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1 **A MODEL FOR SYSTEMATIC INNOVATION IN CONSTRUCTION COMPANIES**

2

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15

16 **ABSTRACT**

17

18 The reasons that drive construction companies to innovate, as well as the processes they use,
19 have not yet been fully explored in the specialized literature. This paper describes the “hows”
20 and “whys” behind the push for innovation in a construction company. The research method
21 is founded on a review of current theory and practice, as well as a case study, based on a
22 medium-sized construction company which implemented and certified an innovation
23 management system, as established by the Spanish standard UNE 166002. The studies
24 conducted by the authors over a five-year period generated a set of 18 propositions reflecting
25 an explanatory model of innovation management. This paper reports on the validation of the

26 model; the results fully corroborate 15 of these propositions. The conclusions of this research
27 are limited by the small amount of experience accumulated to date about the standardization
28 of these systems. Therefore the proposed model should be challenged or improved at a future
29 date with a larger number of companies, more mature in innovation management, and with
30 externally certified systems available.

31

32

33 **KEYWORDS:** Construction Company; Business Management; Innovation; Process;
34 Standardization

35

36

37 **INTRODUCTION**

38

39 Innovation management within a company is implemented through a series of activities and
40 decisions which increase the value of the products and services offered to external clients or
41 other stakeholders, or that fulfill other strategic business objectives (Ko 2009, Trkman 2010).
42 Its final goal is to strengthen the competitiveness of the company for its long term survival
43 (Evangelista et al. 1997). However, this relationship between innovation and competitiveness
44 is still not clearly understood by construction companies (Winch 1998, Harty 2008). This
45 motive drove the creation of a model to explain the process and reasons which drive
46 innovation management in a construction company, and to identify barriers that impede the
47 adoption of innovative business strategies which would increase the competitiveness of this
48 type of organization.

49

50 Modern companies are managed by processes which tend to transform vertical organizations,
51 structured by functions, into horizontal organizations focused on activities which add value to
52 the client (Vanhaverbeke and Torreman 1999). These processes are usually continuous and
53 at least partially recurring in their activities (Tidd et al. 1997, Gann 2000, Gann and Salter
54 2000); therefore, these companies develop procedures to systematize and simplify them.
55 Davenport (2005) justifies the standardization of processes, indicating that they make the
56 company's internal and external communications easier; they also allow resource
57 interchangeability, which grants more flexibility, improves the efficiency of the process, and
58 allows benchmarking. Current technologies which support these business processes are
59 suitable for standardization and the exchange of data and information.

60

61 Innovation management can be described as a business process which is critical for an
62 organization's ability to compete (Tidd et al. 1997, Vanhaverbeke and Torreman 1999); it is
63 an extremely complex and uncertain process because of its evolutionary and interactive
64 nature (Veugelers and Cassiman 1999). Gann (2000) highlights the characteristics of
65 companies that manage their production by processes (mainly in the construction sector)
66 where there are additional coordination challenges which impact the knowledge management
67 within the organization and inhibit the innovation ability of these companies. Some authors
68 (Dulaimi 1995, Gann 2000, Gann and Salter 2000, Pellicer et al. 2008) indicate that
69 innovation can be planned, organized, managed and controlled in the construction industry
70 just like any other business process; however, the reality is that many companies produce
71 innovations sporadically, rather than as part of an idea generation process that is methodical
72 and continuous.

73

74 There are authors who indicate the low innovation ability in the construction industry which
75 is highly traditional and closely tied to local practices (Serpell 2001, Blayse and Manley
76 2004, Taylor and Levitt 2004). Other contributions go into great detail about the specifics of
77 innovation in construction (Winch 1998, Gann and Salter 2000). Problems that come up in
78 construction sites require specific solutions or spontaneous inventions (Nam and Tatum
79 1992). This informal approach to innovation does not take advantage of the benefits of its
80 systematization as a process, which provides added value to clients and other stakeholders
81 involved in the infrastructure life-cycle, as described by Manseau (1998).

82

83 One approach that supports innovations and allows its systematization is the adoption of
84 voluntary standards, such as the UNE 166002. The UNE 166002 standard is based on a set of
85 sub- processes focused on generating and documenting a company's innovation projects.
86 These sub-processes include: (a) technological watch, (b) creativity, (c) planning and
87 executing innovation projects, (d) technology transfer, and (e) protection of results (AENOR
88 2006, Pellicer et al. 2008, Yepes et al. 2010, Mir and Casadesus 2011). The UNE 166002
89 standard is based on continuous improvement of processes, which are part of the ISO 9001
90 standard for quality management (Pellicer et al. 2008). There is specialized literature which
91 supports that adequate quality management in a company improves its ability to innovate
92 (Perdomo-Ortiz et al. 2006 & 2009). Casadesus et al. (2011) confirm that the coordinated
93 application of different management systems standards is beneficial for the company due to
94 the synergies created. The advantages recently obtained by Spanish companies applying and
95 certifying systems to manage innovation, drove Portugal (NP 4457 standard), Chile and
96 México to also incorporate versions which were adapted from these Spanish standards
97 (Teixeira et al. 2009).

98

99 This paper presents the final phase of a five-year research project conducted by the authors
100 regarding innovation management. This research has been possible due to the constant
101 collaboration with a medium-sized construction company, as well as the specific
102 collaboration with other companies and professionals from this sector. Prior research
103 included: (1) a complete literature review and the conception of a theoretical framework
104 (Correa et al. 2007); (2) the introduction of the UNE 166000 standards, as well as prior
105 research regarding innovation in the Spanish construction industry (Pellicer et al. 2008); (3) a
106 strategic analysis of a company selected as a case study (Pellicer et al. 2010); (4) the
107 implementation of an innovation management system in that company (Yepes et al. 2010);
108 and (5) the explanation of the model derived from the case study (Pellicer et al. 2012).

109

110 The goal of this research is to propose an evidence-based explanatory model of innovation
111 management in a construction company, using a case study methodology. The research
112 contributes evidence which allows construction companies to understand how innovation
113 develops in their companies, the factors it is dependent upon, and its main barriers. Thus, this
114 paper is organized in five sections. First, propositions are created from theoretical and
115 empirical evidence, using case study methodology based on an innovation management
116 model. Second, there is a description of the research method used to validate the propositions.
117 Then the results of the validation are described and discussed, to finalize with conclusions
118 and suggestions for future research.

119

120

121 **A MODEL FOR INNOVATION MANAGEMENT**

122

123 Innovation management includes all the necessary activities to efficiently implement an idea
124 for a product or a process which will increase the ability of the organization to compete
125 (Eaton 2001). Tidd et al. (1997) advise that innovation management should be understood as
126 the generation of the necessary conditions within an organization in which technological,
127 strategic, or organizational changes are made in situations of high uncertainty. Innovation
128 management can be implemented in the construction sector at varying levels, and to a greater
129 or lesser extent (Correa et al. 2007): (a) the national research and development (R&D) system
130 (Gann 1997); (b) within the company (Gann and Salter 2000); (c) in projects or products
131 (Tatum 1987, Nam and Tatum 1992); and (d) throughout the construction process (Kangari
132 and Miyatake 1997).

133

134 The process for innovation management in construction companies has been studied by
135 multiple authors. Manseau (1998) encourages industry to adopt a systemic, broad perspective
136 so as to understand and expand innovation in construction. Most theoretical proposals
137 evaluate innovation in construction companies based on the appropriate response to
138 environmental and internal factors, using the reference of the general systems theory. The
139 most noteworthy models, based on literature reviews, are mentioned here.

140

141 Manseau (1998), and Seaden and Manseau (2001) propose a general model which is
142 applicable to each sub-sector but focused on the company. It considers the whole
143 infrastructure life-cycle including all the stakeholders and the different types of interactions
144 among them. For Winch (1998), innovation in construction companies comes from the
145 mutual relationship between construction projects and companies. Gann and Salter (2000)
146 develop this idea into a model highlighting six dimensions: companies, supply chains,
147 projects, technology, institutional regulations, and knowledge transfer. Seaden et al. (2003)

148 proposes linking the environment and business strategy, since both of them affect the
149 innovative capacity of the organization. Sexton and Barrett (2003) define a model based on
150 the innovation process, as well as the internal and external context in which it occurs. The
151 internal context includes business strategy, market positioning, work organization,
152 technology and human resources; the external strategy includes the various business
153 environments and their interactions. Dikmen et al. (2005) proposes a systematic model for
154 innovation made up of five basic elements: objectives, strategies, environmental sources and
155 barriers, as well as organizational factors.

156

157 The model which explains innovation management in construction companies is presented in
158 Figure 1, and it is aligned with the proposal of Seaden and Manseau (2001) regarding
159 company-focused knowledge systems; they propose that the company is the center of a
160 network of suppliers, clients, competitors and resources. This model also incorporates
161 previous proposals of the authors (Correa et al. 2007, Pellicer et al. 2012). Construction
162 companies generate new ideas which turn into innovation projects. However, the success of
163 this process rests on a business strategy which is clearly aligned and focused on generating
164 innovation. The strategy which supports innovation must be solidly supported and integrated
165 into the business environment, mobilizing all the organizational capabilities of the company
166 toward reaching its goals. Also, the strategy should embrace the distribution of information
167 and communication throughout the organization. Therefore, this innovation strategy supports
168 the results of the innovation projects which impact not only the company but also the
169 construction projects.

170

171 The results of the research focused on a construction company, as well as the observations
172 and data obtained from other companies and professionals generated 18 propositions that are

173 shown in Table 1 (Pellicer et al. 2010, 2012). These propositions were organized according to
174 key aspects of the innovation management process (Correa et al. 2007, Pellicer et al. 2012):
175 drivers of innovation, results of innovation, innovation system, business environment, and
176 organizational capabilities (see Figure 1). Table 1 also includes bibliographic references
177 which support the formulation of each one of the propositions in the case study. This
178 qualitative research was developed following the procedure proposed by Yin (2003). The
179 chosen company is referred to as *Lambda*, so as to not disclose its true identity.

180

181 <TABLE 1 HERE>

182

183 An innovation management system transforms drivers into specific results and benefits. The
184 system is influenced by the business environment and the organizational capabilities of the
185 company. Innovation management begins with the identification of opportunities which are
186 derived from the requirements of the stakeholders (employees, clients, suppliers, and the
187 environment), as well as from difficulties which come up during the construction project. The
188 best ideas are selected by the upper management to become innovation projects. The
189 department responsible for innovation organizes and designates the necessary resources, as
190 well as implements and oversees the projects. These innovations are evaluated and codified,
191 becoming lessons-learned which can be transferred to future projects. The innovation results
192 are applied to construction projects or to the company; these results are a fundamental
193 feedback loop for continuous improvement. This process for innovation management is
194 described in detail in Yepes et al. (2010).

195

196 <FIGURE 1 HERE>

197

198

199 **VALIDATION OF THE PROPOSITIONS**

200

201 The case study research process follows the guidelines proposed by Yin (2003). This process
202 includes six steps: (a) literature review, (b) design of a logical model, (c) data collection, (d)
203 data analysis, (e) report of results, and (f) validation of results. To ensure the quality of the
204 research, Yin (2003) proposes four design tests: (1) construct validity, (2) internal validity,
205 (3) external validity, and (4) reliability. Its application in this research is explained below.

206

207 The validity of the constructs was assured using many information sources and generating
208 chains of evidence; both were applied during data collection. Internal validity refers to the
209 causality logic of the qualitative study. According to Yin (2003), this is achieved in two
210 ways: building explanations of the phenomenon being studied (“explanation-building”), and
211 contrasting what the theory predicts with the observed reality (“pattern-matching”). External
212 validity is the main goal of the research discussed in this paper. The reliability was achieved
213 with the development of a protocol prior to this case and a database containing all the
214 information and evidence collected.

215

216 As indicated previously, the research process requires an external validity (Yin 2003). This
217 entails corroborating the propositions so the model can be generalized to the universe of
218 construction companies with an innovation management system. To achieve this, interviews
219 were conducted with managers of seven Spanish construction companies which had an
220 innovation management system certified by the UNE 166002 standard (see Table 2). There
221 were a total of eight certified companies at that time, so the sample was considered to be
222 representative. The managers interviewed included directors of the department in charge of

223 innovation (being four of them also responsible for quality management), with a minimum
224 experience of 15 years in the construction sector and university degrees in civil engineering
225 (in 4 cases) or industrial engineering (3 cases). These interviews were structured in three
226 stages:

- 227 1. Obtaining basic data describing the company (summarized in Table 2).
- 228 2. Validating the propositions with a questionnaire survey (included in the Appendix).
- 229 3. Using a guided interview, lasting a minimum of 120 minutes per company, to explore the
230 barriers and benefits of the innovation process.

231

232 <TABLE 2 HERE>

233

234 Eight directors of the *Lambda* company were also interviewed (internal validation) as well as
235 nine construction industry experts, who were independent of this company. Managers of the
236 *Lambda* company were all department directors with a minimum of ten years of experience in
237 the construction sector; seven of them were civil engineers and one was a chemical engineer.
238 The experts include representatives from different organizations: material supplier,
239 consultant, real estate developer, government, city council, professional association,
240 certifying body, and university professor; they had a minimum of 20 years of experience
241 working in the sector. Seven of them were civil engineers and two of them were architects.
242 The interview was tested and refined with a pilot interview done with three university
243 professors, who had more than 20 years of professional experience in the construction
244 industry.

245

246 The degree of acceptance of these propositions resulted from the analysis of the responses
247 from the groups interviewed: certified companies (7), managers from Lambda (8) and,
248 experts (9). The appendix includes the complete questionnaire.

249

250 The possible responses were scaled so that the mean could be computed for each group.
251 Questions with possible answers of "high," "medium," and "low" received a value of 2, 1,
252 and 0, respectively. However, answers to questions with alternatives such as "strongly agree,"
253 "agree," "disagree," and "strongly disagree" had designated values of 2, 1, -1, and -2,
254 respectively. Using these values as a reference, an average was calculated for each
255 proposition and group. A proposition was rated as "strong" (S) when the average was over
256 1.3, and "weak" (W) when the average was less than 0.7. For intermediate situations, the
257 proposition was categorized with an evaluation of "medium" (M).

258

259

260 **RESULTS**

261

262 All the propositions received a "strong" rating by all the groups that were interviewed, with
263 the exception of the propositions shown in Table 3. This table indicates the specific
264 proposition (by code) and the level of support received from each interviewed group: strong,
265 medium or weak. The results are shown in a graph (Figure 1) as follows: (a) strong (bold text
266 and heavy line); (b) medium (regular text and heavy line); and (c) weak (cursive text and
267 narrow line).

268

269 <TABLE 3 HERE>

270

271 Table 3 shows that the results obtained by the companies and Lambda's managers are in full
272 agreement. This indicates an alignment between the company's reality and its managers'
273 views regarding innovation. However, there are discrepancies with the experts, since they
274 valued four of the propositions with a lower rating, and only proposal P₄ with a higher rating
275 (medium). It is worth noting that this proposition P₄ was the only one that had a weak support
276 from the group of certified companies.

277

278 Other interesting results were obtained from the interviews that were not directly related to
279 the model's evaluation, as highlighted below:

- 280 • Four companies indicated that certification bodies associate innovation with scientific
281 research. This uncertainty regarding the scope of the standard makes it difficult to justify
282 simpler technological innovations.
- 283 • One aspect which was reiterated by companies is the conflict which occurs when clients'
284 needs are different than the standard or customary construction practices.
- 285 • There is evidence linking innovation, quality and knowledge management. Two of the
286 companies used teams of specialists to implement innovation on site. If these innovations
287 provided results, they generated new procedures that were added to the quality
288 management system of the company with a feedback loop of lessons learned.
- 289 • Companies highlight the need for, and importance of, technological watch for the
290 generation of innovative ideas, in spite of its difficulty.

291

292

293

294 **DISCUSSION**

295

296 An analysis of the results shows that the proposed model is highly supported, since 15 of the
297 18 propositions were strongly rated; two had a medium validation, and only one had a weak
298 validation. Figure 1 includes a graphic representation of the results; they were supported by
299 managers of external companies and those of the company under study. A review of this
300 section focuses mainly on analyzing the propositions which were assessed as medium and
301 weak, and also analyzing cases where there was a slight discrepancy between the response of
302 the external experts and the managers of the construction companies.

303

304 There is overall consensus regarding the influence of the drivers of innovation; however, the
305 influence of the outputs is not as clear, not only for the construction company, but also for its
306 projects; the only exception is the increase in the technological capabilities presented in
307 proposition P₁₄. Proposition P₄, indicates that “by adopting an innovation management
308 system, innovation follows a previously defined strategy”; it showed a weak acceptance level
309 in spite of its importance in the literature (Nam and Tatum 1992, Eaton 2001, Seaden et al.
310 2003, Sexton & Barrett 2003, Taylor & Levitt 2004, Hartmann 2006, Lim et al. 2010). It is
311 difficult to draw a cause-effect explanation between adopting strategies focused on
312 innovation through a management system, and achieving innovative results. Companies do
313 not acknowledge the existence of a previous and specific strategy for innovation. However,
314 this has not been a barrier to innovation, coming from companies that have certified their
315 innovation management system. Therefore, there are informal business strategies of
316 innovation that exist in non-mature stages of innovation management processes.

317

318 A second level of discrepancy is reflected in propositions P₁₅ and P₁₆. Both the companies
319 interviewed, as well as the Lamda managers and the experts consulted, do not clearly
320 perceive a relationship between the adoption of an innovation management system and the
321 increase in the construction company's ability to compete (P₁₅). This perception is also
322 evident in other areas of business management where the simple certification of a quality
323 management system with the ISO 9001 standard does not guarantee an increase in the
324 company's ability to compete. While the adoption of an innovation management system helps
325 to improve competitiveness of a construction company, this measure seems insufficient, on
326 its own to reach this final objective. Proposition P₁₆, which states that "the certification of an
327 innovation project improves the results of construction projects," was not overwhelming
328 confirmed. There was a weak relationship expressed by the experts, versus the average of the
329 other groups. One possible interpretation comes from the financial results demanded in the
330 short term from projects. Innovation generates benefits, which are not just profit; this benefit
331 can expand to the entire organization with an adequate knowledge management system.
332 There are taxes, organizational and competitive benefits which are sometimes difficult to
333 express as profit for a given construction project. While it is clear that innovation contributes
334 to achieving the goals of a construction company and its construction projects, the short run
335 may distort the visibility of the cause-effect relationship between innovation and financial
336 results. This distortion is accentuated when the success of a construction project is subjected
337 to other factors than innovation.

338

339 The third level of disagreement is where experts differ regarding the internal motivation of
340 the innovation management process. In this sense, proposition P₂ says that "construction
341 companies innovate to meet client requirements." This may be due to the close relationship
342 which construction companies have with their clients; a relationship which the experts do not

343 have. Even though there are other sources of innovation, it is clear that client requirements
344 are one of the most important reasons to innovate. This small discrepancy between the
345 experts and the rest of the groups is also seen in propositions P₇ and P₁₇. The first states that
346 “the implementation of an innovation management system improves knowledge
347 management.” Experts are not as strongly in agreement with this proposition, possibly
348 because they do not have the experience of the certified construction companies, where
349 simply standardizing innovation has allowed them to open vertical and horizontal
350 communication channels in the company, greatly influencing the flow of information and
351 knowledge. Also, the experts did not consider managers’ support of innovation to be decisive.
352 This vision that competitive strategy based on innovation should receive the support of upper
353 management is a fact clearly viewed differently by the construction companies. This may be
354 somewhat minimized in the experts’ opinion, since they are more likely to emphasize the
355 influence of technical personnel on topics related to innovation.

356

357 Therefore, the strong support of the propositions that outline the model allows clarifying the
358 process and reasons which drive innovation management in construction companies. The
359 discrepancies exist mainly for propositions P₄, P₁₅ and P₁₆, and they may be explained by the
360 lack of cumulative experience in innovation processes of these companies within the outline
361 of standardized management. Moreover, the lack of visibility of long term competitive
362 advantages is diminished within the organization when innovation processes are based on
363 informal strategies.

364

365

366 **CONCLUSIONS**

367

368 This paper presents the validation of an innovation management model for construction
369 companies; it is based on research conducted using a case study of a medium-sized company,
370 with the additional collaboration of other companies and professionals working in the
371 Spanish construction sector. This entailed having 18 propositions reviewed by managers of
372 companies, which are externally certified in innovation management, managers of company
373 under study, and independent experts. The result was a broad consensus between the different
374 groups interviewed, and a strong support for 15 of the propositions presented. As a result of
375 this research, it was possible to conclude that:

- 376 • Technical problems in construction projects, client requirements and upper management
377 are the strongest drivers of innovation in construction companies.
- 378 • Construction companies mainly innovate through processes and their related products.
- 379 • Innovation opportunities are identified as a result of examination of the internal processes
380 of the company, as well as the construction projects and the environment.
- 381 • Identifying, developing and transferring an innovative solution requires the integration of
382 multiple disciplines:
 - 383 ✓ Environment observation, including technological watch, in order to look for
384 opportunities to innovate, feasible solutions and technological partners who add
385 value to the innovation process.
 - 386 ✓ Knowledge management in the organization can transfer findings to other
387 projects, whether they are related to construction or innovation.
 - 388 ✓ The ability to detect requirements from the demanding clients.
- 389 • Collaboration with technological partners and management of multidisciplinary teams are
390 necessary conditions to have innovation in construction companies.

- 391 • The main benefit of innovation management is an increase in technical capability.
- 392 • The implementation of an innovation management system can benefit from a quality
- 393 management system already in place.

394

395 The proposition with the least support states that “by adopting an innovation management

396 system, innovation follows a previously defined strategy”; this can happen because of the

397 existence of informal innovation strategies at times when innovation management is not

398 mature yet. Besides, it is not clearly perceived that there is a connection between the adoption

399 of an innovation management system and an increase in the competitiveness of the

400 construction company. This situation may be due to the fact that, when the research was

401 conducted, these processes were in their earlier stages of implementation. Also, while

402 companies clearly agree, the experts do not show the same appreciation of the importance of

403 client demands, the influence of management personnel on innovation, or the positive impact

404 of innovation on knowledge management.

405

406 Finally, the impact of the time variable on the results and the local determining factors are

407 aspects that should be analyzed more in depth in future research, which is already underway.

408 On the one hand, there is research going on regarding multiple cases of Chilean construction

409 companies to contrast the level of maturity of innovation management in an environment

410 which is different than the one already analyzed. On the other hand, there is a broader

411 reaching survey of Spanish construction companies which have already certified their

412 innovation management processes. This will help to corroborate or improve the proposed

413 model.

414

415

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417

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423 suggestions and constructive comments.

424

425

426 **APPENDIX: QUESTIONNAIRE**

427

428 1. Construction companies develop innovation projects with the goal of (indicate if it is
429 “high,” “medium,” or “low”): (a) accessing new markets or obtaining a higher market
430 share; (b) resolving technical problems in the construction project (P₁); (c) responding to
431 client requirements (P₂); (d) increasing the quality of the infrastructure; (e) improving the
432 ability of the company to compete (P₃); (f) Other.

433

434 2. Has your company done any of the following types of innovation? (indicate “high,”
435 “medium,” or “low”) (P₆): (a) Product; (b) Process; (c) Organizational; (d) Marketing.

436

437 3. The following propositions refer to aspects of an innovation management system
438 (indicate your level of agreement as “strongly agree,” “agree,” “disagree,” or “strongly
439 disagree”): (a) The implementation of an innovation management system improves
440 knowledge management in a construction company (P₇); (b) Organizations that adopt an

441 innovation management system understand better their external environment (P₈); (c)
442 Having a certified quality system in accordance with the UNE 9001 standard makes it
443 easier to implement an innovation management system (P₁₀); (d) Innovation requires the
444 participation of multidisciplinary teams (P₁₃); (e) The active involvement of the site
445 manager in the innovation process has a significant impact on innovation results (P₁₂); (f)
446 The certification of an innovation project improves the results at the construction site
447 (P₁₆); (g) The control of internal processes (production, management, etc.) is fundamental
448 for innovation (P₉); (h) Having a system for innovation management facilitates
449 subcontracting specialized companies that add value to the innovation process (P₁₁); (i)
450 Innovation systems are implemented in construction companies due to the need to create
451 positive differentiation that clients will perceive (P₅); (j) Adopting a system of innovation
452 management increases the construction company's ability to compete (P₁₅); (k) Adopting
453 an innovation management system increases the technical capacity of a construction
454 company (P₁₄); (l) A construction company requires an innovation management system to
455 innovate as part of a predefined strategy (P₄).

456

457 4. What are the primary barriers to innovation? (indicate if "high," "medium" or "low"): (a)
458 Prioritization of productive processes (P₁₈); (b) Lack of incentives; (c) Lack of an
459 appropriate culture; (d) Underestimation of I+D+i as a competitive strategy (P₁₇); (e)
460 Lack of leadership in I+D+i (P₁₇); (f) Lack of personnel trained in I+D+i; (g) Other.

461

462

463

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597

CODE	PROPOSITION	REFERENCES
P ₁	Innovation comes from technical problems that arise in project execution at the construction site	Slaughter (1993), Nam and Tatum (1997), Winch (1998)
P ₂	Construction companies innovate to meet client requirements	Nam and Tatum (1997), Mitropoulos and Tatum (2000), Blayse and Manley (2004)
P ₃	Senior management propels innovation projects to improve the competitiveness of the company	Tatum (1987), Winch (1998), Slaughter (2000)
P ₄	By adopting an innovation management system, innovation follows a previously defined strategy	Gann and Salter (2000), Seaden et al. (2003), Stewart and Fenn (2006)
P ₅	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)
P ₆	Construction companies generally innovate in processes	Gann and Salter (2000), Sexton and Barrett (2003)
P ₇	The implementation of an innovation management system improves knowledge management	Winch (1998), Parikh (2001), Hardie et al. (2005)
P ₈	Construction companies that adopt an innovation management system understand their environment better	Tatum (1987), Pries and Janszen (1995), Seaden et al. (2003)
P ₉	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)
P ₁₀	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)
P ₁₁	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)
P ₁₂	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)
P ₁₃	Innovation in construction requires the participation of multidisciplinary teams	Gann and Salter (2000), Bossink (2004)
P ₁₄	The adoption of an innovation management system improves the company's technological capabilities	Tatum (1987), Nam and Tatum (1992), Slaughter (2000)
P ₁₅	The adoption of an innovation management system improves the company's competitiveness	Tatum (1987), Nam and Tatum (1992), Mitropoulos and Tatum (2000)
P ₁₆	The certification of an innovation project improves the results of construction projects	Marimon and Cristobal (2005), Coelho and Matias (2010), Veá et al. (2010)
P ₁₇	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)
P ₁₈	The prioritization of production processes hinders the identification of innovation opportunities	Tatum (1986), Pries and Janszen (1995), Gann and Salter (2000)

Table 1. Propositions of the case study and main supportive references (Pellicer et al. 2012)

Company	Average Values (data from 2007)				
	No. Employees	Turnover (millions of Euros)	Investment in R&D (thousands of Euros)	No. Projects with External Certification	No. Projects under Execution
Lambda	430	488	200	1	3
A	3,100	2,600	18,000	20	28
B	2,200	900	4,000	12	12
C	7,000	2,700	18,500	25	62
D	15,000	3,500	1,500	1	6
E	80	60	5	0	4
F	500	190	300	3	5
G	500	150	2,000	0	8

Table 2. Basic characteristics of the companies

Table 3

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	P₂	P₄	P₇	P₁₅	P₁₆	P₁₇
Companies	S	W	S	M	M	S
<i>Lambda</i>	S	W	S	M	M	S
Experts	M	M	M	M	W	M
AVERAGE	S	W	S	M	M	S

Table 3. Discrepancies among the level of validation of the propositions

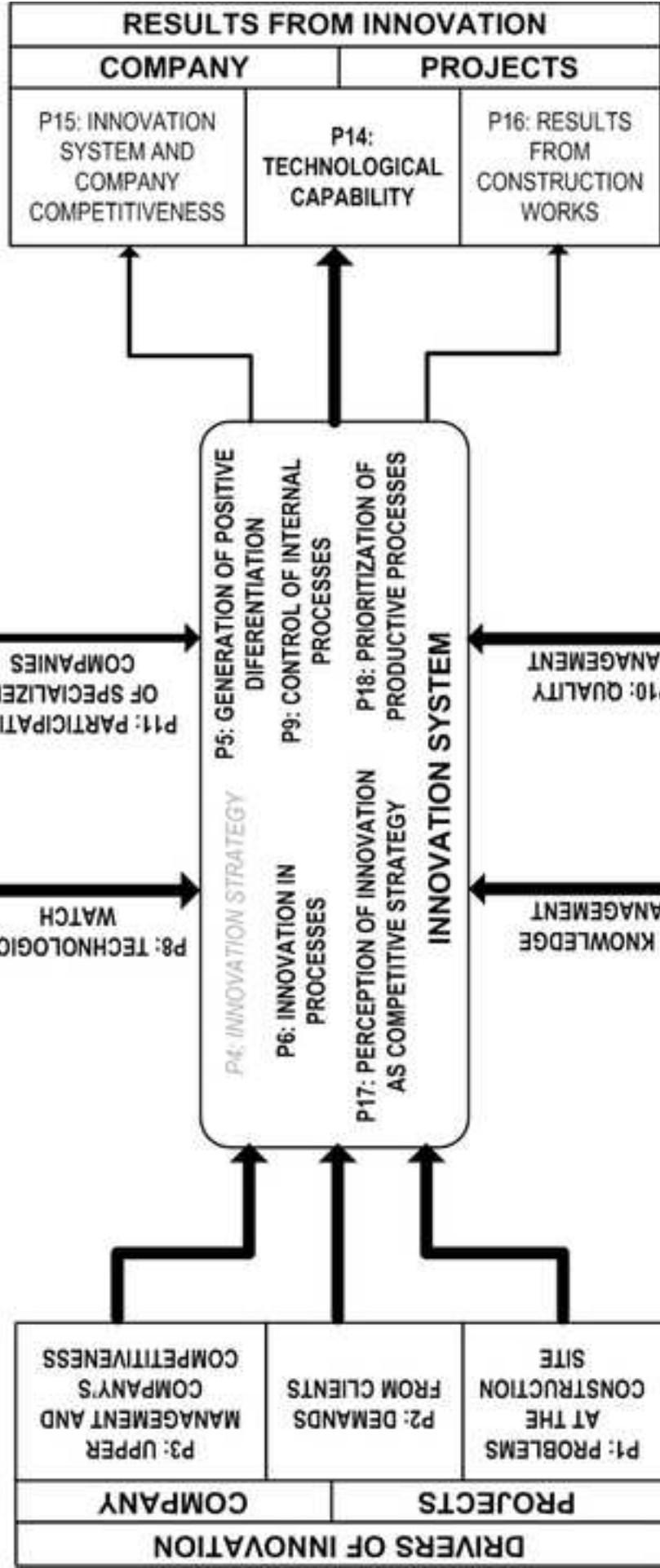


Figure 1
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