

The Dilemma of Innovation in the Construction Company: A Decade of Lessons Learned

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Abstract Innovation can be defined as the integration of non-trivial ideas capable of generating positive changes that increase a company's competitiveness. For construction companies, innovation is not an easy task, since their production is based on single projects built in different locations. This article summarizes the exploratory research conducted by the authors over the last decade, focused on the implementation, development and monitoring of a standardized innovation management system in a mid-size Spanish construction company. Collected evidence, also contrasted with other companies as well as with the sector as a whole, provide lessons learned, not only for the analyzed company, but also for construction companies in general. Innovation, in this kind of businesses, may not be a spontaneous act that appears on solving a specific problem, becoming a managerial process that can be systematized and homogenized. It allows faster identification of the involved tasks in creating new processes, products and services for companies and, therefore, their market competitiveness is improved.

Keywords Construction company • Innovation • Management • Standardization • Systematization

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1 Introduction

Innovation is an open concept that can have different meanings. Many authors historically have contributed their own definition of innovation, depending essentially on the context or scope in which they undertake their activity. Nevertheless, to avoid confusion, in this study, innovation is defined as the application of new ideas for the organization, regardless of whether these ideas are focused on products, processes, services or organizational, administrative or commercial systems, capable of generating positive changes that increase a company's competitiveness (definition adapted from Gibbons et al. 1994). Innovation management, on the other hand, can be considered as the creation of suitable conditions in an organization to make technological, organizational or commercial changes in an environment of uncertainty (Tidd et al. 1997). Having defined these two basic concepts, the problem detected must now be posited, serving as a starting point for the research reflected in this article.

The innovative capacity of a country depends on several key factors including, in particular, public policies that facilitate the advancement of innovation, the existence of regulations and laws that guarantee intellectual property, and a continuous collaboration between research centers and companies and institutions (Gann 1997; Mitropoulos and Tatum 2000; Seaden and Manseau 2001). Consequently, applying the commitments made in 2000 by the European Union in Lisbon, the Spanish government implemented various initiatives in the first decade of the new millennium, which in chronological order are the following:

- Law 4/2004 of Modification of Tax Rates and Benefits (Government of Spain 2004), which invites companies that invest in innovation activities to take advantage of tax incentives.
- The Ingenio Program (www.ingenio2010.es) launched in 2005, which seeks to reduce the innovation gap with the other Western economies through investment in public and private innovation.
- Set of standards UNE 166000, published in 2006 by AENOR, the aim of which is to systematize innovation management (AENOR 2006a, b, c).
- Inclusion of incentives in tendering for government contracts (up to 25% of the final score) for companies who show the implementation of innovative activities, preferably based on the set of standards UNE 166000 (Pellicer et al. 2008).

It is for this reason that, as the situation stood in 2006, many construction companies discussed whether innovation could be managed like any another additional company system (similar to quality, the environment or safety), so that it could be systematized and evaluated externally by a certifying agency according to the set of standards UNE 166000, for example (Pellicer et al. 2008). This is the point of departure of the research synthesized in this article, which yields the following main research question: Can innovation be systematized in a construction company? From this main question two more specific research questions arise:

Is the systematization of innovation beneficial for a company? What barriers exist to systematizing innovation?

This article summarizes the research conducted by the authors over the last nine years (2006–2014) focused on the implementation, development, evolution and follow-up of a standardized innovation management system in a mid-size Spanish construction company. The findings, also contrasted with other similar companies as well as the sector, provide lessons learned, not just for the company analyzed, but also for construction companies in general.

The article is organized as follows: First, the authors' research method is described. Next, the innovation management processes, implemented in the pilot company according to UNE 166002 standard, are explained. The following section justifies the in-company innovation management model developed by the authors. Then, the main results of the in-company implementation are presented. In the following section the most significant lessons learned are summarized. Finally, the conclusions, limitations and ongoing work are presented.

2 Research Method

As previously mentioned, in 2006, large and mid-size Spanish construction companies understood the systematization of innovation (according to the set of standards UNE 166000) as an opportunity to increase their company's competitiveness (Correa et al. 2007; Pellicer et al. 2008). At that time only one Spanish construction company was certified by the UNE 166002 standard (Pellicer et al. 2008, 2012). This is why the authors launched an exploratory investigation using analytical induction in the form of a single case study (Pellicer et al. 2010, 2012), based on the following research question: Can innovation be systematized in a construction company?

To select the company to study, the construction sector was researched in terms of its structure, considering two variables that define the size, revenues and employees (European Commission 2004), as well as the number of branch offices. Sixty five mid-size construction companies belonging to the associations FECOVAL, ANCI and SEOPAN were examined (Pellicer et al. 2012). Three companies very close to the average were identified, and were invited to participate; one accepted and became the focus of the case study. This construction company has been active in building and civil engineering projects since the 1960s, with revenues of approximately 400 million euros in 2006 (Pellicer et al. 2010, 2012).

The unit of analysis was the construction company as a whole: the headquarters, branch offices and construction sites. An in-depth analysis was carried out for three years that made it possible to implement the different processes required by the UNE 166002 standard and to verify their fulfillment and evolution. During that time all the branch offices were visited at least once, as were the ongoing construction

projects (more than a hundred), essentially those where potential innovative ideas arose. During the first year the company was analyzed in-depth (Pellicer et al. 2010), as well as the implementation of the innovation system according to the UNE 166002 standard (Yepes et al. 2016). In the two following years the success factors, benefits of and barriers to innovation were identified (Pellicer et al. 2012). In the first quarter of the fourth year, the results (success factors, benefits and barriers) were contrasted with other companies that had also implemented their innovation management system according to UNE 166002 (Pellicer et al. 2014). From 2009, a follow-up was done of the evolution of the innovation management system as well as of the company itself (Pellicer et al. 2012; Yepes et al. 2016).

The case study conformed to the guidelines proposed by Yin (2003), including the following six steps (Pellicer et al. 2012): (a) literature review; (b) theoretical model design; (c) data collection; (d) data analysis; (e) results of the study; and (f) generalization of results. With the first five steps, a comparison was made between theory and reality using multiple sources of evidence and logically linking the facts in order to explain this scenario. To fulfill this objective, the following sources of information were used (Pellicer et al. 2012, 2014): (1) participant observation for short periods of time (normally days); (2) monthly meetings with company management; (3) analysis of documents issued by the company or related to it (including websites); (4) external survey applied to 148 Spanish construction companies regarding their perception of innovation in construction; (5) annual survey (in the first three years) of the company management; (6) survey administered to company employees (in the second year of the study); (7) survey of suppliers and subcontractors (also during the second year); and (8) workshops for management and clients held annual or biannually from the third year on.

To ensure the quality of the research using a single case study, the indications of Yin (2003) were followed: (a) use of multiple data sources (as mentioned previously) to triangulate the facts; (b) generation of chains of evidence; (c) contrast of the theory with the observed reality (or pattern matching); and (d) explanation of the phenomenon in a logical manner (or explanation building). The first two aspects ensured the construct validity of the case study, whereas the last two guaranteed the internal validity of the research (Pellicer et al. 2012).

The external validity was accomplished using semi-structured interviews with the management of seven Spanish construction companies (of the eight possible ones) that had an innovation management system certified by UNE 166002 at the beginning of 2009 (Pellicer et al. 2014). The heads of each one of the company's innovation department were interviewed, all of whom had more than 15 years of experience in the sector. Additionally, eight managers from the company under study were interviewed as well as nine experts from the construction sector not linked to contractors.

3 Innovation Management Processes Based on UNE 166002

UNE 166002:2006 “R&D&i management: requirements for R&D&i management systems” defines the innovation management system (AENOR 2006c). This system comprises the company’s global management system that includes the organizational structure, planning, responsibilities, processes, procedures, records and resources. UNE 166002 defines the manner of developing, implementing, executing, reviewing and maintaining the company’s innovation policy (AENOR 2006c). The innovation system is divided into five basic processes (Yepes et al. 2016): (a) technological watch (according to UNE 166006); (b) creativity; (c) planning and development of innovation projects (according to UNE 166001); (d) technology transfer; and (e) protection of results.

Next, the five basic processes that include the innovation management system implemented in the pilot company are described (Yepes et al. 2016):

- Technological watch is a constant and organized effort to observe, obtain, analyze, disseminate and recover accurate information pertinent to the business context. It endeavors to detect opportunities and threats, as well as to anticipate changes that minimize decision making. The process of technological monitoring is regulated by UNE 166006:2011 “R&D&i management: technological watch and competitive intelligence system” (AENOR 2011).
- Creativity is the generation of ideas on the part of the employees that can stem from the analysis of the weaknesses, threats, strengths and opportunities of innovation, or from issues that arise in the construction works. The ideas are stored in a database. These ideas are valued according to their technical and economic feasibility and their affinity with the strategic lines previously established by the company.
- The planning and development of the innovation project not only considers its detailed design, but also its implementation in the construction project. On many occasions, both aspects can be almost parallel when the cause is to solve a problem that has arisen on the site. Normally, the person in charge of the project is the construction site manager. A detailed report including the project planning is needed prior to implementation; then follow-up reports are necessary, finalizing the process with the preparation and delivery of a closing report. The process is regulated by UNE 166001:2006; “Management of R+D+i: Requirements of a R+D+i project” (AENOR 2006b); each project can be certified externally by an agency recognized by the Government of Spain (Pellicer et al. 2008).
- Technology transfer is the process of acquisition, transfer, exchange, granting of licenses and permissions, and positioning in the market. It is oriented toward securing a competitive advantage in the market from the outcomes of the innovation activities. It can end up with signing a contract. In any case, it is advisable to evaluate the technology transfer.

- The company also seeks to protect sensitive information through confidentiality clauses when new employees are hired or cooperation agreements are signed with other organizations. As in the previous case, it is also advisable to evaluate the protection of results.

This set of processes involves feedback from the system. It is therefore important to have indicators, as well as results of the previous implementations, even if they are partial results or recommendations by those in charge of the innovation projects or construction site managers (Yepes et al. 2016). These results can be stored in a database to which all members of the organization have access. They can include usual sources of information, technological monitoring records, ideas, certified projects, partners, etc.

4 Innovation Model in Construction Companies

The proposed innovation management model is based on the open systems theory (Bertalanffy 1968), which comprises a set of interrelated elements to achieve specific objectives. It begins with the proposal by Seaden and Manseau (2001) focused on the company as a knowledge system, interlinked with suppliers, clients, resources, and even competitors. The innovation management model developed (Pellicer et al. 2012, 2014) considers that construction companies obtain novel ideas (input) from the company itself (normally at organizational or commercial level), as well as from construction sites. These ideas are transformed into innovation projects (output). All this is developed in the construction industry where the company is active (environment). To design a suitable innovation strategy, the company's business environment and organizational abilities are taken into consideration. These are reflected in the goals and policies that facilitate communications within the organization. Consequently, the results of the innovation projects have an impact on the company and its construction projects.

The results of the study generated 18 propositions, which are shown in Fig. 1 (Pellicer et al. 2012, 2014) and detailed in Table 1 (Pellicer et al. 2012, 2014). These propositions are organized around the following aspects of the innovation management process (Correa et al. 2007; Pellicer et al. 2012): innovation drivers, results from innovation, innovation system, business environment, and organizational capabilities. Table 1 also includes the scientific contributions that support each of the propositions in the model.

These 18 propositions were subjected to validation as explained in the research method. The results of the validation revealed a broad consensus among the three groups interviewed, which confirmed 15 of the 18 formulated propositions beyond doubt. Three of the propositions were only weakly supported: P4, P15 and P16. The proposition with the least support states that when adopting an innovation management system in a construction company, innovation can be achieved using a

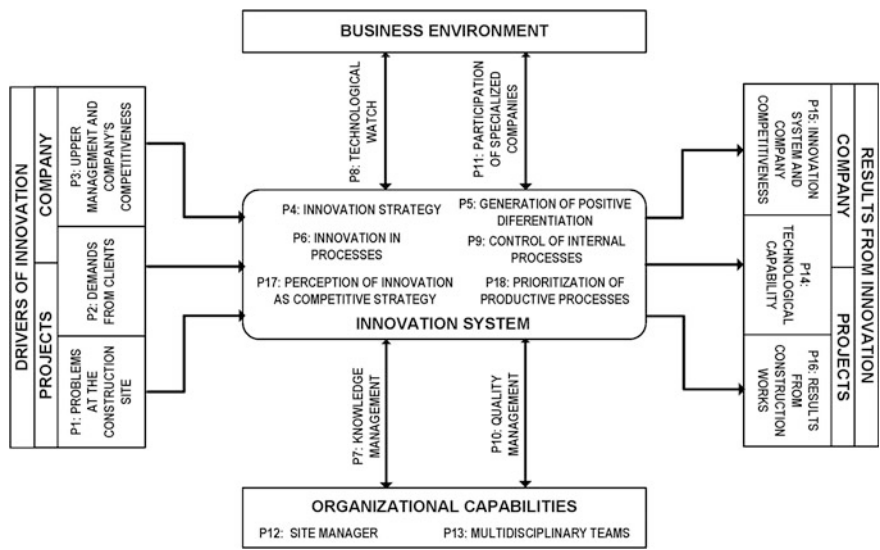


Fig. 1 Innovation management model and its propositions (Pellicer et al. 2012, 2014), with permission from ASEM and ASCE respectively

previously defined strategy. It is possible that, when innovation management is not sufficiently mature, informal strategies do not allow perceiving the advantages of innovation.

5 Results of the Implementation

Once the main phase of the research had been carried out (2006–2009), which included the implementation of the processes and formulation of the propositions that define the innovation management model, a follow-up was done of the company’s performance. Table 2 shows the company’s evolution during the nine years of observation (from 2006 to 2014, although in this last year only partially). The data include revenues, profits before taxes, employees with university degrees and employees working in the innovation department, and innovation projects that have been certified by an external agency. The company implemented the innovation management system in 2007 and it was certified by AENOR (external agency) in 2008 (Pellicer et al. 2012). The data in Table 2 must be interpreted in the context of the crisis in the Spanish construction sector starting in 2008 (Torres-Machí et al. 2013; Oviedo-Haito et al. 2014). To facilitate comparison with the sector in general, the production indexes in building and civil engineering in Spain for that period are also included (SEOPAN 2014).

Table 1 Propositions and main references that support them (Pellicer et al. 2012, 2014)

Code	Proposition	References
P1	Innovation comes from technical problems that arise in project execution at the construction site	Slaughter (1993), Nam and Tatum (1997), Winch (1998)
P2	Construction companies innovate to meet client requirements	Nam and Tatum (1997), Mitropoulos and Tatum (2000), Blayse and Manley (2004)
P3	Senior management propels innovation projects to improve the competitiveness of the company	Tatum (1987), Winch (1998), Slaughter (2000)
P4	By adopting an innovation management system, innovation follows a previously defined strategy	Gann and Salter (2000), Seaden et al. (2003), Stewart and Fenn (2006)
P5	By implementing an innovation management system, the company responds to the need to generate positive differentiation that is valued by clients	Slaughter (2000), Sexton and Barrett (2003), Van den Ven and Poole (2005)
P6	Construction companies generally innovate in processes	Gann and Salter (2000), Sexton and Barrett (2003)
P7	The implementation of an innovation management system improves knowledge management	Winch (1998), Parikh (2001), Hardie et al. (2005)
P8	Construction companies that adopt an innovation management system understand their environment better	Tatum (1987), Pries and Janszen (1995), Seaden et al. (2003)
P9	The control of internal processes (mainly production and management) constitutes a basic source for generating innovative ideas	Dulaimi (1995), Stewart and Fenn (2006), Kornish and Ulrich (2011)
P10	The existence of a quality system certified by the ISO 9001 standard facilitates the implementation of an innovation management system	Prajodo and Sohal (2006), Santos-Vijande and Alvarez-Gonzalez (2007), Casadesus et al. (2011)
P11	The existence of an innovation management system stimulates subcontracting to specialized companies and adds value to the innovation process	Blayse and Manley (2004), Wagner (2006)
P12	The active involvement of the site manager in the innovation process has a significant impact on the results of innovation	Park et al. (2004), Dulaimi et al. (2005)
P13	Innovation in construction requires the participation of multidisciplinary teams	Gann and Salter (2000), Bossink (2004)
P14	The adoption of an innovation management system improves the company's technological capabilities	Tatum (1987), Nam and Tatum (1992), Slaughter (2000)
P15	The adoption of an innovation management system improves the company's competitiveness	Tatum (1987), Nam and Tatum (1992), Mitropoulos and Tatum (2000)
P16	The certification of an innovation project improves the results of construction projects	Marimon and Cristobal (2005), Veá et al. (2010)
P17	Innovation in construction is delayed when senior management does not perceive it as a competitive strategy	Nam and Tatum (1997), Slaughter (2000), Blayse and Manley (2004)
P18	The prioritization of production processes hinders the identification of innovation opportunities	Tatum (1986), Pries and Janszen (1995), Gann and Salter (2000)

Table 2 Evolution of the company and the Spanish construction industry for the period 2006–2014 (Yepes et al. 2016)

Indicators (data from 12/31/2014)	2006	2007	2008	2009	2010	2011	2012	2013	2014
Revenues (in millions of Euros)	451.3	488.1	567.6	591.2	475.6	396.8	279.9	238.6	NA
Profit before taxes (in millions of Euros)	6.7	8.2	15.4	17.9	12.2	3.1	−7.8	0.5	NA
Employees with university degree	37	42	53	56	48	45	40	38	39
Employees working at the innov. dept.	1	3	4	4	4	4	4	3	4
Annual innovation projects certified	0	1	1	6	11	9	8	5	11
Production index for building	183	174	146	121	100	81	78	80	NA
Production index for civil engineering	150	147	123	145	100	79	67	63	NA

Analyzing the data in Table 2, it is observed that company profits tripled from 2006 to 2009, while the revenues increased only a third and the construction sector remained stable, at least in civil engineering. In that period, there was a spectacular increase in certified projects, as well as in qualified personnel and technicians working in the innovation department. These results show the benefits of implementing an innovation management system in a mid-size company, at least from the point of view of the innovation projects; obviously, this does not necessarily mean that there is a direct relation between profits and innovation, this being a question for future research.

For 2010–2014, company revenues and profits decreased, just as it did in the Spanish construction industry as a whole. However, the innovation department stayed stable for three years (2010–2012) despite the crisis, maintaining the same personnel and with an acceptable production in innovation projects.

Additionally, the company's innovation department garnered great prestige among company employees, given that even in times of crisis it worked at a good pace. For example, some innovation projects increased productivity, such as optimization of manufacturing, transportation and application of asphalt mixtures, or the improvement in the process of shoring and removal of formwork in underground parking lots. Other projects improved the flow of information: between the offices and construction sites using mobile devices, with suppliers and subcontractors through a computerized system, or with workers on site using an intelligent planning and control procedure. For these reasons, the directors and managers of the company sensed that, over time, clients, suppliers and subcontractors came to see the company as an innovator. For company management, implementation of the innovation management system was a success.

6 Lessons Learned

The systematization of innovation helps to assimilate new ideas and, therefore, to disseminate new knowledge in the company. Initially, the main sources of creativity in the construction company were solving problems at construction sites and meeting client demands, always with the support of company management. Once the system was implemented, however, the following processes were followed: technology watch, creativity, project planning and development, technology transfer and protection of results. In any case, problem solving continues to be the main innovation source, fulfilling several objectives: (1) those inherent to each construction site; (2) improvement of the productive processes that can be replicated on future projects; and (3) increased scoring (in the innovation section) for upcoming public tenders.

During the nine years of this investigation, the lessons learned regarding the implementation, development and evolution of the systematic management of innovation in construction companies have been many, especially the following:

- The establishment of an innovation management system modifies the company's organizational structure, even if this is only by the creation of a specific innovation department.
- The previous existence of a quality management system facilitates and benefits the implementation of an innovation management system.
- The construction company mainly innovates through processes and their related products.
- Innovation opportunities are identified as a result of the evaluation of the company's internal processes, as well as construction projects and the environment.
- The identification, development and transfer of innovative solutions require the integration of several disciplines: (1) observation of the environment, including technological watch, to identify opportunities to innovate, feasible solutions and technology partners who add value to the innovation process; (2) knowledge management in the organization so that findings are transferred to other projects, either innovation or production projects; and (3) the ability to discern the specific demands of clients.
- Collaboration with technology partners and the management of multidisciplinary equipment are necessary conditions to generate innovation in construction companies.
- The main benefit of innovation management is an increase in technical capacity.
- The two main barriers to innovation are the prioritization of production over everything else and the underestimation of innovation as a competitive strategy on the part of the company's senior management.
- Standardizing innovation different benefits are obtained for the company: improvement of the organization, increased technical capacities, profit, and client satisfaction.

- The implementation of an innovation management system is an opportunity to implement a knowledge management system in the company (Pellicer et al. 2008; Yepes et al. 2016).

7 Conclusions

This article presents the implementation, development and evolution of an innovation management system in construction companies. It is based on the case study of a mid-size construction company, the results of which were contrasted through interviews with other companies also certified by the UNE 166002 standard. Moreover, the study also includes an analysis of the evolution of the company once the system has been implemented.

Most companies generate innovative products and processes; however, the main difficulty lies in carrying out continuous and methodical innovation, far from occasional efforts and happy ideas. Innovation must be planned, organized, directed and controlled, like any other business activity.

Innovation in companies in the construction sector may cease to be a spontaneous act that only arises when solving a specific problem, and become a systematized and homogenized management process. The standardization of innovation, therefore, makes it possible to accelerate the identification of the activities involved in the creation of new processes, products and services in companies in the industry, and thus to improve their competitiveness in the market. The systematization of innovation not only facilitates the incorporation of new ideas, but also increases the capacity to acquire, develop and use new knowledge.

The main limitation of the present investigation is the generalization of the results obtained. This model cannot yet be generalized, despite contrasting the results of the implementation using semi-structured interviews with managers responsible for innovation in other certified companies. To this end, a validation could be carried out, for example, by means of a survey administered to a sufficient number of companies with an adequate degree of maturity in the systematic management of innovation. The implementation in other countries is another line of enquiry initiated by the authors; they aim to conduct case studies in countries like Chile, Portugal or Mexico.

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