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Innovation Management System for Construction Companies

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Abstract

A number of innovation management systems have proven to be successful to companies in several industries from automotive to software development. These systems include for example innovation portfolio management process (Cooper, 1990) and open innovation (Chesbrough, 2004). However, these innovation management systems are not widely adapted in the construction sector. In fact, companies in the sector seem to lack a structured innovation management system. This study aims to develop an innovation management system for construction sector companies that can be applied in practice.
The study was conducted by developing and testing an innovation management system in real-life innovation projects with the top management of major publicly listed Finnish construction companies during 2012-2014. The innovation management system has four key functions, which are Strategy, Market input, Development process and Competencies and resources. Also, the results are analyzed to identify what innovation management system features gave most value for the case companies.
The main finding of this study is that construction sector companies can utilize and benefit from innovation management systems found in literature. Interestingly, the analysis of the innovation projects' results highlighted that especially the market input function added significant value to the existing innovation processes of the companies. The function complemented existing innovation processes of the companies as it was the function that was missing or that was not systematically implemented. The market input function helps to steer the development process and facilitate fact-based innovation investment decision-making. The function consists of four elements, which are Customer needs, Regulation, Technology, and Competitors. After the completion of the present study, the market input function has been widely adapted in the Finnish construction sector and applied in more than 120 major industry projects.

Keywords: construction; decision-making systems; innovation; knowledge management; risk analysis

1. Introduction and research question

Innovation management is a widely researched topic in the academic literature covering both management and leadership issues. A number of managerial systems for innovation management are widely adapted and proved to be successful to companies in several industries from automotive to software. The necessity of having a systematic approach to managing innovation is summarized well by Lewis Lehr, the former CEO of 3M: "Innovation can be a disorderly process, but it needs to be carried out in an orderly way" [1]. However, these managerial systems are not widely adapted in the construction sector. The rate of innovation in construction sector lags behind most other sectors. A systematic approach is needed to manage both the development of innovation and adoption of innovation in construction projects. [2, 3, 4, 5, 6].
In practice, there is an urgent need to understand how innovation is currently managed in the construction sector and to develop means to speed up the innovation process. For example, as the requirements related to a building's design and performance increase constantly, investigation of client needs and utilization of client feedback in management, design and development of new services and products are essential for construction innovation [7]. In particular, there is a practical need for a construction innovation management system tailored to company top management.

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Hence the research question of this paper is formulated as follows:

"How construction companies can utilize innovation management systems?"

In order to answer the research question, this paper aims to develop a system for construction company innovation management. The research methodology in this study is inspired by constructive research approach (CRA), which was originally introduced by Kasanen, Lukka and Siitonen [8]. CRA was selected because it emphasizes the practical applicability of the research results [8]. The present study is carried out in 3 research phases. First, literature is reviewed to develop a theoretical framework for the innovation management system. Second, the theoretical framework is developed further based on feedback from construction company top management and results from 10 innovation projects implemented with four major construction sector companies. Finally, the results from the innovation projects are reported and the functions of innovation management system are described.

The contribution of the paper is in the development of a system for construction company innovation management and analysis of the innovation project results. By developing the system this study increases understanding of how construction companies can manage innovation and how they can increase the efficiency of their innovation systems.

In this study, construction sector comprises the functions of construction project management, on-site production activities or manufacturing and distribution of construction products and components. Construction company is defined as a company that performs one or more of these functions. Innovation on the other hand is defined as creating new products and services, which can mean both new technology and new ways of marketing and selling existing products.

2. Literature overview and formulating the framework for innovation management system

This section introduces the literature streams that have motivated this research and the key concepts that have been utilized in this research. Finally, based on literature overview a theoretical framework for the innovation management system is formulated to be tested in practice.

2.1. *Construction innovation characteristics*

Innovation in the construction sector has been studied for several decades. While the subject has been studied both from single company's point of view and from the industry's point of view, the emphasis has been on the latter perspective. Construction sector has several characteristics, which have an effect on innovation management. Value chains in the sector are usually long and complex by nature, activities are project based, the regulatory influence on the sector is substantial and the industry is often considered to be conservative [2, 9]. The role of regulations as a driver and barrier of construction innovation has been emphasized particularly in sustainability innovation studies [10, 11, 12].

Several studies have pointed out that these characteristics pose challenges to construction innovation [2, 3, 4]. Kajander et al [5] found that modern innovation processes that involve customers and value network are not widely adapted among construction companies. Sivunen et al [13] found that some of the key challenges for construction companies appear to be team building, high R&D-intensity and commercialization management. The innovation process in the construction sector can be cost-intensive with very indefinite returns and companies might lack the proper tools to manage the innovation process [12, 14]. In addition, construction innovations tend to be incremental instead of aiming to create new business [6].

Based on the reviewed literature, it is evident that construction sector has numerous challenges for innovation management, and that these challenges are relatively thoroughly studied in earlier literature. However, only a few studies have tried to look at the problems form a single company's point of view. In effect, there is a lack of innovation management system for construction companies that addresses the problems from a company level.

2.2. *Theories behind the innovation management system*

In the following, selected innovation management systems for construction company innovation management challenges are briefly reviewed. The aim is to identify the theories and innovation systems to develop the framework for construction innovation management system.

Cooper [15, 16] has studied extensively how to manage product development processes. Cooper [15] introduced a systematic way called the Stage-gate model to manage innovation process inside an organization. In the Stage-gate system the R&D process starts from a set of R&D ideas and is divided into a predetermined set of five stages: 1) preliminary assessment of potential R&D ideas, 2) detailed investigation of the selected idea, 3) development,

4) testing and validation, 5) full production and market launch. The system does not describe the generation of product ideas, except that they are invented in-house [15]. Cooper et al [16] have also studied how companies should manage their product development process as a portfolio. When managing a portfolio of R&D projects, the company has four goals: maximizing the value of the portfolio, creating a balanced portfolio, building strategy into the portfolio and choosing the right number of projects. The decision of selecting projects can be made with help from financial methods, strategic approaches, scoring models etc. [16].

The product development innovation systems have mainly focused on closed R&D that is conducted inside an organization, which has been very successful in the past yielding excellent results that have been feeding even more innovation and profits [17]. In the last couple decades, the closed innovation paradigm has begun to shift towards a paradigm of open innovation. In the era of high mobility of workers and private capital available for investments, the open innovation seems to be more natural way to produce innovations. Open innovation essentially means that firms can and should use both internal and external resources in idea generation and idea commercialization [18]. A company can acquire necessary technology through IP or company acquisitions and can sell IP of designs that are not useful for the company's business model as well as doing all this in-house. Also spin-off companies originated from company's R&D activity are common. Spillovers created by R&D can thus be utilized and seen as an advantage rather than a cost of doing business [18].

The Service-Dominant logic innovation theory [19, 20, 21, 22] has been developed to explain discontinuous innovation processes by removing the distinction between product and service innovation. The S-D logic focuses on customer's role and provides a customer-centric view to analyzing, managing, and developing innovation processes. According to the S-D logic, innovation development should always be strategically targeted at a specific customer need [19].

Innovation leadership and corporate innovation governance has been widely researched by Jean-Philippe Deschamps. Deschamps [23] claims that because of the complexity nature of innovation different types of leaders seem to be needed at different stages of the innovation process. For example, innovation activities, and thus leadership imperatives, are quite different at the ''fuzzy front-end'' and ''speedy back-end'' of the innovation process. The front-end of innovation depends upon sensing new market needs, exploring new technologies and generating new ideas in support of the business strategy. It also involves seeding and developing new concepts for products and services, as well as nurturing new ventures through their early stages. The back-end of innovation, by contrast, depends on getting to the market fast in order to reap the rewards. It deals with concrete but critical tasks such as developing, testing, engineering, producing and launching new products or services. [23].

However, it is not obvious what kind of innovation systems different organization should adopt. Hansen and Birkinshaw [24] have created a system called "innovation value chain" for companies to find the best way for them to manage the innovation process. They provide tools for utilization of both internal and external resources in the innovation process. The innovation value chain provides concrete measurements for selecting the innovation systems that are appropriate for each company. Each case is different and companies thus need to figure out which systems make the most sense for them to adopt. This system helps the company to find the weak spots of the innovation process instead of focusing on the good sides to excess.

2.3. *Formulating the framework for innovation management system based on the literature overview*

Groundwork for the framework was laid in the process of studying innovation systems and challenges found in the literature overview. Based on review of the chosen innovation systems and challenges, main functions for the framework were constructed. Table 1 presents the framework for the innovation management system.

Table 1, Framework for the innovation management system

Innovation challenges in the construction sector	Related innovation management systems	Corresponding main function of the framework
Scattered value chain [2]	Open innovation [17], SD-logic [19]	Market input, competences and resources
Project based nature [2]	Innovation leaders and strategy [23]	Strategy, development process
Incremental innovation [6]	Innovation leadership and strategy [23], innovation portfolio management [16]	Development process
High R&D intensity [13]	Open innovation [17]	Competences and resources
Lack of proper tools [5]	Innovation portfolio management and stage-gate tool [15, 16], innovation value chain [24]	Development process
No driving organization for innovation [2]	SD-Logic [19], innovation leadership [23]	Development process

3. Development of the innovation management system

Further development and practical testing of the innovation management system was carried out between 2012 and 2014 together with four major Finnish construction sector companies. 10 real-life innovation projects were implemented. Companies involved in the projects have an annual revenue of over 10 billion euros and companies have significant operations throughout Europe in addition to operations in Finland. Companies include both contractors and construction product manufacturers. The case companies were already implementing various innovation activities before the projects. Main goal of the projects was to test whether the functions presented in the theoretical framework were relevant for the companies and to deepen the content of the framework with sub-functions that would be observed during the projects. Furthermore, an important goal of the projects was to solve problems related to the companies' innovation management process.

Before the actual innovation projects were implemented, the framework for innovation management system was analyzed with the top management of the companies. First, a workshop was held where each company's specific innovation management related problems were pinpointed. Second, interviews with the company representatives were carried out during some of the projects. Third, the collected data was analyzed. Data collected in the workshops and interviews were sources of information for further developing the framework. Sub functions were added to the framework based on the analyses. Finally, the developed sub-functions as well as main functions of the innovation management system were assessed by the authors and company top management. The aim was to analyze whether the functions and sub functions of the framework were relevant for the companies. Based on the results of the workshops and interviews, following sub-functions presented in Figure 1 were added to the framework.

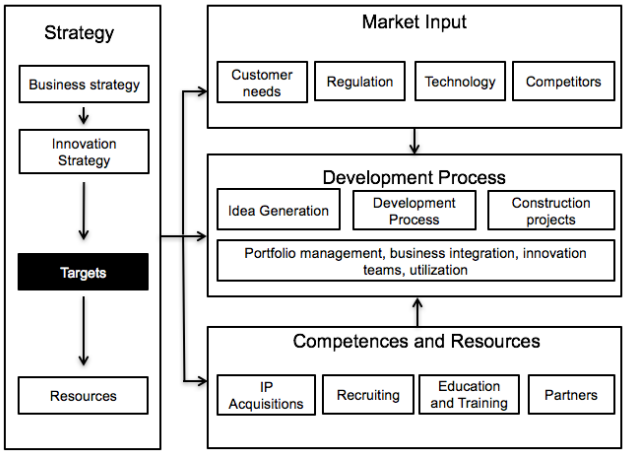

Figure 1. Innovation management system for construction companies

In the next phase, companies tested the innovation management system in innovation projects. Now the emphasis was on solving particular innovation related problems of the companies. Companies 3 and 4 were willing

to test the whole innovation management system. Company 1 was interested in testing market input, competences and resources and development process –functions. Company 2 was willing to test the market input –function.

Strategy function was tested by companies 3 and 4. Result of the projects was an analysis of the companies' innovation strategy. Current innovation strategies were analyzed and main problems related to the implementation of the strategy were identified. Based on the problems identified, the best practices of innovation management were analyzed from several leading companies and a revised innovation strategy was formulated. Companies 1 and 2 were already implementing the strategy function at a level that projects addressing the function were not perceived to add significant value for the companies.

Market input function was tested by all companies. The projects related to market input function were for example analyses of target customer needs and feedback, projects of competitor companies and technological development. Also most potential production technologies to be adapted by the companies, for example on-site robotics, were analyzed. All of the projects related to market input function addressed customer needs, technology and competitors and project results were used in the innovation investment decision-making of the companies. A key problem for all companies was how to make fact-based innovation investment decisions in a very short timeframe with limited and ambiguous data. Regulation –sub function was tested with company 3 by analyzing potential changes in relevant regulatory topics.

Competences and resources function was tested with companies 1, 3 and 4. The projects were related for example to analyzing intellectual property of competitor companies by studying new patent filings and product launches. Also idea generation was implemented in the spirit of open innovation by analyzing competitors' new products and technologies. Company 2 assessed that further testing the function would not provide significant value for the company.

Development process function was tested with companies 1, 3 and 4. Emphasis was on the analysis of companies' innovation management processes. Problems and challenges related to the development process were identified and solved based on the theories included in the framework presented in Table 1. Company 2 was already implementing the strategy –function at a level that projects addressing the function were not perceived to add significant value for the company.

4. Description of the innovation management system's functions

The strategy function aims to steer the innovation activities in construction company. It contains four elements. First business strategy is the most important element in the strategy section. During the research process the business strategy was mainly taken as given since business strategy is a starting point for all of the activities of the company. The scope of the projects was in the innovation strategy level. Innovation strategy is formulated based on the business strategy. The innovation strategy aims at facilitating innovation activities that enhance the implementation of the business strategy. Based on business innovation strategy, targets of innovation activity are derived. Then resources are allocated based on the strategies and targets. All of the companies had an existing innovation strategy of some kind. In some projects the strategy was evaluated and updated according to the results of the project in particular. The case companies found target setting especially important in order to successfully implement the three other functions.

The market input function aims to steer the development process and to facilitate effective innovation investment decision-making. The function consists of four elements, which are customer needs, regulation, technology, and competitors. Customer needs can contain for example new customer problems, new breakthrough ideas for R&D, information about budget restriction in the economic sense or the changing preferences of consumption. The regulatory side is especially important in the construction sector as mentioned in the literature overview. This means that regulatory market input is especially important. Regulatory input can contain information about national legislation, the political environment or government subsidy allowances. Technology and competitor project inputs were found very important as well by the companies.

The development process function can be compared to traditional innovation management systems found in innovation management literature. Idea generation can be done both in-house or it can be outsourced. Development of the product and piloting of the product is also included in the development process. It is decided in the utilization phase whether the new innovation is tested in construction projects and whether it is introduced to the market. Further development of the concept at hand can be done based on the results of the pilot project by feeding the information from project to the R&D process. Development process function was found especially relevant by one company that mainly operates at construction product manufacturing.

Competences and resources can be found both in-house or from the outside the company as open innovation theory implies. Outside resources can be utilized via intellectual property acquisitions from other companies. Outside competences and resources can be also obtained by forming partnerships with collaborating companies. This is especially important in the construction sector. One of the companies was especially interested in

addressing the problem with fragmented value chains by partnerships that align the interests of different stakeholders. Also company acquisitions were found to be significant for larger companies. Competence can also be acquired from the market by recruiting new talent. Education and training can be organized within the company or bought outside.

The link between the functions is essential. Strategy is the most important function of them all and it guides the other functions. The three operational functions thus aim at implementing both the business strategy and innovation strategy. Development function utilizes the information and resource feed from the three other functions. However strategy guides what kind of information or resources are utilized in the other functions. It was observed during the research process that all of the functions and sub-functions were more or less relevant depending on the company and its strategy. Application the framework in practice can begin from adapting some functions of the framework. However, the strategy function can be considered essential since it steers all of the other functions.

5. Summary of the results

All functions – Strategy, Market input, Competences and resources and Development process – were found to be relevant for the case companies. Especially the function Market input was found to be relevant for the case companies. The function complemented the existing innovation processes of the companies, as it was the function that was missing or that was not systematically implemented in existing innovation processes.

According to the feedback from case companies, implementing the market input function added significant value to the innovation process of the companies. The companies experienced that the market input function brought critical investment decision-making information for finding and investing in innovations that are valuable. In particular, market input function added value for selecting a few innovation investment opportunities out of a larger set of scanned opportunities for a deeper pre-investment analysis before making a final decision. Interestingly the projects that were related to strategy, development process or competences and resources did not generate significant new value for the companies. It seemed that existing innovation processes of the companies were already in acceptable level.

6. Discussion and conclusions

The main finding of this study is that construction sector companies can utilize and benefit from innovation management systems. The system developed in the present study seems to provide construction sector companies a structured way to manage their innovation activities. Especially market input function added the most value for existing innovation management process of the project companies. After the completion of the present study, the market input function has been widely adapted in the Finnish construction sector and applied in more than 120 major industry projects. The system also proved to be successful in integrating various innovation systems that are commonly used in manufacturing industry. However, when generalizing from the results, this study has some important limitations. For example, research applied only to Finnish companies that were relatively large at size.

Further research topic could be doing a follow-up study for the companies that reviews the results of adapting the innovation management system. Another interesting research topic based on this paper would be testing the innovation management system as a construction company management system instead of concentrating merely on innovation management.

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