A systematic approach for evaluating innovation management in construction companies
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Abstract
The increasing competition within the construction industry has created a growing concern for innovation, being appreciated as an important lever for competitive advantage. However, despite its need, there are some critical barriers that make innovation in construction very difficult. In addition, the perceived risk of innovation is almost unacceptable to the sector’s culture. These factors limit the innovation efforts being made. Thus, appropriate mechanisms are needed to overcome these limitations and propose actions to promote innovation and innovation management in constructions’ firms. The aim of this paper is to describe an approach to innovation management that includes a system for evaluating the status of innovation management in construction companies (SEGi by its acronym in Spanish), i.e., all activities undertaken by a company to integrate innovation opportunities to improve its performance. The system has been structured based on both quantitative and qualitative methods, whose application allows evaluating the state of innovation management and generating proposals for actions to solve the detected limitations.

Keywords: construction companies, evaluation, innovation, management, system.

1. Introduction
A society without innovative organizations limits its development and is condemned to retardation and poverty (Schumpeter, 1978), and its lacking is a characteristic of developing countries (Matos, 2007). The competitiveness of a country depends upon the ability of its industries to innovate and improve (Porter, 1991).

Although there is a consensus in other industries about the importance of innovation, the construction industry is reluctant to incorporate innovation and innovation management. This scenario then shows a shortage in the performance of innovation management as well as the need of counting with an evaluation system for this function in construction companies so that performance gaps and deficiencies can be identified, and companies supported for improvement. This paper proposes a system for the evaluation of innovation management (SEGi by its acronym in Spanish) of construction companies that was tested in three construction companies that were used as case studies. The next sections describe the research general background, methodology and main results.

2. General background
In the literature it is possible to find many definitions of innovation, but according to Seaden and Manseau (2001) in all of them there is certain trend and convergence: it is increasingly seen as a process that improves the competitive position of a company through the implementation of a wide spectrum of new ideas. Regarding innovation management, it is important to consider that the process of innovation cannot be separated of the strategic and competitive context of a company (Afuah, 2003) because it allows aligning the operation approach of the organization.

2.1. Innovation in construction
Within different industries, the construction industry is often considered behind of the others regarding innovation, showing the greatest inherent inability for innovation and a great difficulty in adopting innovations from other areas (Harty, 2008). Since Bowley (1960), the literature refers to two types of innovation in construction: 1) process innovations, and 2) product innovations. However, there is no consensus about the importance of each type for the construction industry, a fact that produces disunion in the innovation’s strategy.
and resources (Lim and Ofori, 2007). Lately, the growing competence in the construction sector has promoted concerns about innovation as a lever for success.

In addition, it is known the fact that in the construction industry it is very difficult to innovate and its risk is considered almost not acceptable (Blázquez, 2005) for companies. Some studies show that in the construction industry, there is a lack of trust in front of ideas and proposals of change and innovation (Serpell, 2002). The majority of companies do not consider attractive to invest in research, development and innovation (R+D+i) because they have not understood it as a key factor for competitiveness (Correa et al, 2007). Even more, Ocaranza (2001) concludes that it is necessary to have an efficient and structured system to promote innovation in construction in Chile. One of the inputs for a system like this is the evaluation of the capability of construction organizations with regards to innovation management.

2.2. Maturity models

A maturity model provides a systematic framework to carry out the comparative evaluation and improvement of performance (Demir and Kocabas, 2010). These models lead the organization strategically and link it with continuous improvement alternatives, requiring a deep knowledge of the current position of the organization in a defined domain and the desired future position (Brookes and Clark, 2009).

A search for maturity models was carried out and two were found that resulted appropriated for the application under development. The first was the CMMI (Capability Maturity Model Integration) model largely appreciated due to its extensive adoption by different industries (Chrissis et al, 2009). Its purpose is to help organizations to improve their processes for development and maintenance and allows to approach this improvement using two different representations: continuous and by stage. The second was a maturity model related to risk management that resembles the kind of structure to be used for innovation management (Yeo and Ren, 2009).

3. Research Methodology

The research focused on how to evaluate the innovation management in a construction company and, starting from this evaluation, to propose better practices for improvement. Then the SEGi was the expected result of this research effort. To develop this system, the following activities were carried out:

1. Literature review.
2. Data gathering through questionnaires and focus groups.
3. Results analysis using descriptive statistics and qualitative analysis.
4. Pilot case study and case study of three companies that were used for the application of SEGi, and
5. Validation of results through case studies, statistical tools and intern consistency.

Then, the experimental model in this case corresponds to the development of an evaluation system in which the dependent variable is the innovation management capability and the independent variables are the innovation drivers (iD). A maturity model was then built using the innovation drivers and the maturity models found in the literature.

For the interaction with companies, two approaches were selected as indicated above: questionnaires and focus groups. Characteristics of participant companies are shown in table 1. The internal validation was carried out by showing the results of the questionnaire to a team formed by professionals and managers of each company (different from those that answered the questionnaire). They reviewed the obtained maturity levels for each innovation driver obtained by each company together with the description of each driver, so that they could indicate if the results corresponded to each company's reality in this topic. To analyze the data from questionnaires a regression analysis was carried out and used to study the relationship between the dependent variable (innovation management) and the independent variables (innovation drivers).

| Company | Size | Trades                | Number of participants professionals | Number of focus groups |
|---------|------|-----------------------|--------------------------------------|------------------------|
| Company A | Large | Engineering and Construction | 16                                   | 2                      |
| Company B | Medium | Real estate and Construction | 14                                   | 2                      |
| Company C | Medium | Construction only      | 20                                   | 2                      |
4. The innovation management evaluation system (SEGi)

SEGi contains three major components: 1) innovation drivers, 2) an innovation management maturity model, and 3) an application methodology with its instruments.

4.1. Innovation drivers

From a bibliographic review, more than 20 preliminary innovation drivers were identified. Later, with the support of the three construction companies shown in table 1, and through the application of a methodology based on focus groups, these preliminary innovation drivers were analyzed in depth and grouped into six major categories as shown in figure 1. These drivers are described below.

![Figure 1. Innovation drivers model](image)

The culture and human capital driver addresses the attitude of professionals and executives of the company in front of change, the workers’ perception about the management commitment with innovation, the practice of training of professionals and executives, and the level of support to team work. The organizational structure driver centers on the way in which decisions are made inside the organization and the level of autonomy of decision-making. The technology driver focuses on the application of technology in the construction processes and methods, considering both, the kind of technology used as well as the frequency of application of it. The research and development driver addresses the ways and reason of the company for realizing innovation and development. The partnering driver refers to the alliances or association of a company with external companies, research centers and universities for innovation and development purposes. Finally, the knowledge management driver refers both to internal and external knowledge.

4.2. The innovation management maturity model (MGi)

The MGi considers five maturity levels that measure the condition of each of the six innovation drivers. Its architecture is based on the representation by stages of the CMMI, because it is a systematic and structured way of approaching to improvement. To achieve the description of each driver for each maturity level, a combination of innovation and risk models was used. An example of the maturity levels and their description is shown in table 2.
Table 2. Maturity levels of the MGi

| Level | Name        | Description                                                                                                                                 |
|-------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | Basic       | The innovation is ad-hoc, and it depends on individual efforts. There is a lack of knowledge about the need of innovation management and there is no attempt to recognize the benefits of innovation. There is no investment in training. |
| 2     | Accepted    | Innovation management and its benefits are accepted. The research is carried out by necessity and is planned. Some training intents are realized. There is a recognition of the need of information management processes. |
| 3     | Conscious   | There is consciousness of innovation at the organizational level and of the own knowledge. There is a definition of formal processes of innovation management and a beginning of its application. A more proactive behavior in front of changes is starting. |
| 4     | Systematical| Systematization and diffusion of innovation through the organization as a whole. Repetitive processes with continuity trends, and controlled and evaluated. Establishment of innovation management. |
| 5     | Optimized   | Innovation management processes are optimized. Continuous learning and synergy in the organization. Innovation management integrated to the culture and way of life of the company. |

4.3. The application methodology with its instruments

Two methods of data recollection were designed: 1) the application of a questionnaire (quantitative method) and the realization of a focus group (qualitative method). The questionnaire is used for measuring the maturity level of the innovation management capability. The latter is used for obtaining more depth in the scope of the analysis.

To apply the questionnaire and obtain the maturity level for each innovation driver and for the innovation management capability as a whole, a scale from 1 to 7 was defined. This scale has been divided into five segments, one for each maturity level with the relative weights for combining the assessment values as shown in table 3.

Table 3. Relative weights of the codification scale

| Segments: | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|-----------|---------|---------|---------|---------|---------|
| Proportion| 1       | 1       | 1       | 2/3     | 1/3     |
| Relative weights | 0.25   | 0.25   | 0.25   | 0.167   | 0.083   |

These weights were determined after the application of the pilot case in which, all the levels were assumed to have the same relative weight. Then, using the weights shown in table 3 and considering the scale from 1 to 7, in table 4 it is possible to see the segment limits of the codification scale, for each maturity level of the MGi.

Table 4. Relative weights of the codification scale

| Segments: | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|-----------|---------|---------|---------|---------|---------|
| Lower limit | 1       | 2.5     | 4       | 5.5     | 6.5     |
| Upper limit | 2.5     | 4       | 5.5     | 6.5     | 7       |

Then, the questionnaire allows the contextualization of the innovation drivers through situational descriptions of these for each maturity level, assuring that this instrument gets the data that is looked for.

To summarize what has been described in the last sections, figure 2 shows the general application process of the SEGi.
5. Research results

The SEGi was applied to three construction companies. Besides obtaining the maturity levels of each company, the research team obtained a set of interesting opinions about the system. First, the questionnaire was well accepted by the participants. They highlighted the reduced time required to fill out the instrument. Second, they indicated that when they did not recognize by its name a factor (innovation driver) to be evaluated, the situational description of the factor allowed them to recognize the factor within the company. Third, the description of the factors allowed them to appreciate different situations of a same variable, widening the understanding of each one and differentiating better the situation of the company. In addition to these opinions, they greatly approved the application of the focus group approach since it allowed a better comprehension of the meaning of the maturity level and, in this way, self-evaluate, accept and understand the gaps that existed for each innovation driver.

5.1. Maturity evaluation results

The results obtained by the companies are shown next. The table 5 shows the maturity level of each company for each innovation driver.

| Innovation drivers                | Company A | Company B | Company C |
|-----------------------------------|-----------|-----------|-----------|
| Culture and human capital         | 3         | 3         | 3         |
| Organizational structure          | 2         | 2         | 2         |
| Knowledge management              | 2         | 2         | 2         |
| Research and innovation           | 2         | 2         | 2         |
| Technology                        | 3         | 2         | 2         |
| Partnering                        | 2         | 2         | 2         |
| **Maturity level of the company** | **2**     | **2**     | **2**     |

It can be seen that the maturity level of the three companies was very low and similar. Professionals and managers that participated in the internal validation of the results considered that the results of the evaluation reflected to a great measure the real situation of the companies regarding innovation management capability. Regarding the focus groups, the results obtained are:

1. The understanding of the shortcomings of the company allowed them to contextualize more clearly the innovations drivers inside the company and to establish cooperation and interdependency relationships between them.
2. They concluded that the major impact of innovation in a construction company is produced when the innovation add value to the final product of the company.
3. They concluded that the strongest barrier in front of innovation is the culture and human capital management practices.
6. Conclusions

A brief description of a systematic approach for evaluating innovation management capabilities in construction companies that has been developed as the result of a research undertaking has been presented in this paper. This methodology has been successfully applied in three construction companies by the way of a system for evaluating innovation management organizational competences.

It can be concluded that the application of SEGi in the cases studied was able to obtain satisfactory results regarding the evaluation of the innovation management capability of each company. Even more, all the R² coefficients obtained for each questionnaire are over 0.75, a number that is considered acceptable. If in the future, more cases are studied it will be possible to increase the reliability of the obtained evaluations and to adjust the different elements of the measurement methodology.

The participants of the study expressed their satisfaction with the quality of the results and the value of the tool. With the results obtained in the evaluation and with the added internal knowledge of the organization, a construction company can obtain a good understanding of the factors that affect its innovation management capability, identify the weakest issues, and to better focus the improvement efforts in this area.

The research in this area might consider new areas of study, like a system for monitoring and controlling the application of best practices using a framework like the Balanced Scorecard, an expert system that uses the evaluation system as a learning tool, and to study how to increase the effectiveness of the best practices proposed by the SEGi.

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