries

This subsystem 4 involves the setting of the existential, boundary goals for a global business unit and the goals-attainment by redefining business-unit boundaries for interactions in global offering markets (Mode O4) and global resource markets (Mode R4). When a unit is redefining its global business-specific boundaries (Mode O4), often as part of a corporation’s business portfolio, and interacting in global offering markets, a unit’s systemic competences in boundary redefinition are needed also for revising the offering market-focused Modes O3, O2, and O1 (i.e. the business model, plans, and actions) accordingly. Boundary solutions are exemplified by HOCHTIEF AG’s migration to become the leading life-cycle services specialist and by its assumptions (Figure 5, right side).

When a unit is redefining its global competitiveness boundaries (Mode R4) as part of its competence platforms and roadmaps and interacting in internal and global, external resource markets, a unit’s competences in systemic boundary redefinition are needed also for revising the resource market-focused Modes R3, R2, and R1 (i.e. the competitiveness model, development programs, and activities). In the case of HOCHTIEF, innovation management is emphasized (Figure 5, left side).

<table>
<thead>
<tr>
<th>RM</th>
<th>Global competitiveness boundaries (Mode R4)</th>
<th>Global business boundaries (Mode O4)</th>
<th>OM</th>
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<tbody>
<tr>
<td>At HOCHTIEF, innovation takes place at the central management level and as market-driven and project-related innovations. Innovation Committee helps create new profitable business areas with forward-looking ideas, e.g. renewable energies. New knowledge is generated to unlock future areas of business early on and to optimize existing processes. Worldwide cross-module knowledge transfer is the basis for success. A warning system (to match Section 91(2) of German Stock Corporations Act) is identifying at an early stage any development that might cast doubt over the Group’s ability to continue as a going concern.</td>
<td>In the early 1990s, HOCHTIEF was a traditional German-style construction company. By 2009, HOCHTIEF has become the globally leading services provider. The Group comprises a management holding company and six corporate divisions: Americas, Asia Pacific, Concessions, Europe, Real Estate, and Services. HOCHTIEF’s planning is based on the assumptions that financial and capital markets will normalize again from 2010, that no ongoing recessionary slowdown will occur in the global economy, and that the situation in areas of political tension will not deteriorate.</td>
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Figure 5: Contractor’s global boundary solutions exemplified by HOCHTIEF AG of Germany (HOCHTIEF, 2009). Key: OM/RM refers to offering/resource markets

The attainment of boundary goals is enabled by the two 4th-order boundary redefinition competences which, over time, need to be redefined, recreated, and redeveloped, too. In practice, pioneering business managers rely on their foresights, integrate contradictory driving forces along the eight systemic modes, define reality heavens versus reveal vision graveyards along competence spectrums, and incorporate both boundary-freezing and boundary-pushing forces within a twin set of alternative global business and competitiveness models. Thus, the ultimate purpose is to enable such managers to self-enhance their cognitive-systemic competencies needed for envisioning, anticipating, foreseeing, influencing versus adjusting, and even pre-empting alternative trajectories, boundaries, and forces related to attractive business potentials in the future. Thus, business creation, vision realization, and progress making along one of the trajectories imply that a unit’s competence platforms, pools, paths, business-wide standards, and alike must be foreseen concurrently.
4. Conclusions

It is herein concluded that the successful management of a business (unit) and the sustaining of its competitive advantages in global capital investment markets involve a mastery of all the four subsystems or the eight systemic modes, i.e. the eight kinds of tacit and explicit knowledge, situational information, reflections, decisions, concepts (i.e. boundaries, models, and plans), and interactions in global offering markets and global resource markets. In other words, it is assumed that a high degree of systemic advancement is one of the necessary attributes of any concept that will be proven to be highly viable to actually manage a business across global capital investment markets. No single concept is enough. Any concept corresponds only to one or two systemic modes or criteria of global BM viability. Instead, a set of eight concepts is needed.

In the same vein, it is suggested that some insightful construction-related management scholars respond to current and future challenges that global firms are facing and that such scholars combine their forces for planning and realizing a joint research agenda and establishing a school of applied thought on managing firms and their businesses in global capital investment markets in the foreseeable future.

References


Abstract

Prefabrication is realised as a novel direction to conquer the chronic problems such as low productivity, high waste production, inferior working conditions and insufficient quality in construction. Despite benefits of prefabrication, inherent issues related to inefficiencies have been identified from its production process. Lean Production Principles are recognised as a paramount concept which enables to address production process related inefficiencies. This study aims to investigate the concept of Lean Prefabrication as means of mitigating inefficiencies in Prefabrication Production Process (PrefabPP) and its effect towards sustainability. Observations and semi-structured interviews were conducted to collect data within selected three case studies in Sri Lanka (prefabrication production yards) targeting executive level professionals who engaged in ‘prefabrication bridge beam production process.’ The collected data were analysed using code-based content analysis and mapped using tables and matrices. Findings revealed twenty (20) PrefabPP issues, out of which ten (10) were highly severe, four (4) were moderately severe and six (6) were less severe as inefficiency issues. The study revealed that by adopting lean principles into PrefabPP that it will offer eleven (11) key benefits to PrefabPP and its customers. Results also indicated that the application of Lean Production Principles to PrefabPP offers long-term benefits to construction by contributing towards sustainability. The study highlights implications to prefabrication companies, construction professionals, researches and those who deal with sustainability issues.

Keywords: prefabrication production process, lean production principles, lean prefabrication, sustainability, Sri Lanka
1. Introduction

The construction industry is generally characterised as a labour-intensive industry, which comprises of several wet-trade activities. Thus, it suffers from drawbacks such as lengthier construction duration, cost overruns, low quality, poor safety records (Chan and Ma, 1998) and environmental impacts. Further, clients’ expectations have grown up on aspects leading to ‘maximum value and minimum waste’ (Luo et al., 2005). Industrialisation (i.e. prefabrication and modularisation) has been viewed for a long time as one direction of progress to conquer this challenge by providing solutions for above mentioned problems in construction (Koskela, 1993). In particular, Prefabrication offers several benefits such as reduce waste generation; improve site safety; enhancing quality under factory production; encourage recycling construction waste; leading to environmental protection; process standardization; shorten lead time; and, sustainability (Hendricks and Pietersen, 2000; Luo et al., 2005; Tam et al., 2007).

Despite the benefits of off-site construction as any factory production, prefabrication relies on extensive use of mechanisation and automation in the manufacturing settings (Pheng and Chuan, 2000), which could lead to other type of wastes such as; overproduction, waiting time, transportation, too much machines (over processing), inventories, moving, making defective parts and products (Imai, 1997; Shingo, 1984; Walton, 1999). Further, Prefabrication Production Process comprises of demerits, such as high initial cost; lack of variety in design; usage of advanced technology; requirement of well-trained people; need of comprehensive quality control techniques; and, need of more efficient testing (Pheng and Chuan, 2000). Thus, adoption of appropriate techniques or mechanisms to overcome the persistent problems in Prefabrication Production Process becomes vital.

The primary goal in Lean Production is to avoid waste of time, money and equipment (Shingo, 1992). Hence, it should formulate conversion activities (which adds value to outputs) more efficient and reduce or eliminate non-value adding flow activities such as inspection, waiting and moving (Koskela, 1993). Previous research confirm that the adaptation of lean principles facilitate manufacturing through increasing productivity, reduction of manufacturing space, improving quality and safety, reducing the lead time, reduce human effort, reduce investments in tools, reduce engineering hours to develop a new product and ultimately increasing of sustainability values (Koskela, 1992). Further, Bertelsen (2005) identified prefabrication/modularisation as a third approach to make lean construction. Thus, it is argued that many problems persistent with Prefabrication Production Process can be solved or reduced by adopting lean principles. Hence, adoption of Lean Production Principles to address the issues in Prefabrication Production Process in the construction industry needs a thorough investigation in order to gain advantages/improvements achieved by the manufacturing industry to the construction industry and ultimately towards sustainability. Next section explains the research issues related to this aspect through a literature review.
2. Prefabrication and Lean Production

2.1 Prefabrication

Prefabrication in construction is defined in different ways by different authors. However, some of the definitions are narrowed in explanations, yet in line with general definitions. For instance, Tatum (1986) defines prefabrication as “the transferring stage of construction activities from field to an off-site production facility”. A more detailed definition given by Bjornfot and Sarden (2008, p.266), is, “prefabrication is making of construction components at a place different from the point of final assembly, may lead to better control of the inherent complexity within the construction process.” On the other hand, Chiang et al. (2006) define prefabrication as “manufacturing and pre-assembly process, generally taking place at a specialized facility, in which various materials are joined to form a component part of the final installation.” Thus, following definition can be put forward incorporating key attributes of aforementioned definitions;

“Prefabrication is a manufacturing and pre-assembly process, whereby, construction components are made at a location different from the place of final assembly, under specialized facilities with different materials, may lead to better control of the inherent complexity within the construction process”

Prefabrication has some unique features such as centralization of production, mass production, standardization, specialization, effective organization, integration, repetition, light weight components, factory production (Pheng and Chuan, 2000; Tam et al., 2007). These unique features facilitate effective construction techniques in terms of quality, time, cost, function, productivity, safety, waste minimization and sustainability. Further, it offers benefits such as saving site space; on-site less labour-intensive operations; and, opportunities for good architecture. Features of prefabrication on sustainable construction includes: increase potential of improved supply chain integration of green materials; safer working conditions; easier recycle of materials in an off-site environment; enhance flexibility and adoptability; reduced overall life cycle cost; reduced environment impact; and, reduced economic impact (Bae and Kim, 2007).

These merits of prefabrication confirm its appropriateness, whilst identification of the associated demerits may lead to possible improvements to enhance the soundness of the prefabrication technique for building construction. A number of studies (Luo et al., 2005; Tam et al., 2006; Tam et al., 2007; Waskett, 2001; Wong, 2000) identify key issues in prefabrication as; higher initial construction cost; time consuming for design, construction planning, procurements and approval procedures; use of extensive mechanisation and automation leads to significant waste; overproduction, waiting time, transportation, over processing, inventories, moving, making defective parts or products; lack of variety in design; high technology usage; required well trained people; issues related to site; high quality control techniques; more efficient testing. Further, Waskett (2001) identified barriers to apply prefabrication in construction industry such as general image; perceived performance; customer expectations; perceived value; industry culture; and product awareness. These demerits and barriers should be reduced or eliminated to reap the optimal benefits from prefabrication.
Since prefabrication is a manufacturing process found in construction, techniques which are used to improve the manufacturing processes of factory productions in other industries could be applied to it. Thus, this study argues that ‘Lean Production’- an application in manufacturing settings can be applied as a potential way to improve and overcome the above mentioned issues in PrefabPP.

2.2 Lean Production and Sustainability

‘Lean Production’ considers both the flow and conversion activities. Koskela (1992) mentioned that, production is a flow of material and/or information which transfers raw material to an end product. In this flow, the material is processed (converted), inspected or kept waiting or moving. Conversion aspect of production is represented by ‘processing’ and flow aspect is represented by ‘inspecting’, ‘moving’ and ‘waiting’. The inefficiency of conversion activities creates rework and scrap. Hence, the above concept of Lean Production implies a duel view of production flow process: in particular;

I. Conversion activities – activities which add value to the material or piece of information being transformed into a product. Represent by processing.

II. Flow activities – activities which conversion activities are bound together, but do not add any value to the product. Represent by inspection, moving and waiting.

The key attributes of the flow processes of production can be identified as time, cost and value. Here, value refers to the fulfilment of customer requirements. While all activities expend cost and consume time, only conversion activities add value to the material or piece of information being transformed to a product. Thus, the lean concept urges, making conversion activities more efficient, while reducing or eliminating non-value adding activities as its primary focus (Koskela, 1993). Hence, for the overall efficiency of a production process while delivering a project, there should be an ongoing effort, which maximizes the value and minimizes waste. Womack and Jones (1996) also offer five principles of ‘lean thinking’ that focus on value in a production process. Koskela (2004) claims that application area of these five lean principles is limited to the transformation of mass production and construction being largely out of scope. Hence, he moves beyond these five principles towards a production theory that applies to construction in which the primary focus: i.e. making conversion activities more efficient, while reducing or eliminating non-value adding activities remains unchanged.

The adoption of Lean Production brings significant benefits to an organisation. For example, Schmenner (1988) reports that all possible techniques for improving productivity are only those related to the new production philosophy and demonstrated as effective in manufacturing industry. Similarly, according to the study of Womack et al. (1990), Lean car production can be characterized as a production which uses lesser of everything compared to mass production: half the human effort in the factory, half the manufacturing space, half the investments in tools, half the engineering hours to develop a new product in half the time. Moreover Stalk and Hout (1989) discovered that Japanese companies have doubled their typical factory productivity rates over a five year period, as a result of implementing the new principles. According to Harmon and Peterson (1990) Lean Production typically targets a reduction of manufacturing space by 50%.
Hence, the application of Lean Production Principles in any production process offer benefits such as improved productivity, reduced wastage, reduced working space requirements, reduced human effort, more sustainability, lesser production time, increased quality and safety, and shorter lead time (Mohan and Iyer, 2005). Further, it provides a better value for the owners as well as customers through value maximisation principles of Lean Concept. Further, lean can contribute to sustainability, but only if and when the customer values sustainability (Bae and Kim, 2007). According to Huovila and Koskela (1998), there are two major contributions of lean construction to sustainable development: eliminating waste and adding value to the customer, mainly related to materials.

Sustainability not only aims of adding value while minimising waste; but it also means ‘Triple bottom lines’ economic, social and environment sustainability. Hence some researches focused on corporative benefits in economic, social and environment perspective of Lean Philosophy (Hawken et al., 1999). According to the research finding of Bae and Kim (2007), Lean Philosophy provides a concrete basis for economic, social and environmental perspectives in sustainable construction by adopting project delivery process of green facilities. Ballard (2000) illustrates the stages of construction process, interconnecting with the lean concept as Lean Project Delivery System (LPDS) extending from project definition, design, supply and assembly with the sustainable areas of economic, social and environment. Here prefabrication is identified as a better option which facilitates ‘Lean Assembly’; as one of the best procurement methods for sustainable construction. Hence, it is argued that adoption of lean principles in PrefabPP offers similar benefits, through addressing inefficiency issues prevailing in the prefabrication process in the construction industry.

3. Research Method

A literature review was carried out to identify the PrefabPPs, its activities and issues, pros and cons, available systems as well as Lean Production Philosophy, its applications and current level of knowledge towards the PrefabPP and effect of Lean Prefabrication towards Sustainability. Then the empirical study was conducted with the use of case study research approach, since this research is needed to be conducted by studying real-life production processes. Prefabrication companies and their yards were selected as unit of analysis and three (3) PCBBPPs in Sri Lanka were selected for data collection, based on the popularity, demand and wide coverage of the activities in PrefabPP. The brief description of case study samples as in Table 1.

Observations and semi-structured interviews were undertaken to collect data using triangulation logic as data collection tools targeting executive level professionals who engaged in PCBBP. Accordingly, executive staff of prefabrication production yards in the capacities of Production Engineers, Civil Engineers, Quantity Surveyors, Batching Plant Operators and Store Keepers, who are supposed to be well experienced with the PrefabPP, formed the 15-member Interviewee panel (i.e. 5 members from each case).
**Table 1: Brief description about the selected cases**

<table>
<thead>
<tr>
<th>Precast Concrete</th>
<th>Yard A</th>
<th>Yard B</th>
<th>Yard C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Company type</strong></td>
<td>Private</td>
<td>Semi government</td>
<td>Semi government</td>
</tr>
<tr>
<td><strong>Experience</strong></td>
<td>20 years</td>
<td>47 years</td>
<td>59 years</td>
</tr>
<tr>
<td><strong>Prefabrication elements produced</strong></td>
<td>Bridge beams, SBS slabs, Soffit blocks, Kerbs, Cement blocks, Paving, Spun pipes, Pergolas</td>
<td>Bridge beams, Light poles, Spun pipes, Kerbs, Tie beams, Column putting, Paving, Spun pipes</td>
<td>Bridge beams, Light poles, Spun pipes, Kerbs, Tie beams, Column putting, Cement blocks, Paving</td>
</tr>
</tbody>
</table>

| Interviewees | A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | C1 | C2 | C3 | C4 | C5 |
|--------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| **Profession** | Quantity Surveyor | Store keeper | batching plant supervisor | Civil Engineer | Manager | Quantity Surveyor | Store keeper | Civil Engineer | Civil Engineer | Manager | Quantity Surveyor | Store keeper | Civil Engineer | Manager |
| **Experience (Yrs)** | 18 | 3 | 8 | 4 | 12 | 7 | 16 | 3 | 12 | 5 | 30 | 3 | 4 |
| **Process - Section** | Estimating | Concrete batching | Costing | Overall process | Estimating | Concrete batching | Costing | Overall process | Estimating | Concrete batching | Costing | Overall process |
| **Duration hrs** | 1 ½ | 1 ½ | 2 | 1 ½ | 1 ½ | 1 ½ | 1 ½ | 2 | 1 ½ | 1 ½ | 1 ½ | 1 ½ |

Data were collected to identify the production process; evaluate production processes related issues; identify effect of lean application; benefits, and link between lean prefabrication and sustainability. In addition, interviews identified the perception of interviewees regarding application of lean principles as mean of mitigating issues prevailing with the PrefabPP. Code based content analysis was used to analyse data. Since, content analysis support to capture important concepts from the transcripts and for effective interpretation of those. The NVivo computer software was used in this study to simplify the clerical works relating to content analysis.
4. Research Findings

Identification of current issues and possible causes of such issues are one of the major objectives of this study. Hence through interviews, it was identified twenty (20) key issues in PrefabPP. Among twenty (20) key issues, ten (10) were identified as highly severe issues, four (4) were identified as moderately severe issues and other six (6) were identified as less severe. Table 2 presents key findings related to PrefabPP issues including severity of issues and possible causes of such issues. The findings reveal that these identified issues must be eliminated or minimised in order to reap the maximum benefits from prefabrication and its production process. Thus, next attempt was made to identify the benefits of application of ‘Lean Production Principles’ in PrefabPP as a potential way to overcome the above-mentioned issues.

Study identified that by applying Lean Production Principles to PrefabPP offer 11 key benefits such as: increase productivity, increase quality, increase sustainable values, provide better value to the customer, reduce lead time, reduce manufacturing space, reduce wastage, reduce production cost, reduce production time and reduce the human effort (refer Figure 1). Study found that lean application can offer these 11 benefits, since it was basically focused on increasing the efficiency of value adding activities, elimination/minimisation of waste in unnecessary flow activities and ultimately focused to enhance customer value. Further, study reveals that requirement of continuous monitoring process in long-run to get the maximum benefits through lean application.

Finally, findings revealed that these benefits of Lean Production Principles offered potential solutions to eliminate or minimise the above identified issues in PrefabPP and moreover it offer sustainable benefits to PrefabPP. Thus, next attempt was to explore how this concept of ‘lean prefabrication’ can be treated as a sustainable approach.
### Table 2: Current issues and possible causes of such issues in PrefabPP

<table>
<thead>
<tr>
<th>Issues</th>
<th>Severity</th>
<th>Possible causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production time</td>
<td>●●</td>
<td>Curring time, effectiveness and efficiency of labour force, limited number of shutters, limited numbers of beds, large heavy component</td>
</tr>
<tr>
<td>Waiting time</td>
<td>●●●</td>
<td>Poor planning and programming of work, inefficient management controlling, breakdown of machineries, delay issuing of materials, weather conditions, delay approvals, late material purchasing</td>
</tr>
<tr>
<td>Initial cost</td>
<td>●</td>
<td>Fabricate moulds, construct precast beds, buy machineries, batching plant, get approval from authorities, land, buildings</td>
</tr>
<tr>
<td>Production cost</td>
<td>●●</td>
<td>Depend on length of beam, concrete grade, labour involvement, material usage</td>
</tr>
<tr>
<td>Quality controlling</td>
<td>●●●</td>
<td>Huge costly component quality check must, minimise errors, quality of shutter work highly affect, concrete grade, stressing of reinforcement, curring, strength of component</td>
</tr>
<tr>
<td>Testing</td>
<td>●●●</td>
<td>Concrete, material testing, testing of final product, to assure the quality of product</td>
</tr>
<tr>
<td>Store keeping</td>
<td>●●●</td>
<td>Timely issuing of materials and equipments, maintaining competitiveness</td>
</tr>
<tr>
<td>Defective products</td>
<td>●</td>
<td>Improper compaction, less quality of concrete, errors in shutters</td>
</tr>
<tr>
<td>Over processing</td>
<td>N/A</td>
<td>Huge cost, only produce ordered quantity</td>
</tr>
<tr>
<td>Inventories</td>
<td>●●●</td>
<td>Future references, audits</td>
</tr>
<tr>
<td>Moving</td>
<td>●●</td>
<td>Materials, components, plant, machineries and labour moving, long distance between stores, casting yard</td>
</tr>
<tr>
<td>Transportation</td>
<td>●</td>
<td>Transportation of materials</td>
</tr>
<tr>
<td>Sound and dust</td>
<td>●</td>
<td>Sound of machineries, cement dust, dust due to movement of machines, dust while cleaning shutters and beds</td>
</tr>
<tr>
<td>Productivity, efficiency</td>
<td>●</td>
<td>Sufficient productivity, can cater the demand</td>
</tr>
<tr>
<td>Over production</td>
<td>N/A</td>
<td>Huge cost, unless sales huge loss</td>
</tr>
<tr>
<td>Standardization, mass production</td>
<td>●●●</td>
<td>Standardize production, but mass scale not involve</td>
</tr>
<tr>
<td>Variety in design</td>
<td>●●●</td>
<td>Cross sectional shape generally flat or I shape, only vary from span</td>
</tr>
<tr>
<td>Usage technology</td>
<td>●●●</td>
<td>New materials (ex: admixtures), plant and machineries, production techniques and management techniques</td>
</tr>
<tr>
<td>Well trained people</td>
<td>●●●</td>
<td>Highly skill labours required</td>
</tr>
<tr>
<td>Labour, plant and machinery</td>
<td>●●●</td>
<td>High plant and machineries involvement and labour incentive</td>
</tr>
<tr>
<td>Safety</td>
<td>●</td>
<td>Maintain safety at site well</td>
</tr>
<tr>
<td>Environmental effects</td>
<td>●</td>
<td>Very less</td>
</tr>
</tbody>
</table>
The link between lean prefabrication and sustainability was developed through the findings as depicted in Figure 2. It shows how benefits of lean prefabrication connect with sustainability from the economic, environment and social perspectives.

Figure 2: Link between Lean Prefabrication and sustainability

I. Economic Sustainability- reduce production cost, provide better value to customer, reduce production time, increase productivity, reduce lead time and increase quality of product and productivity are identified as economic sustainable features which facilitates through application of Lean Prefabrication. Interestingly, application of Lean Production Principles to PrefabPP provides better value for money spent which is a clear economic sustainability feature.

II. Environmental Sustainability- reduce wastages and reduce manufacturing space directly connect with the environment sustainability. Since lean application eliminates unnecessary wasteful activities from the production process it reduces material, time and labour wastages. Utilize resource only at the required level.

III. Social Sustainability- as social sustainable values lean facilitates several benefits such as increase safety, reduce human effort, reduce working hours and increase skills of labour.

Moreover, findings revealed that the people attached to the production process agree with the lean application in PrefabPP yards. Interviewees’ perceptions related to Lean Production Principles, as better option to achieve their company targets provide better value to the customer with a reasonable cost at target time in a competitive market. Yet, production yards needs several changes in terms of the proper implementation of lean principles such as top management commitment to the implementation, sufficient technical experts regarding the Lean
Production; a quest for a culture of continuous improvement within the company as well as at prefabrication yards, fullest dedication of workers towards the implementation; awareness of employees regarding lean principles, change people’s attitudes and sufficient management expertise to induce the changes in the production flow process.

5. Conclusions

This research has investigated the application of lean principles in the context of PrefabPP. The research has given an account of PrefabPP related inefficiencies, issues and how lean concept can mitigate these issues while enhancing the efficiency of PrefabPP. Additionally, the research focused on the relationship between Lean Prefabrication and sustainability.

The study identified twenty (20) key issues related to PrefabPP. From those, ten (10) were highly severe issues namely; waiting time, inventorying, moving, high quality controlling, requirement of efficient testing, stock keeping, less flexibility to varying design, usage of technology, standardization/ mass production and requirement of well train people and resources (i.e. labour, plant, machineries). These issues need to be minimised in order to reap successful benefits from prefabrication. The application of Lean Production Principles offer 11 key benefits to PrefabPP such as increase productivity, increase quality, increase sustainable values, provide better value to the customer, reduce lead time, reduce manufacturing space, reduce wastage, reduce production cost, reduce production time and reduce the human effort. Furthermore, the study identified that Lean Prefabrication contributes to sustainability by facilitating economics, environment and social sustainability goals. Thus, key conclusions can be drawn from the present study that the application of lean principles helps to eliminate or minimise the identified issues/inefficiencies in PrefabPP along with several benefits which can be achieved through continuous improvements to the production process. This ensures that lean prefabrication is a sustainable approach for construction industry.

Finally, the study found that the people attached to the production process are willing to adopt lean application in PrefabPP yards. Yet, production yards need several changes in terms of the proper implementation of lean principles such as top management commitment to the implementation, sufficient technical experts regarding the Lean Production; a quest for a culture of continuous improvement the company as well as at prefabrication yards, fullest dedication of workers towards the implementation; awareness of employees regarding lean principles, change people’s attitudes and sufficient management expertise to induce the changes in the production flow process.

References


Leveraging Economy of Scale across Construction Projects by Implementing Coordinated Purchasing

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Abstract

The paper presents a case study of the implementation of coordinated purchasing in a large Nordic contractor as an example of a successful but challenging radical innovation.

The paper describes the practices and tools for analysing the existing purchasing activities, categorizing the purchasing volume, and the different strategies for addressing the different categories. In particular the interface between the project and central purchasing activities is portrayed.

The paper further describes the implementation struggle, which have required a significant change of mindset in the organisation. A much greater challenge than initially imagined. The implementation of central purchasing activities has been in direct conflict with predominant project culture, as the project culture and identity formation is tightly coupled to the project based purchasing activities.

Finally the paper discusses how coordinated purchasing is an important step in the attempt to rethink the existing business model in construction. Going from competing on overhead (in a red ocean) to start to compete on company specific core competencies. The paper concludes highlighting the next milestones at the journey leveraging economy of scale even further, though the use of platforms, modularization and configuration.

Keywords: purchasing, culture, identity, industrialization
1. Introduction

The construction industry is often criticized for its inefficiency compared to other industries, its inability to innovate, to improve its practices and to provide value for its clients (Egan 1998). As a symptom of this fundamental challenge have the construction cost increased by approx. 4.6 % per year the last 20 years (Danish statistic 2010)

Despite the increasing costs are the companies in the centre of the value chain struggling with creating profit – as illustrated in figure 1.

![Figure 1: EBIT margin in the value-chain (Internal presentation)](image)

As an example, are the large contractors in the Scandinavian countries having an average EBIT margin\(^1\) between 0-3%. These very small margins compared to their cash flow make their businesses extremely vulnerable to changes in price levels and market development.

The existing production regime in construction is heavily influences by realizing one of a kind projects. Thuesen et al (2009) argues this is according to an often celebrated sectorial myth viewing buildings as uniquas. Today’s predominant view of buildings – as unique – implies that:

1. the nature of the construction processes is chaotic
2. the buildings are realized through onsite project work rather than offsite production
3. project management is the fundamental management principle
4. the inter-organisational cooperation is temporary

\(^1\) A profitability measure equal to “Earnings Before Interest and Taxes” divided by net revenue. This value is useful when comparing multiple companies, especially within a given industry.
These characteristics of the building process are also mirrored in the physical product. Today buildings are getting increasingly complex, manufactures of building parts are constantly pushing new technologies to the market which needs to be integrated and optimized in each physical building.

The consequence is that construction today is a mixture of new materials, processes and architectural visions - realized through a specific division of labour and institutionalized roles such as the manufacturers of the basic parts, building companies (including craftsmen), engineering companies and architects. Under this existing regime, have the value-chain got more and more fragmented. As illustrated in figure 2.

Figure 2: Structure of the value chain (Internal presentation)

A consequence of this development is that most construction businesses operate from a Cost+ model, making the companies compete on their overhead rather than their core processes (Nicolini et al 2001). In this sense are the market place characterised as a typical red ocean environment – as described by Kim and Mauborgne (2004, 81):

<table>
<thead>
<tr>
<th>Red ocean strategy</th>
<th>Blue ocean strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compete in existing market space.</td>
<td>Create uncontested market space.</td>
</tr>
<tr>
<td>Beat the competition.</td>
<td>Make the competition irrelevant.</td>
</tr>
<tr>
<td>Exploit existing demand.</td>
<td>Create and capture new demand.</td>
</tr>
<tr>
<td>Make the value/cost trade-off.</td>
<td>Break the value/cost trade-off.</td>
</tr>
<tr>
<td>Align the whole system of a company’s activities with its strategic choice of differentiation or low cost.</td>
<td>Align the whole system of a company’s activities in pursuit of differentiation and low cost.</td>
</tr>
</tbody>
</table>
Although the red ocean market puts pressure on margins in each company making them struggle for survival, it also represents an opportunity for creating an uncontested market space - pursuing a blue ocean strategy.

An internal analysis in one of the large Nordic contractors identified that 80% of the cash flow was spend on purchases of consultants, construction materials, rental services, subcontractors etc. In other words: If they wanted to improve their profitability (EBIT), they should focus on the 80% and not the 20%. This was the fundamental insight which was the start of a long journey implementing coordinated purchasing activities in the organisation.

The ambition of this paper is to analyse the implementation of coordinated purchasing activities in one of the large Nordic Contractor – as an example of leveraging economy of scale in project based environments and thereby rethinking the predominant business model in construction.

2. Methodology

The analysis is inspired by a Grounded theory approach (Glaser & Strauss, 1967) where the empirical material has been collected prior to the theory formulation. In this way the theoretical categories and elements is induced from the empirical material and other theories regarding purchasing processes is only referenced for situate the findings in a larger perspective. Here it is worth stating that most academic contributions for understanding and developing purchasing seems to focus on project level (e.g. Khalfanand McDermott 2006) whether as this research looks upon purchasing as company specific strategy influencing the traditional project practices.

The induced approach for developing and implementing coordinated purchasing describes the tools and practices for analysing the existing purchasing activities, categorizing the purchasing volume, and the different strategies for addressing the different categories. Furthermore is the interface between the project and central purchasing activities is portrayed.

As the paper only analyzes one single case is the ambition not to adopt a classical quantitative methodology. The ambition is on the other hand to create qualitative insights from this particular case (Yin 2002) - raising key learning points, which subsequently can be subject to more detailed quantitative and qualitative analysis.

The empirical material for the case study is collected through the author’s previous employment within the contractor. Over a period of 6 year the development and implementation of coordinated purchasing has been followed both as an active part in a specific purchasing project and as an outsider. Consequently it is recognised that the author potentially is bias towards the players in construction (Loosemore & Tan 2000). In an effort to minimise this problem the interpretations and analysis have been discussed with the people within the company and academia.

The empirical material subject to the analysis encompass depth interviews with construction managers, an 18 month ethnographic study at a constructions site and an extensive amount of internal material including reports, analysis, presentation resumes etc. As a part of this material is confidential.
some of the figures in this paper are modified. Furthermore has the company has chosen to remain anonymous, but has approved the analysis and the conclusion of the paper.

3. Case analysis

The process of developing a strategic approach for coordinated purchasing in the contractor follows 4 stages:

1. Identification of categories
2. Prioritization of the categories
3. Running sourcing projects for the important categories
4. Implementation of the purchasing agreement for the category

3.1.1 Identification of categories

The first process is to get an overview of the how the money is spent in the organisation. This information can be gathered in different ways... but as this organisation didn’t have an existing purchasing system this was gathered from the economical system. Based on the list of creditors in the financial system, 103 different purchasing categories were identified and the purchasing volume for each category was estimated. Figure 3 below illustrates some of the different categories.

Figure 3: Different purchasing categories (Internal presentation - modified)
3.1.2 Prioritization of the categories

The next step in the process is to prioritize the identified categories. Based on interviews within the organization each category was evaluated in terms of the saving potential and how challenging the implementation would be. The result of this analysis is illustrated in figure 4.

Based on this figure it was possible to identify the most “promising” categories like concrete elements – and thereby prioritize the subsequent sourcing processes only addressing the most important categories. Three implementation waves were identified – estimating the potential savings for the first wave to several mio EUR.
Based on the different waves the categories were – as illustrated in figure 5 – categorized in strategic, high prioritized, low prioritized and other categories, each representing a decreasing percentage of the purchasing volume.

### 3.1.3 Running sourcing projects for the important categories

Based on the prioritization of the categories sourcing projects are initiated based on the following process.

![Figure 6: The sourcing process](image)

The definition of “the current situation” consists of the following major activities: Define Assortment, Specify Purchasing volumes, Map current suppliers, Make volume prognosis, Map current purchasing pattern, Map current logistic solution, Specify current prices, terms and conditions, Identify price drivers for the assortment, Make price comparisons, Identify National Standards and Legal Requirements.

In the next phase “mapping of potential suppliers” possible suppliers nationally and internationally are identified, possible trade obstacles are analyzed, supplier evaluation criteria’s are defined, financial control of potential suppliers are carried out, supplier shortlist are proposed and product test and supplier workshops are facilitated.

Based on these two phases the purchasing strategy is developed including positioning in Kraljic’s Matrix\(^2\) and estimation of potential savings. This strategy is presented to the board of directors who has to approve the execution of the strategy.

If the strategy is accepted the process continues with evaluation of proposals from the suppliers, assessment of each supplier, negotiations, selection of supplier, calculation of potential savings and development of documentation for the final decision.

Hereafter the agreement is signed with one or several selected suppliers including definition of evaluation parameters (internal and supplier related), description of roles, responsibilities and routine for follow up activities and formal communication of the agreement to the rest of the organization.

---

\(^2\) Kraljic’s Matrix (Kraljic 1983) is a tool for analyzing the purchasing portfolio of a company based on two dimensions profit impact and supply risk.
3.1.4 Implementation of the purchasing agreement for the category

After the sourcing process is ended and an agreement is established the formal implementation phase follows. Here different parameters influences the actual call-off process (project purchasing process)

- Categories of the agreement: Based on the sourcing process the agreement is labelled as being mandatory (1), optional (3) or something in between where the suppliers has to be asked in the project purchasing process (2)

- Type of product/service: Since the purchasing of subcontractors and highly complex products are very different from the purchasing of standard and bulk products, the call-off process is different. In the situation of simple products the construction manager requests the products from the contractors own whole-saler company being responsible for delivering the product to the construction site. In the case of more complex products and services “competence centres” are used. A competence centre is a group of specialist within a particular field like “facades and steel structures”. In collaboration with the project members they assist the project in the purchasing process.

As a consequence of the different parameters 15 different call-of processes are used in the project purchasing processes.

4. Reflections

The implementation of coordinated purchasing activities however faced tough resistance from the rest of the organization. The main reason for this resistance should be found in the fact that purchasing properly is the most essential practice for construction managers – both in relation to managing risks and more broadly as a part of their personal and cultural identity. It is through purchasing activities construction managers negotiate deals for their projects and thereby enable them to control their budgets. Furthermore is this negotiation a core part of the contractor identity and culture.

As a result was the initial response from the construction managers to the new purchasing strategy - denial. They simply ignored the negotiated purchasing deals/agreements – and continued their existing local purchasing practices. Especially among experienced project managers were the resistance profound. And since they represented a strong cultural driver they were setting the agenda for upcoming construction managers.

The board of directors response to the resistance was that construction managers, that didn’t followed the central negotiated agreements, were asked to find them self another contractor to buy for. The implementation was in this sense a very top-down driven process with potential dramatic personal consequences.

However, the severe resistance from the organization on the other hand initiated a revision of the purchasing strategy. After an internal workshop, central construction and design managers agreed upon that coordinated purchasing were an important strategy to pursue. However, according to them,
the potential of coordinated purchasing were not volume concentration, but the ability to buy the right "stuff". As a consequence it was not the purchasing process which was important but the design process. Their response was that it required

1. good project management skills (the ability to engage the right competences at the right time in the project)
2. that the contractor had the best competencies within the competence enters

Based on this insight they developed the division of labour illustrated in figure 7, highlighting the interplay between the competences centres and the project practices.

Based on the critique of the system the ambition of coordinated purchasing was revised. The board acknowledge that the initial high ambition was unrealistic and a target for the coordination of purchasing was established on 45% of the volume - leaving 55% to traditional purchasing practices. This target was established, in order to ensure a continuous drive for leveraging similarity across the projects. In this way the implementation of coordinated purchasing represents an organisational learning process which through incremental improvements gradually establishes a purchasing platform.
4.1 Value chain integration

Fernie et al. (2004) argues that integrated procurement strategies create an evolving context within which alternative managerial practice emerges. The implementation of coordinated purchasing is an exemplary case on this.

The implementation of coordinated purchasing has been a part of a cultural shift tying together the project based organization into an organization which leverages size and capabilities across projects in order to reduce cost and create value. This integration of the value chain occurs both upstream and downstream.

4.1.1 Downstream value chain integration

The basic idea of the purchasing strategy is to change the fragmented nature of the downstream value chain as illustrated in figure 2. By bypassing non-value adding parts of the value-chain cost can be further reduced as building materials are bought directly from the producers (nationally and internationally). This however requires that the material and labour costs are split, also changing the business model of subcontractors of the system. Consequently is the purchasing strategy in the contractor not only changing the purchasing practices within the organisation but also changing the very organization of the value chain. This is illustrated in figure 8.

Figure 8: Reorganizing the value-chain downstream

A similar development is found in the aerospace industry (Graham and Ahmed 2000) and other major sectors of industry (Thorburn and Takashima, 1993) reducing the list of supplier in terms of the number of companies included but extended geographically, both nationally and internationally.
4.1.2 Upstream value chain integration

The coordination of purchasing also represents an offset for new development initiatives integrating the value chain upstream. The upstream integration is driven by a desire to define “what to buy”... an activity which usually has been in the hand of architects and engineers. Inspired by the car industry the basic idea is to develop technical platforms (system deliveries) which address a certain market.

Platforms are well known in classical product oriented industries as a strategy for leveraging economy of scale - across products. Meyer & Lehnerd (1997) defines a platform as "a set of subsystems and interfaces that form a common structure from which a stream of derivative products can be efficiently developed and produced." (Meyer and Lehnerd, 1997, p. 39) These platforms can be developed at building level (e.g. an office platform) or at a component level (e.g. an installation shaft). This strategy is illustrated in figure 9.

Figure 9: Reorganizing the value-chain upstream by the use of platforms

Thereby is the adoption of coordinated purchasing an attempt to escape the existing red ocean market and establish a long standing competitive advantage through the development of core competencies around company specific purchasing.

5. Conclusion

This paper has analyzed the implementation of coordinated purchasing as a strategy for rethinking the predominant business model in construction. Based on a grounded theory approach the paper presents a process for developing and implementing coordinated purchasing by describing the practices and tools for analysing the existing purchasing activities, categorizing the purchasing volume, and the different strategies for addressing the different categories. In particular the interface between the project and central purchasing activities has been portrayed. The implementation of coordinated purchasing requires a significant change of mindset in the organisation challenging the predominant
project based culture. However despite the challenges coordinated purchasing represents as promising strategy for rethinking the business model within large contractors. A strategy which can be a part of a larger journey leveraging economy of scale even further, though the use of platforms, modularization and configuration.

References

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Abstract

The US Bureau of Labor Statistics (Teichloz, 2004) reported that construction industry is facing a severe decrease in labor productivity. Current research (Tommelein, 1999; Solis, 2007) in the industry shows evidences that complexity, variability, and uncertainty are the major causes of this decrease in productivity. Last Planner® System (LP®S) is a set of principles, functions and methods or tools that are designed to make construction plans more predictable. Several industry professionals have applied LP®S to solve different problems associated with uncertainty causes, the root of unpredictability. This research paper is based on critical rationalism method of LP®S using Karl Popper’s method of conjecture and refutation (1972) to identify and analyze what is the problem(s) that LP®S is addressing, the theories behind the problem solution, the methods and techniques used to eliminate errors and identify the problems that remain or are created. This research highlights the major causes of problems at both the front and back end that bracket LP®S solutions.

Keywords: Last Planner® System, lean construction, Karl Popper’s method
1. Introduction

Koskela’s 1992 Center for Integrated Facility Engineering (CIFE) report initiated the conception of the application of lean thinking in construction. In this report, Koskela explained the transformation flow and value (TFV) concept. It has motivated further elaboration and application by researchers throughout the industry with the goal of generating value for clients and reducing waste. Mitigation of waste from the bottom up in the supply chain was identified as an indirect source of generating value. A group of researchers and scholars, the International Group of Lean Construction (IGLC) was established in 1993 to further the quest for mitigating waste and generating value. In 1997 Lean Construction Institute (LCI) was established to research and develop knowledge regarding project based production management in the design, engineering and construction of capital facilities. Ballard (2000) of the LCI developed the Last Planner® System (LP®S) of production control. Moreover, Lean tools developed for work flow smoothening, performance measurement, among others, are implemented in the construction industry for different project types such as buildings, highways, heavy industrial, prefabrication etc.

Ohno (1988) has defined seven wastes in manufacturing that lean construction has adopted: overproduction, conveyance, inventory, waiting, processing, motion and correction. Case studies published in IGLC conferences, LCI journals, Construction Industry Institute (CII) reports, American Society of Civil Engineers (ASCE) conferences and journals and other relevant publications on lean construction are good resources to study how construction industry’s lean practices address these seven types of waste; what lean theories are applicable; what lean and other tools and techniques are employed; and most important, what are the resultant, remaining or emerging problems that require focused attention. For example CII publication “Road map to Lean Implementation at Project Level” (Ballard, 2007) lists fifteen case studies, some anecdotal from lean practitioners and others from controlled observation and experimentation. The case studies included in lean construction literature cite the theories and principles invoked, mentions the tools and techniques employed and reports on the results from the implementation of lean tools.

2. Assumptions and limitations

The world of lean thinking comprises manufacturing of products and construction. This research is limited to lean thinking and practices in construction of differing project types (i.e. building, highway etc.)

Literature search points to a set of approximately 250 reported building construction case studies from academia and from practitioners. This research is has catalogued the set of reported and available building construction case studies from literature search into these two categories. Critics of the lean movement argue that lean case studies do report the remaining or ensuing problems while critics of professional practice case studies argue that the evidence cited is anecdotal and not verified by an independent third party. For the purpose of this study, the identified set of case studies is taken at face value. Secondary data is used to support the argument.
This research focuses on LP®S which narrows the case study set to approximately 112. Literature of these case studies must mention LP®S as the referenced system in a building construction project and the application of LP®S tools and techniques. Other systems of lean thinking are not in the scope of this research.

The set of case studies is randomly narrowed down to 50 by using Monte Carlo simulations (Robert C. et. al, 2004) because of time and financial constraints. For the purpose of this study, the working set of case studies is considered to be representative of the industry for statistical purposes.

3. Objectives

The objective of this research effort is to identify the existing problems reported by the authors of the case studies, showing the authors use of LP®S tools to solve the problems and analyze the reported outcomes to seek emerging or residual problems. For example: A case study reports problems (such as work plan unreliability, Ballard 2000) as well as solutions (such as applying LP®S) however obstacles, barriers, new problems remain or are created in the implementation of lean principles (difficulty in changing an organization culture, the increased amount of meetings and report, reversion to command and control management practices when crisis arise, etc).

4. Research method

Karl Popper’s (1972) method of conjectures and refutations serves as a framework to analyze how the perceived problem initiates a quest for tentative theories and error elimination as a way of solving an identified problem. However, Popper’s method states that the result is a new version of the problem or an unintended problem (Solís, 2009). This paper applies Popper’s method to a selected set of case studies that use LP®S (see formula below):

\[ P_1 = TT_1 + EE_1 = P_2 \]

\( P_1 \): Original Problem

\( TT_1 \): Tentative Solution or Tentative Theory

\( EE_1 \): Error Elimination

\( P_2 \): Emerging problem

5. Literature review

The world of lean applies to manufacturing and construction. Within the construction lean movement, there are a set of projects that have documented and published the application of lean thinking, principles, tools and techniques along with results, findings and problems. This research literature review seeks to find the set of case studies in construction that use lean and then refine the set to those
that have used LP®S due to the assumptions and limitations cited. Therefore this literature review aims to understand the problems, theories, principles, tools and techniques that are found in LP®S along with the criticism that has emerged from the academic and professional practice.

5.1 Background

1973’s oil crisis brought Toyota Production System (TPS) into lime light of world automobile industry. Toyota Production System was created by Mr. Ohno of Toyota Motors. “The basis of TPS is the absolute elimination of waste. The two pillars of TPS are just-in-time (JIT) and autonomation (automation with human touch)” (Ohno, 1988). Here we begin the application of Popper’s method: a crisis, a theory with a process of error (waste) elimination and new problems arising.

Based upon the studies of the car manufacturing industry in Japan and other countries worldwide Womack et al. (1990) coined the term lean production to describe the implementation of the ideas inherent in the TPS. In 1992 Koskela pointed out the need to understand the new production philosophy (lean production) and he explained it with the theory of transformation flow and value (TFV). In Popper’s method (our framework for analysis): construction industry’s lack of value and abundance of waste is construed as a problem. The theories of TPS are adapted and applied and a process of error elimination (increased tools and techniques) is created to solve the problem and new problems remain or arise.

Lean construction principles and practice have been examined and developed in two interacting research streams. The practical stream started with Ballard and Howell’s (1995) observations that typically only half of the tasks in a weekly plan get realized as planned on site (problem that causes waste in production processes). In a series of experimental work, a new approach to production control, called the LP®S was developed (Ballard 2000). The LP®S addresses constant production improvement methods that seek to indentify and minimize waste.

Popper’s method requires that the solutions to problems be based on theories, principles, and methods for error elimination. We now consider these in view of lean thinking.

5.2 Lean principles

The ideas of lean thinking were originally encapsulated within Toyota Production System and are well articulated by Womack et al. (1990), lean thinking subsequently because the generic term to describe its universal application beyond manufacturing (Womack and Jones 1996).

Lean thinking comprises different ideas including continuous improvement, flattened organization structures, teamwork, elimination of waste, efficient use of resources, relational contracting and cooperative supply chain management, among others. In the construction industry, the language of lean thinking has since become synonymous with best practice, a term that Green (2000) objects. The most frequently cited definition of lean principles found in the literature is that of Womack and Jones (1996);
(1) Specify value (2) Identify the value stream for each product (3) Make the product flow without interruptions (4) Let the customer pull value from the producer and (5) Pursue perfection.

The application and benefits of lean thinking, principles, functions and methods in construction are under investigation and a number of case studies are published. For example, Thomas et. Al’s, (2003) case study reports that more reliable flows lead to a better labor performance.

5.3 Koskela’s TFV theory based on lean principles

Research in lean construction is robustly shaped by the emergence of the Koskela’s Transformation-Flow-Value (TFV) theory. Koskela described the traditional perception of construction production as a transformation of inputs into outputs. Complementing the current transformation view with the value and flow concept, the TFV theory introduced a new paradigm of production centered on flow to reduce waste and maximize customer value. This theory advocates designing, operating and continuously improving production from the combined perspective of transformation, flow, and value (Koskela 1992).

5.4 Last Planner® System of Production Control (LP®S)

Last Planner® System of production control can be characterized in terms of the principles that guide thinking and action, the functions it enables to be performed, and the methods or tools used to apply those principles and perform those functions (Ballard 2009).

Howell and Ballard’s studies (1994) about the “Last Planner” technique showed that the use of formal and flexible production planning procedures is the first step to keep the production environment stable.

5.4.1 Principles of LP®S

(1) Plan in greater detail as you get closer to doing the work (2) Produce plans collaboratively with those who will do the work (3) Reveal and remove constraints on planned tasks as a team (4) Make and secure reliable promises (5) Learn from breakdowns.

5.4.2 Functions of LP®S

(1) Collaborative planning (2) Making Ready (2a) Constraints identification and removal (2b) Task breakdown (2c) Operations design (3) Releasing (4) Committing (5) Learning

5.4.3 Methods and tools used to apply LP®S/ (LP®S sub-systems)

(1) Reverse phase scheduling (aka ‘pull planning’, ‘pull scheduling’, ‘phase scheduling’, stickies-on-a-wall)-
A pull technique is based on working from a target completion date backwards, which causes tasks to be defined and sequenced so that their completion releases work; i.e., achieves a handoff. A rule of “pulling” is to only do work that releases work – requested by someone else (Howell et. Al, 2003)

(2) Look-ahead Planning-

Each responsible individual (RI) for a group of performers (crews, teams, and individual performers) reviews the work in the coming six weeks, identifies whatever is needed to do the work, and makes the requests and receives promises necessary to assure the wherewithal will be available when required. The Ris ask for help whenever they lose confidence that the work will be ready when required. The team adjusts or reaffirms the plan in regular meetings during the lookahead period. The lookahead plan establishes what can happen and serves as the basis for securing reliable promises for the coming week’s work.

(3) Weekly Work Planning-

Final coordination of the work in the coming week (or two) is completed as each RI makes promises to the project manager stating what will be delivered and by when. Capacity is allocated by day in support of those promises. These promising conversations occur in a group setting allowing other Ris to assess coherence with their own promising. Adjustments to the weekly work plan (WWP) are made during the meeting.

(4) Daily Planning-

Brief “stand-up” meetings (or conference calls) are held daily to report WWP completions, adjust to the circumstances, re-promise as necessary, get help from each other, and record plan variances and their reasons. This meeting serves as a controlling or steering function that allows those closest to the work to adjust to the always-changing circumstances of the project.

(5) Percentage Plan Complete: Percent Plan Complete (PPC) is the number of planned activities completed, divided by the total number of planned activities, and expressed as a percentage.

Refer to figure-1 to see the role of LP®S during the planning process.
6. Data collection

This research is a qualitative research, where literature survey method is applied to map (1) the lean principles applied to implement LP®S (2) the LP®S functions used (3) set of lean methods and tools used to apply LP®S (4) existing problems and their solutions on the use of LP®S (5) emerging and residual problems on the use of LP®S. Green (2000) is a foremost critic of lean in construction and a major contributor to critical rationalism in the area.

Case studies, using LP®S, published in refereed journal papers, conference proceedings, dissertations, technical reports (publications such as ASCE, IGLC, LCI, CIFE, and CII) and other related resources comprise the set for study. Selection of case studies for this research is done through the repeated random sampling using Monte Carlo Method (Robert C. et. Al, 2004).

Table: 1 – Data form

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Existing problems for which LP®S was used (P1)</th>
<th>Lean principles applied to implement LP®S (TT1)</th>
<th>Lean methods and tools used to apply LP®S (EE1)</th>
<th>Emerging and residual problems (P2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Analysis

The following example illustrates a case (also shown in table-2):

\( P_1 = \text{Adversarial relationships between project participants} \)
\( TT_1 = \text{Koskela’s (1992) transformation, flow and value} \)
\( EE_1 = \text{Partnering and collaboration} \)
\( P_{2.1} = \text{Redistribution of power} \)
\( P_{2.2} = \text{Employees reject new system} \)
\( P_{2,3} = \text{Lack of clarity about responsibilities} \\
\( P_{2,4} = \text{Cost benefits of change are unclear} \)

**Table: 2 - Example: (Barlow J. 1996)**

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Existing problems for which LP®S was used (P1)</th>
<th>Lean principles applied to implement LP®S (TT1)</th>
<th>Lean methods and tools used to apply LP®S (EE1)</th>
<th>Emerging and residual problems (P2)</th>
</tr>
</thead>
</table>
| CS1        | Adversarial relationships between project participants | Collaborative planning; Partnering; Make the production flow without interruptions | Lookahead planning, weekly work plan, daily huddle meeting, percentage plan complete, constraint analysis, pull scheduling | (1) Redistribution of power  
(2) Employees reject new system  
(3) Lack of clarity about responsibilities  
(4) Cost benefits of change are unclear |
| CS2        |                                              |                                              |                                              |                                   |

8. Verification

A structured survey will be created from the findings of this research. Glenn Ballard, Gregory Howell, Lauri Koskela, S. Bertelsen, Iris Tommelein and S. Green will be surveyed and questioned on their perception of the major problems that remain or are created by the application of LP®S. The information gathered will be compared with the research findings.

9. Significance of the Research

This research investigates if LP®S, as a system conceived to solve identified problems, creates manifestations of old or new problems. Emerging or new problems will be grouped by types and used to make recommendations for improvements in lean thinking.

References


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A Model at the Construction Firm Level of Interrelationships of Competitiveness Factors and Indexes

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Abstract

Today’s competitive situation among construction companies, characterized by globalization and the need to survive, has lead to an urgent need for competitiveness management. On this regard, there exist several studies around the world trying to find out what are the most important factors affecting contractors’ competitiveness. Also, because of the wideness of the competitiveness concept, several indexes have been proposed to measure it. All these variables linked to competitiveness do not provide enough useful information for managers. A model which shows how they interact between them is missing. Based on a proposed interrelationship model between competitiveness factors and indexes, this paper presents the findings of a survey aimed to know the most relevant subfactors and sub-indexes in Chilean construction industry. This survey is an intermediate stage in order to find those subfactors and sub-indexes that are going to be analyzed in the interrelationship model, besides it allows knowing the competitiveness’ criteria that rules the Chilean construction industry. As a conclusion of this intermediate stage, we can confirm that competitiveness for Chilean contractors has different areas of interest than other countries, and they need to be studied in order to find how they are related to each other.

Keywords: competitiveness, interrelations, factors, indexes.
1. Introduction

The “competitiveness” concept has been largely accepted and handled across all industries and countries since Porter published his book “Competitive Strategy” in 1980. This concept has gained interest for both practitioners, who have to take the competitive environment that influences their actions into account, and researchers, who have been trying to improve their understanding of this phenomenon.

The construction industry is one of the most important industries in many countries since it usually represents a substantial percentage of the gross domestic product (GDP) (Ericsson and Henricsson, 2005; Flanagan et al., 2005a). Current market situation, within a global context, generates in companies the need to be competitive in order to survive, and this hyper-competitive age has created the need for an explicit management of competitiveness (Ambastha and Momaya, 2004). As stated by Flanagan et al. (2005a), it is vital for nations to increase their knowledge and understanding of competitiveness in the construction industry. In order to formulate strategies for competitiveness, managers need to know what the variables that affect the expected results are, and how are they interrelated. Literature about competitiveness presents two kinds of variables; on the one hand, there are factors, sources or determinants of competitiveness; on the other hand, there are indexes, measuring the competitive performance of the construction company at a specific point in time. Some interactions between those factors and indexes have been analyzed by several researchers (e.g. Phua, 2006; Cheah et al., 2007). However, a more comprehensive framework is needed, which would consider factors, indexes and the interrelationships between them. In their literature review, Flanagan et al. (2007) also support that more research is needed to help firms formulate competitive strategies and tactics. In line with this need, we have developed a preliminary conceptual model of the interrelations between competitiveness factors and indexes at the firm level, and this paper presents the theoretical basis for the model and results of an intermediate stage of this research about what are the most relevant competitiveness subfactors and sub-indexes for Chilean contractors to take into account for the interrelationship model.

2. Literature review

2.1 Concept of competitiveness

Despite its wide usage, there is no consensus about the meaning of competitiveness (Flanagan et al., 2005a; Lu, 2006). There are many definitions for this concept; however, some relevant elements can be extracted from them to get a better understanding about it. Some of them are presented in Table 1.
Table 1 Elements that are relevant for defining competitiveness

<table>
<thead>
<tr>
<th>Element</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is a concept more powerful than traditional economic indicators</td>
<td>Lu, 2006</td>
</tr>
<tr>
<td>such as profitability, productivity or market share</td>
<td></td>
</tr>
<tr>
<td>It is a cause, an outcome, and a means</td>
<td>Waheeduzzan and Ryans, 1996</td>
</tr>
<tr>
<td>Associated with achieving an objective</td>
<td>Flanagan et al., 2005a</td>
</tr>
<tr>
<td>It is relative to competitors</td>
<td>Buckley et al., 1988</td>
</tr>
<tr>
<td>It belongs to the eye of the beholder (it means different things for</td>
<td>Waheeduzzan and Ryans, 1996;</td>
</tr>
<tr>
<td>different people)</td>
<td>Flanagan et al., 2007</td>
</tr>
<tr>
<td>Not only reflects past performance, but also allows the perception of</td>
<td>Buckley et al, 1988</td>
</tr>
<tr>
<td>potential…</td>
<td></td>
</tr>
<tr>
<td>It must satisfy the needs of clients</td>
<td>Momaya and Selby, 1998</td>
</tr>
<tr>
<td>It must satisfy the needs of the personnel</td>
<td>Momaya and Selby, 1998; Invancevich et al., 1994</td>
</tr>
<tr>
<td>It is related to superior quality</td>
<td>Momaya and Selby, 1998</td>
</tr>
</tbody>
</table>

Besides those elements, competitiveness is also related to high productivity (Flanagan et al., 2005a; Flanagan et al., 2005b), innovation (Momaya and Selby, 1998), value for shareholders (Momaya and Selby, 1998), and profitability (Flanagan et al., 2005b), among other qualities. In summary, as stated by Flanagan et al. (2007), the ultimate purpose of competitiveness is to improve and achieve a better long-term performance for firms. The above mentioned elements, altogether, should be used as a guide in the selection of the appropriate factors and indexes.

2.2 Competitiveness factors at the firm level

At the firm level, there are factors that influence the competitiveness level of a company, and also, there are indexes which altogether measure the competitiveness reached by the firm. At the same time, competitiveness factors for a company can be split in endogenous and exogenous. Endogenous factors are those which are produced inside the company, so management can act on them in order to achieve its goals. Exogenous factors are originated outside the company; they form the environment in which companies have to compete, and management has not, or almost no influence over them.

Fifty eight endogenous subfactors have been found in at least two different sources, and they have been grouped into seven factors, which are: (1) strategic management, (2) project management, (3) human resources management and organizational culture, (4) innovation, R&D, and technical/technology factors, (5) financial capacity, (6) institutional and business relationships, (7) bidding factors. Figure 1 shows an example of sub-factors included in the first two endogenous factors.
The factors and sub-factors have been arranged in a descending order based on the number of times that each of them was cited in the literature to get an idea about the relative importance of each one. The number of times mentioned could be an indirect measure for their relevance, but it needs to be confirmed through interviews and surveys directed to construction companies CEOs in the analyzed environment, which in this case will be the Chilean construction industry. Besides, as both industry and firm effects are considered important in shaping business results (Rumelt, 1991), we have also found eleven exogenous subfactors mentioned in at least two different sources.

### 2.3 Competitiveness indexes at the firm level

The performance indexes traditionally have concentrated on finance performance, but they tend to measure only the past and the easily measurable. Since the late 1980s, increased globalized competition has forced companies to consider non-traditional measures (Kagioglou et al., 2001). Competitiveness is a complex concept and, according to the elements in its definition, it comprises several performance measures. Literature about competitiveness assess company’s performance through nine indexes: (1) financial indicators, (2) non-financial productivity, (3) traditional project performance indicators, (4) client satisfaction, (5) market share, (6) society satisfaction, (7) bidding effectiveness, (8) future capabilities, and (9) personnel satisfaction. Each of these groups comprises a certain number of indicators. A comprehensive list of competitiveness indexes was developed (an example is provided in figure 2 showing only two indexes with their respective indicators).
Strategic planning has a low profile in the construction industry and receives a low level of attention (Bassioni et al., 2004). Construction companies, for the same reason, are traditionally pursuing a cost leadership strategy instead of designing a competitive strategy better suited for them (Bassioni et al., 2004). Strategic planning, in a simple way, is about breaking down a goal or set of intentions into steps (Ngowi and Rwelamila, 2001). Its process, as it has been discussed in Venegas and Alarcón (1997), includes proposing, studying, and choosing action courses intended to reduce the existing gap between current and expected position and involves a whole stage of strategies formulation, evaluation, and selection of action options. The expected position, for a company, can be established through clear goals (i.e., indexes), and in order to fulfill them, managers need to know how factors are associated with those results.

Since managers, at this stage of the strategic planning process, need an adequate amount of information, the proposed preliminary model presents interrelationships between competitiveness factors (endogenous and exogenous) and indexes that have to be taken into account, helping construction executives to understand the variables and effects involved in their decisions, as requested by Venegas and Alarcón (1997). The preliminary model (see figure 3) exhibits the variables and interrelationships that would determine competitiveness in a construction firm. It is used to identify how competitiveness factors impact the firm’s competitive performance. The model has three main components: (1) exogenous factors; (2) endogenous factors; and (3) competitiveness indexes. In the literature, some interactions between endogenous factors and indexes have been analyzed empirically, while others have been assumed theoretically. Additional hypothetical feasible relationships will need to be created in order to generate a complete network between them.
Figure 3 Preliminary conceptual interrelationship model for competitiveness at firm level.

The quantitative analysis of the proposed model will contribute to a better understanding of the interrelationships between variables determining company competitive performance, and this cognition could be associated with the performance of the business, as suggested by Jenkins and Johnson (1997). This approach intends to support strategic planning in construction companies, by helping managers to direct company’s efforts to those factors that mostly contribute to the specific indexes that need to be improved. Understanding the interrelationships allows the identification of relevant factors affecting each index, and also the quantification of the magnitude of their effect. As it has been argued by Kagioglou et al. (2001), it is only by understanding how the organization arrives at a particular performance, that an organization might start to improve and increase its market share.

4. Most relevant subfactors and sub-indexes

As we have shown in the conceptual model, we would like to know the interrelationships between the most relevant competitiveness subfactors and sub-indexes. In order to do that, we need to find out which of them are the most relevant for Chilean contractors. In this regard, Ericsson and Henricsson (2005) have found differences in how experts from Finland, Sweden and UK have arranged competitiveness factors in their countries. But, they also differ from those found by: Yates (2004) in United States of America; Shen et al. (2006) in China; and E-Diraby et al. (2006) in Canada. Then, prior to analyze competitiveness at any level, you have to take into account how that industry or country understands competitiveness and how do they prioritize their subfactors and their sub-indexes.
As an intermediate stage, in order to analyze interrelationships between the most relevant subfactors and sub-indexes, we have applied a face-to-face survey to twelve contractors’ CEOs. This survey has been designed to know the most relevant subfactors for each factor, and the most relevant sub-indexes for each index. Instructions for our survey were to choose those subfactors or sub-indexes more relevant for each factor or index. They were asked to mark around half of either subfactors or sub-indexes into each factor or index. For instance, if there were twelve subfactors in a factor, CEOs had to mark six of them as the most relevant, but they were free to mark either five or seven, as long as they could differentiate the most relevant from those that are not. Finally, we just have to add up votes for each subfactor and sub-index in order to find those considered relevant for most of CEOs. Table 2 and table 3 present those subfactors and sub-indexes, respectively, voted by more than 80% of interviewed CEOs, but there has to be at least two in each group. It also shows, for each one, the percentage of votes relative to total votes in that group (i.e. factor or index), and the cumulative percentage which give us an idea of in what extent those subfactors or sub-indexes explain each factor or index.

Table 2 Most relevant subfactors for Chilean contractors.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>STRATEGIC MANAGEMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leadership</td>
<td>83%</td>
<td>14.3%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Image and reputation</td>
<td>83%</td>
<td>14.3%</td>
<td>28.6%</td>
</tr>
<tr>
<td>PROJECT MANAGEMENT</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Contract management</td>
<td>92%</td>
<td>14.9%</td>
<td>14.9%</td>
</tr>
<tr>
<td>Health and safety management</td>
<td>83%</td>
<td>13.5%</td>
<td>28.4%</td>
</tr>
<tr>
<td>HUMAN RESOURCE MANAGEMENT AND ORGANIZATIONAL CULTURE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team work</td>
<td>100%</td>
<td>16.7%</td>
<td>16.7%</td>
</tr>
<tr>
<td>Training</td>
<td>83%</td>
<td>13.9%</td>
<td>30.6%</td>
</tr>
<tr>
<td>Incentive and rewarding system</td>
<td>83%</td>
<td>13.9%</td>
<td>44.4%</td>
</tr>
<tr>
<td>Personnel engagement and motivation system</td>
<td>83%</td>
<td>13.9%</td>
<td>58.3%</td>
</tr>
<tr>
<td>INNOVATION, R&amp;D, AND TECHNICAL AND TECHNOLOGICAL FACTORS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical and technological abilities</td>
<td>100%</td>
<td>34.3%</td>
<td>34.3%</td>
</tr>
<tr>
<td>Innovation (products, services, or inner processes)</td>
<td>92%</td>
<td>31.4%</td>
<td>65.7%</td>
</tr>
<tr>
<td>Construction plant capacity</td>
<td>83%</td>
<td>28.6%</td>
<td>94.3%</td>
</tr>
<tr>
<td>FINANCIAL CAPACITY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy and stable financial status</td>
<td>100%</td>
<td>50.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Financing ability</td>
<td>75%</td>
<td>37.5%</td>
<td>87.5%</td>
</tr>
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<td>INSTITUTIONAL AND BUSINESS RELATIONSHIPS</td>
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<td></td>
</tr>
<tr>
<td>Relationship and alliances with owners</td>
<td>83%</td>
<td>29.4%</td>
<td>29.4%</td>
</tr>
<tr>
<td>Relationship and alliances with suppliers</td>
<td>75%</td>
<td>26.5%</td>
<td>55.9%</td>
</tr>
</tbody>
</table>
### BIDDING FACTORS

| Company experience | 100% | 33.3% | 33.3% |
| Ability to compete in price | 75% | 25.0% | 58.3% |

### ENVIRONMENT

| Number and kind of competitors | 83% | 14.9% | 14.9% |
| Shortage of qualify subcontractors and labour | 83% | 14.9% | 29.9% |

### Table 3 Most relevant sub-indexes for Chilean contractors.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>FINANCIAL INDICATORS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit margin</td>
<td>67%</td>
<td>21.6%</td>
<td>21.6%</td>
</tr>
<tr>
<td>Cash flow / Liquidity</td>
<td>67%</td>
<td>21.6%</td>
<td>43.2%</td>
</tr>
<tr>
<td>Productivity of investments (ROE)</td>
<td>50%</td>
<td>16.2%</td>
<td>91.9%</td>
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<tr>
<td><strong>NON-FINANCIAL PRODUCTIVITY</strong></td>
<td></td>
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<tr>
<td><strong>TRADITIONAL PROJECT PERFORMANCE INDICATORS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>83%</td>
<td>23.8%</td>
<td>23.8%</td>
</tr>
<tr>
<td>Quality</td>
<td>75%</td>
<td>21.4%</td>
<td>45.2%</td>
</tr>
<tr>
<td>Time</td>
<td>75%</td>
<td>21.4%</td>
<td>66.7%</td>
</tr>
<tr>
<td>Health and safety</td>
<td>75%</td>
<td>21.4%</td>
<td>88.1%</td>
</tr>
<tr>
<td><strong>CLIENT SATISFACTION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction with service</td>
<td>83%</td>
<td>24.4%</td>
<td>24.4%</td>
</tr>
<tr>
<td>Delivery time</td>
<td>83%</td>
<td>24.4%</td>
<td>48.8%</td>
</tr>
<tr>
<td>Satisfaction with product</td>
<td>83%</td>
<td>24.4%</td>
<td>73.2%</td>
</tr>
<tr>
<td><strong>MARKET SHARE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SOCIETY SATISFACTION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respect for laws and regulations</td>
<td>83%</td>
<td>40.0%</td>
<td>40.0%</td>
</tr>
<tr>
<td>Environmental consciousness</td>
<td>67%</td>
<td>32.0%</td>
<td>72.0%</td>
</tr>
<tr>
<td><strong>BIDDING EFFECTIVENESS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract volume growth</td>
<td>83%</td>
<td>43.5%</td>
<td>43.5%</td>
</tr>
<tr>
<td>Percentage of contracts won</td>
<td>75%</td>
<td>39.1%</td>
<td>82.6%</td>
</tr>
<tr>
<td><strong>FUTURE CAPABILITIES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost-reduction abilities</td>
<td>92%</td>
<td>32.4%</td>
<td>32.4%</td>
</tr>
<tr>
<td>Cutting-edge technology applied in projects</td>
<td>83%</td>
<td>29.4%</td>
<td>61.8%</td>
</tr>
<tr>
<td><strong>PERSONNEL SATISFACTION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personnel motivation</td>
<td>92%</td>
<td>30.6%</td>
<td>30.6%</td>
</tr>
<tr>
<td>Career prospect and employee development</td>
<td>75%</td>
<td>25.0%</td>
<td>55.6%</td>
</tr>
</tbody>
</table>
**Strategic management.** Leadership and company’s image and reputation have been the most voted subfactors for strategic management factor. About company image and reputation, in spite of been an industry based mainly in price as awarding criterion, CEOs believes that this issue can have a major influence over clients. Some of CEOs, who have a more marked client focus, are agree with this idea, and they are always trying to keep a superior image in order to imply a lesser risk for clients.

**Project management.** Since a CEOs perspective, with a more strategic focus in relation to project management, contract management has been considered as the most relevant subfactor (92% of votes). Contractors, as has been mentioned by them, each day are more aware about how to avoid conflicts through very clear and well defined contracts, with clauses that assign risks to those that can handle them. The relevance of this topic is related to client focus because contracts are an instrument to avoid conflict and to keep good relationships.

**Human resource management and organizational culture.** There was consensus among CEOs about the relevance of teamwork, standing out their great interest to attain a team spirit within their companies. Training, incentive and rewarding system, and personnel engagement and motivation level, got 83% of votes.

**Financial capacity.** Healthy and stable financial status is considered one of the most important subfactors for contractor’s competitiveness, according to most of CEOs, and it was voted for all of them. The next most voted subfactor was the financing ability (75% of votes), even that some of the CEOs remarked that their companies are operating just with their own capital.

**Institutional and business relationships.** Relationships and alliances with clients (owners) was the most voted (83%), in accordance with relevance given to client focus subfactor for strategic management factor. It was followed, with 75% of votes, by relationships and alliances with suppliers, which importance has been supported by literature about scale economies and partnering.

**Innovation, research and development, and technical and technological factors.** Technical and technological abilities have been pointed out as the most important subfactor for this factor, getting consensus among CEOs. Lack of technical expertise for certain projects represents a reason for not bidding, as a CEO state. That’s why CEOs get concern about having experienced personnel and technology that allow them to exceed the required specifications in projects. Innovation is the next most voted subfactor (92%). As a result of competitiveness, product, service or process innovation has become a relevant topic for most of contractors. Several actions has been mentioned by CEOs in this regard, as: attending international construction fairs as sources for ideas to develop equipment and processes; using special formworks to rise productivity; having personnel assigned to find new technology or process; developing of equipment prototypes; and rewarding systems to encourage initiatives to improve productivity.

**Bidding factors.** All CEOs agreed that company experience is the most relevant subfactor for this factor. However they also coincide that the next most important criterion for bid assessment is price (voted by 75%). Price reflects a short-term culture of clients, due mainly because they leave aside other relevant factors that cannot be quantify, and it becomes a vicious circle because there are
contractors who have the same approach. However, the strategic focus showed by several CEOs prove that this criterion is changing, or at least, there exist a sub-market where clients take into account more subfactors as: quality, reliability, service, technical ability, reputation, ethics, etc.

**Environment (i.e. exogenous factors).** Regarding environmental subfactors, there have been two of them which were remarked by 83% of CEOs: number and kind of competitors (either local or foreign), and shortage of qualified labor and subcontractors. Those exogenous factors could be a result of the current economic crisis that is affecting normal operations of construction companies. Some CEOs have concluded that due to the decrease in number of construction projects and because developers have temporally become contractors, it has generated an important increase of contractors bidding for available contracts. For instance, before crisis contractors have to compete against three or four companies, but nowadays they have to compete against ten or more. In the other hand, shortage of qualified labor and subcontractors can be though as a consequence of country’s social situation and because of the lack of professionalization of most of subcontractors.

**Financial sub-indexes.** CEOs have chosen three sub-indexes as the most representative for measuring the financial status of a contractor: profit margin (gross profit/total revenue), cash flow or liquidity, and return over equity (ROE). The first two of them with 67% of votes, and the last one with only 50%, however, during interviews CEOs remarked the relevance of ROE, so it will be considered for further stages of this research.

**Non-financial productivity.** Regarding to productivity level due to labor, machinery and equipment, it is checked by all companies at project level, but 83% of CEOs didn’t have productivity indicators at firm level, they just look at financial productivity (e.g. ROE). Some of them have tried to use gross profit versus number of personnel as productivity indicator at firm level, but it wasn’t reliable because of the big monthly fluctuation of work volume.

**Client satisfaction.** As mentioned before, there exists a big concern about client satisfaction in strategic management. CEOs have identified three sub-indexes that mostly represent this index: satisfaction with service provided; satisfaction with on-time delivery; and satisfaction with the product itself. Each of these sub-indexes was voted by 83% of CEOs. Satisfaction through service matches with practices of some CEOs consisting in: giving a personalized service, avoiding conflicts, frequent satisfaction surveys, etc.

**Market share.** Both size and growth in market share were assessed as not relevant for most of CEOs. They don’t use them as indicators. Rather, most of them are focused in surpassing their own established minimum construction volume in order to have presence and cover their fixed costs, and their goal is having a controlled growth that doesn’t mean a loss of control in project management. Most of them expressed to be mainly focused in profitability, not in construction volume.

**Society satisfaction.** In relation to society satisfaction, CEOs considered more relevant the respect for laws and regulations, and environmental consciousness. Even that the former is obligatory, it has to be encouraged and supported by managers’ policies. About environmental consciousness (67%), it could be also generated by regulatory issues more than because of inner policies; however CEOs
have given more relevance to this one than to community support which was voted by just 58% of CEOs. Even that community support obtained fewer votes; it has a great relevance for those companies that are continuously developing projects in rural areas.

**Bidding effectiveness.** About contract volume, every contractor has to cover a minimum, and they try to grow at a rate higher than inflation, however they also have limits to grow because a fast growth can result in a loss of control, as several of them has experimented. The percentage of contract won is also a CEOs’ concern, so several of them are trying to focus their efforts in projects where their companies have more chances to win. Even they try to be very selective about their tenders. During this economic crisis effectiveness percentages have fallen from around 40% to 15%, based on experience from two CEOs.

**Future abilities.** Another relevant index to measure competitiveness is what companies are capable to do in a near future (i.e. potential). In line with this concept and according to Chilean industry situation, CEOs gave more votes to ability for cost reduction (92%) and technological advances applied to project execution. The former reflects the CEOs’ believe that price will continue been one of the most important bidding criteria, and because this ability can increase their profit margin. The other sub-index, technological advances applied to projects, shows the CEOs’ concern about having cutting-edge technology and to innovate to do their projects faster and with better quality.

**Personnel satisfaction.** CEOs, in order to measure personnel satisfaction, have considered two aspects as the most relevant: personnel motivation (92% of votes), career prospect and employee development (75%). In general, CEOs agree that personnel satisfaction is very relevant for company performance.

**Traditional project performance indicators.** Concerning about quality, time, cost, and health and safety, all of them were considered as relevant for competitiveness. CEOs had problems to choose just three of them, so we will take them all for our interrelationship model analysis.

### 5. Conclusions and further work

Research about competitiveness at the firm level has to consider three main elements: endogenous factors, exogenous factors, and indexes. Altogether they present a firm’s competitive performance and provide the necessary information to analyze how they are interrelated. A comprehensive literature review listing main factors and indexes is the basis for further research on competitiveness. The most relevant elements of the concept of competitiveness help in advancing its understanding and allow working to improve long-term performance of companies.

As it was expected, competitiveness subfactors and sub-indexes were prioritized in different way for contractors in Chile than in other countries. This intermediate stage of our study has delimited those elements that has to be taken into account for the interrelationship model. Now, those most relevant subfactors and sub-indexes are going to be measured to find out interrelationships between them. Through qualitative analysis of this model, managers could have a better understanding of the
linkages between competitiveness factors and indexes and therefore a broader picture about their business.

Time horizon for this research is cross-sectional, however, a systematic measurement of indicators periodically allows capturing indicators trends, and generating a dynamic model for competitiveness. This periodical measurement could be a good starting point to analyze long-term competitive performance.

Another further step in this direction is to develop a competitiveness measurement system for this interrelationship model with hard data for internal use at a company. It will allow companies to monitor and to analyze trends in their own competitiveness factors and performance.

**References**


CIB’s mission is to serve its members through encouraging and facilitating international cooperation and information exchange in building and construction research and innovation. CIB is engaged in the scientific, technical, economic and social domains related to building and construction, supporting improvements in the building process and the performance of the built environment.

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- participation in local and international CIB conferences, symposia and seminars
- CIB special publications and conference proceedings
- R&D collaboration

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- Durability of Building Materials and Components (W080, RILEM & ISO)
- Quality and Safety on Construction Sites (W099)
- Construction in Developing Countries (W107)
- Sustainable Buildings regional and global triennial conference series (CIB, iSBE & UNEP)
- Revaluing Construction
- International Construction Client’s Forum

**CIB Commissions (August 2010)**
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- TG63 Disasters and the Built Environment
- TG64 Leadership in Construction
- TG65 Small Firms in Construction
- TG66 Energy and the Built Environment
- TG67 Statutory Adjudication in Construction
- TG68 Construction Mediation
- TG69 Green Buildings and the Law
- TG71 Research and Innovation Transfer
- TG72 Public Private Partnership
- TG73 R&D Programs in Construction
- TG74 New Production and Business Models in Construction
- TG75 Engineering Studies on Traditional Constructions
- TG76 Recognising Innovation in Construction
- TG77 Health and the Built Environment
- TG78 Informality and Emergence in Construction
- TG79 Building Regulations and Control in the Face of Climate Change
- TG80 Legal and Regulatory Aspects of BIM
- TG81 Global Construction Data
- W014 Fire
- W018 Timber Structures
- W023 Wall Structures
- W040 Heat and Moisture Transfer in Buildings
- W051 Acoustics
- W055 Construction Industry Economics
- W056 Sandwich Panels
- W062 Water Supply and Drainage
- W065 Organisation and Management of Construction
- W069 Housing Sociology
- W070 Facilities Management and Maintenance
- W077 Indoor Climate
- W078 Information Technology for Construction
- W080 Prediction of Service Life of Building Materials and Components
- W083 Roofing Materials and Systems
- W084 Building Comfortable Environments for All
- W086 Building Pathology
- W089 Building Research and Education
- W092 Procurement Systems
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- W099 Safety and Health on Construction Sites
- W101 Spatial Planning and infrastructure Development
- W102 Information and Knowledge Management in Building
- W104 Open Building Implementation
- W107 Construction in Developing Countries
- W108 Climate Change and the Built Environment
- W110 Informal Settlements and Affordable Housing
- W111 Usability of Workplaces
- W112 Culture in Construction
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- Condition Assessment of Roofs (CIB 289)
- Proceedings from the 3rd International Postgraduate Research Conference in the Built and Human Environment
- Proceedings of the 5th International Conference on Performance-Based Codes and Fire Safety Design Methods
- Proceedings of the 29th International Symposium on Water Supply and Drainage for Buildings
- Agenda 21 for Sustainable Development in Developing Countries
- Assessment of the World's Most Densely Populated Cities (CIB 288)
- Performance Based Building 2nd International State-of-the-Art Report (CIB 297)
- Performance Based Building 1st International State-of-the-Art Report (CIB 291)
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- Design for Deconstruction and Materials Reuse (CIB 272)
- Value Through Design (CIB 280)

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- Agenda 21 for Sustainable Construction in Developing Countries
- The Construction Sector System Approach: An International Framework (CIB 293)
- Red Man, Green Man: A Review of the Use of Performance Indicators for Urban Sustainability (CIB 286a)
- Benchmarking of Labour-Intensive Construction Activities: Lean Construction and Fundamental Principles of Working Management (CIB 276)
- Guide and Bibliography to Service Life and Durability Research for Buildings and Components (CIB 295)
- Performance-Based Building Regulatory Systems (CIB 299)
- Design for Deconstruction and Materials Reuse (CIB 272)
- Value Through Design (CIB 280)

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Membership will be automatically renewed each calendar year in January, unless cancelled in writing 3 months before the year end

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</table>

| All amounts in EURO |

The lowest Fee Category an organisation can be in depends on the organisation’s profile:

- **FM1** Full Member Fee Category 1 | Multi disciplinary building research institutes of national standing having a broad field of research
- **FM2** Full Member Fee Category 2 | Medium size research Institutes; Public agencies with major research interest; Companies with major research interest
- **FM3** Full Member Fee Category 3 | Information centres of national standing; Organisations normally in Category 4 or 5 which prefer to be a Full Member
- **AM1** Associate Member Fee Category 4 | Sectoral research & documentation institutes; Institutes for standardisation; Companies, consultants, contractors etc.; Professional associations
- **AM2** Associate Member Fee Category 5 | Departments, faculties, schools or colleges of universities or technical Institutes of higher education (Universities as a whole can not be Member)
- **IM** Individual Member Fee Category 6 | Individuals having an interest in the activities of CIB (not representing an organisation)

Fee Reduction:
A reduction is offered to all fee levels in the magnitude of 50% for Members in countries with a GNIpc less than USD 1000 and a reduction to all fee levels in the magnitude of 25% for Members in countries with a GNIpc between USD 1000 – 7000, as defined by the Worldbank. (see http://siteresources.worldbank.org/DATASTATISTICS/Resources/GNIPC.pdf)

Reward for Prompt Payment:
All above indicated fee amounts will be increased by 10%. Members will subsequently be rewarded a 10% reduction in case of actual payment received within 3 months after the invoice date.

For more information contact

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Fax +31-10-4334372
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