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# Firms' Connections and Open Innovation: The Case of Innovative Spanish Firms

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## ABSTRACT

The main aim of this paper is to determine whether or not and to what extent innovative Spanish firms apply open innovation practices. Accordingly, we analyze microdata from the Technological Innovation Panel (PITEC) database. This study develops a methodology that focuses on the description of the existing connections between the elements that constitute a socio-economic system: we extract data belonging to firms that have declared that they apply innovation activities and then we analyze the links between innovative firms based on the concept of systemic innovations (vs autonomous innovations) as a means to explaining open innovation. Systemic innovations require interaction between complementary innovators through different collaboration mechanisms that reveal links between parts of the system. From this perspective, we depict a profile of the innovation links in innovative Spanish firms involved in open innovation practices, together with a characterization of what we call an 'open innovator firm'.

## 1. Introduction

Open innovation (Chesbrough, 2006) consists of the intentional use of knowledge to impulse internal innovation and, at the same time, expand markets to allow the external use of innovation. This concept opposes the traditional model of innovation (closed innovation) that in a global context of labour mobility and market internationalization must adapt to different issues (Chesbrough, 2003): firstly, the international dissemination of knowledge; secondly, the growing difficulty involved in controlling competitive advantages gained from said knowledge; thirdly, the increasing rates of technological obsolescence and the availability of venture capital for new entrepreneurial activities and initiatives; and finally, the obsolescence of traditional intellectual property right models.

The main aim of this chapter is to determine whether or not and to what extent innovative Spanish firms apply open innovation practices. Accordingly, we will use data contained in the Technological Innovation Panel (PITEC) database, a panel database that in 2008 includes a survey carried out by the INE (National Statistics Institute) on 12,813 firms in Spain. The Technological Innovation Panel (PITEC) is a statistical instrument for studying the innovation activities of Spanish firms over time. It is the most comprehensive and exhaustive survey on such topics in Spain. This database is run by the INE (National Statistics Institute), which receives advice from a group of university researchers and the sponsorship of FECYT and Cotec.[1]

The main novelty of this work consists of a methodology that focuses on the description of the existing connections between the elements of a socio-economic system with a specific purpose in common, i.e. the intentional use of knowledge flows to accelerate internal innovation. The basic assumption is that such a structure and its evolution supports the analytical description of dynamic phenomena (Cañibano et al., 2006; Potts, 2000; Witt, 2003), i.e. the processes and practices of open innovation developed by firms.

The analysis of the links between innovative firms will be based on the concept of systemic innovations (Maula et al., 2006) -vs autonomous innovations- as a means to explaining open innovation. Systemic innovations require interaction between complementary innovators (including agents such as firms, start-ups and research centres, etc.) through different

*collaboration mechanisms* that reveal links between parts of the system, such as external venturing practices, research programmes and industrial consortia.

Thus, assuming that one necessary condition for open innovation is the existence of a set of collaborative links -representative of systemic innovation practices- we examine whether or not there are significant connections between firms and between firms and other players in the industry. With regard to collaboration, we will extract data belonging to firms that have declared that they apply innovation activities in order to identify the companies that reveal patterns of collaboration that are compatible with open innovation.

The structure of the chapter is as follows. Section 2 discusses the relationships between open innovation, systemic innovation and connections between firms. Section 3 analyses the innovation links between Spanish firms. Accordingly, we use the sample of innovative firms included in PITEC. We depict the profile of the innovation links in innovative Spanish firms involved in open innovation practices and provide a statistical model that estimates the probability of being an open innovator depending on said links. In this section, we propose an Index of Cooperation to obtain a more precise characterisation of the intensity and quality of cooperation among firms. On this basis, we will offer a characterization of what we call an 'open innovator firm'. Section 4 offers our concluding remarks.

## 2. Open innovation, systemic innovation and connections between firms: a methodological proposal

Many important research questions prompted by open innovation are related to understanding the incentives for generating the new discoveries and inventions that will supply the basis for future R&D innovation activities. Following Chesbrough (2006), there are at least four important perspectives from which to research said incentives: the perspective of the individual; the perspective of the organisation; the perspective of the community; and the institutional perspective.

In this chapter, we are interested in the perspective of the organisation, in particular, in the firm as an organization that has to develop internal R&D to create new products and services. In the open innovation approach, firms scan the external environment before they start up internal R&D activities.

For this research, we have adopted the following methodological decision: the study departs from the analysis of the links between innovative firms based on the concept of systemic innovations as a means to explaining open innovation at the level of the firm. Systemic innovations are innovations that require significant adjustments in different parts of the system in which they are developed (Maula et al., 2006); in other words, they require interaction between complementary innovators -as opposed to autonomous innovations, which can be pursued independently from other innovations (Chesbrough and Teece, 1996).

To perform systemic innovations, firms need to coordinate their R&D activities with direct competitors and with producers of complementary goods to ensure the viability of the innovation itself. This is due to the fact that systemic innovation processes frequently exceed the firm's capacity and therefore require the coordination of various parts of the network or consortium within which the firm operates. These agents include firms, start-ups and research centres, etc. and they are linked by different collaboration mechanisms that reveal connections between parts of the system, such as external venturing practices, research programmes and industrial consortia. In the context of systemic innovations, the appropriation of innovation benefits is said to take place best within a centralized organization, i.e. in integrated companies that control the activities which need to be coordinated by means of a hierarchy (Chesbrough and Teece, 1996). However, mere coordination with suppliers or consumers often occurs in the case of closed innovation models.

The underlying systemic approach to innovation provides a better understanding of open innovation processes; it allows exploration of how firms coordinate with other firms, with producers of complementary products and, in many cases, with direct competitors. As Maula et al. (2006) pose, the development of complementary innovation processes is vital for the commercial success and the creation of value for the internal innovation of the firm. The question is how to identify the proactive practices of systemic innovations and, as a consequence, the managerial practices for developing open innovation processes.

Assuming the systemic approach, it follows that a necessary condition for open innovation processes is cooperation among agents within an innovation system. Thus, we need to analyze whether or not there are important connections between firms and other players within the

system to conclude that such open innovation practices exist and how important they are. Cooperation among agents is also a relevant issue for policy-making (Bozeman, 2000).

Usual indicators of innovation practices, such as expenditure on R&D, the number of new products/services developed in the last year, the sales of new products/services over total revenues and the number of patents, etc. are not necessarily immediately applicable in the case of open innovation in a systemic innovative context.

To evaluate the performance of open innovation practices, the appropriate indicators must be proposed. What variables should we take into account to assess the existence of open innovation practices within an innovation system? As we have pointed out, the methodology proposed is based on the examination of the connections between firms that are provided by the statistics available on innovative firms. We will look for the existence of a set of collaborative links –representative of systemic innovation practices that are compatible with internal R&D open innovation processes.

The framework for this empirical analysis is based on two analytical decisions. Firstly, we identify the main process: the performance of internal R&D activities. Thus, we can identify the firms that are allocating resources to improve their internal knowledge flows as a means for interacting and/or reacting to environmental changes. Secondly, we filter the previous dataset with a second criterion: cooperation among firms or in general. This characteristic is used as a proxy of firms that are interacting for innovation with their environment. We assume that systemic links between innovative agents are established in this subsample of firms, which is also where open innovation processes would be deployed. These two methodological decisions incorporate the necessary condition for open innovation: open innovator firms carry out internal R&D and cooperate with the innovative agents within the innovation system.

# 3. Innovation links between Spanish firms

## 3.1 Data and variables

In this section, we analyze microdata from the Technological Innovation Panel (PITEC). PITEC is a statistical instrument for studying the innovation activities of Spanish firms over time and is designed as a panel data survey.[2] The database is being built by the INE (National Statistics Institute). PITEC applies an anonymisation process to replace the firm-level observations of six quantitative variables (revenues, exports investment, number of employees, innovation expenditures and number of R&D employees).

Data are collected annually. In this chapter, we use PITEC data for the year 2008 because it is the last available year at the present time. The PITEC sample for 2008 includes 12,813 firms, of which only 11,182 provide data for their innovation activities in said year. The other companies present various incidents: mergers, takeovers, out of business, etc. Thus, we have first removed those firms in the panel that present some kind of incident, e.g. those that have stopped trading, have been taken over or merged with others, etc. In other words, we have used here the subsample of firms classified as LI in the panel. Then, among these LI companies, we have focused on the collaboration patterns of the companies that carry out internal R&D (a precondition for open innovation) in PITEC.

PITEC 2008 includes 506 variables. From this huge number, we have focused only on those that allow us a better characterization of would-be open innovation practices. In particular, we have analyzed a subsample of firms included in PITEC that carry out internal R&D and cooperate on innovation activities. Table 1 shows the variables selected for the construction of the subsample.

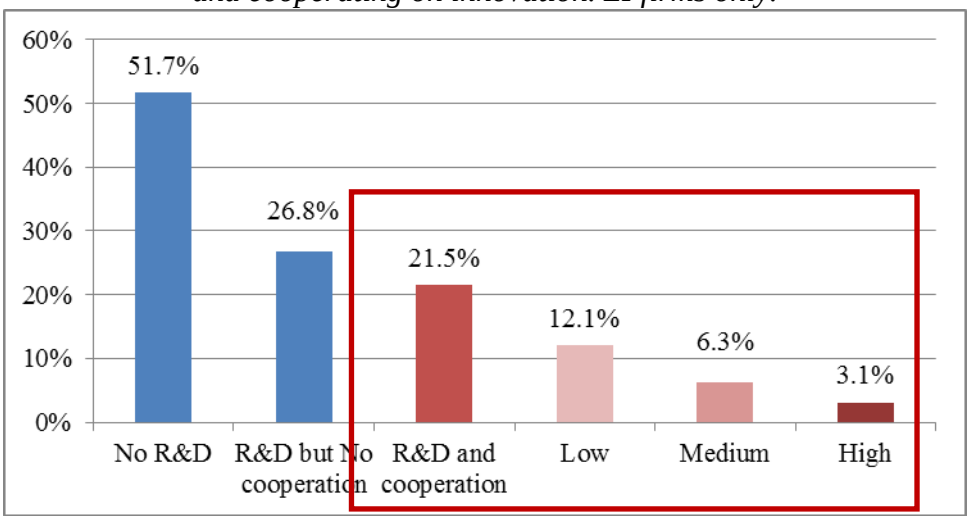
*Table 1. Variables included in PITEC 2008 that refer to cooperation links.*

| VARIABLE | DESCRIPTION |
|---|---|
| IDIN | Firms that carry out internal R&D |
| COOPERA | Firms that collaborate with other agents |
| COOP1-COOP9 | Cooperation depending on type of agent:<br>1. Other firms that are members of the same group<br>2. Customers<br>3. Suppliers<br>4. Competitors<br>5. Consulting and outsourcing<br>6. Commercial Laboratories<br>7. Universities<br>8. Public research agencies<br>9. Science and Technology Centres |

## 3.2 Profile of cooperation links in innovative Spanish firms: a descriptive analysis

It should be mentioned that not all firms included in the panel state that they carry out internal R&D. The results are summarized in Figure 1.

*Figure 1. Distribution of the sample of firms included in PITEC depending on internal R&D and cooperating on innovation. LI firms only.*




*Data: PITEC 2008. Own elaboration.*

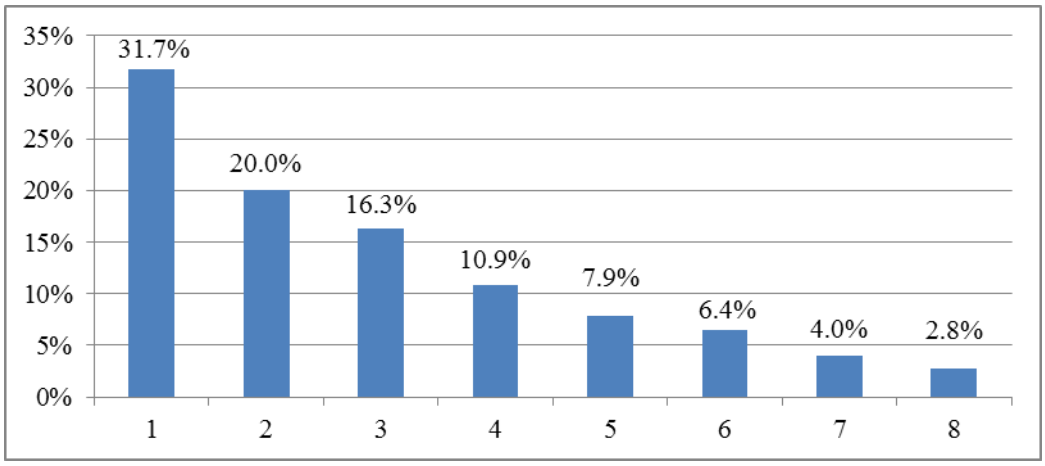
As shown in Figure 1, 51.7% of the companies included in PITEC that have not submitted any incident, i.e. LI firms, do not carry out internal R&D activities. The remaining 48.3% of

firms do carry out internal R&D but most of them (26.8%) do not cooperate on innovation. Only 21.5% carry out internal R&D and cooperate on innovation activities. Overall, there are 2405 firms cooperating on innovation. We assume that this is the group that corresponds to firms that are 'open innovators'. The red frame in Figure 1 shows a breakdown of this 21.5% by the technological level (low, medium or high) of the firms.

A look at firms that carry out internal R&D and that also cooperate on innovation activities shows that most firms' cooperation activities in innovation are carried out with universities (52% of firms that cooperate do so with this type of partner), followed by technology centres (43.7%) and suppliers (42.6%).

A second issue relates to the intensity of collaborations: the number of entities that collaborate with firms. PITEC includes eight types of collaborative organisations: other firms in the same group, suppliers, customers, universities, public firms and agencies, Science and Technology Parks, competitors, and consultants and others. Figure 2 summarizes the results.

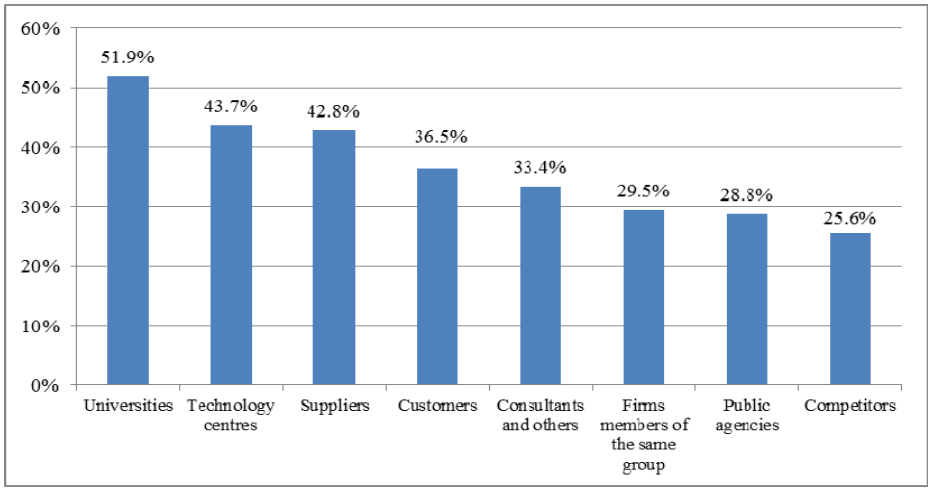
*Figure 2. Distribution of firms by number of collaborative organizations (1-minimum, 8-maximum).*




It can be observed that firms usually cooperate with more than one partner; 68.3% of the firms in PITEC that carry out internal R&D and cooperate on innovation respond to this pattern. Only 31.7% of the firms cooperate with one single partner. 6.7% of firms show a high level of cooperation, as they cooperate with most of the kind of partners included in PITEC (7 or more).

Figure 3 shows the type of collaborating organizations that cooperate with innovative firms. These organizations are included in the PITEC survey and refer to firms in the same group, suppliers, competitors, public firms and agencies, universities, technology centres and consultants and others.

*Figure 3: Cooperation on R&D activities.*




As we have seen previously, very few firms in the panel declare that they cooperate on R&D innovation activities. Nevertheless, as Barge-Gil (2010) has pointed out in a very recent work, it is insufficient to classify innovator firms as opened or closed, since the level of openness of innovation strategies is clearly broader and requires a broader classification. Barge-Gil proposes classifying innovator firms in three categories according to how innovations are achieved and the different sources of information used to innovate.

As one of the main variables for determining the level of openness in cooperative innovation activities is the type of institution with which the cooperation is carried out (cooperating with competitors is not the same as cooperating with others firms in the same group), in this study we propose a new and alternative classification based on the type, variety and quantity of institutions that have been involved in cooperation. Accordingly, the PITEC database is particularly useful as the survey includes several questions that allow us to identify the type of agents that have cooperated on innovative activities. The PITEC distinguishes eight different types of agent: (1) other firms in the same group; (2) consultants and others; (3) public agencies; (4) technology centres; (5) universities; (6) customers; (7) suppliers; and (8) competitor firms. From these variables in the survey, we propose an *Index of Cooperation*

(IC) as a weighted sum of the different level in the intensity of cooperation derived from the different types of agent. The IC is calculated for each firm *i* by the expression (1) as follows:

$$IC_i = \sum_{j=1}^{8} Agent_{ji} * K \qquad (1)$$

Where $Agent_{ji}$ is eight dummy variables, each with the value 1 if the firm *i* cooperates with the agent *j*; otherwise, the value is zero. K is a constant which takes values from 1 to 5 depending on the intensity the cooperation implies. We propose to order the eight types of agent by applying the following criterion: the maximum level of openness is with competitors and the minimum is with firms in the same group (Table 2 shows the values for K assigned to each type of agent).

*Table 2. Values for K assigned to each type of agent: K=1 minimum cooperation value; K=5 maximum cooperation value.*

| $Agent_{ji}$ : Type of agent by declared cooperation practices | K |
|---|---|
| Other firms that are members of the same group *(j=1)* | 1 |
| Consultants and others *(j=2)* | 2 |
| Public agencies *(j=3)* | 3 |
| Technology Centres *(j=4)* | 3 |
| Universities *(j=5)* | 4 |
| Customers *(j=6)* | 4 |
| Suppliers *(j=7)* | 4 |
| Competitors *(j=8)* | 5 |

If a company cooperates will all the possible types of agent, the IC will take its maximum value of 26. A company that cooperates only with *other firms in the same group* will take the value 1, and the IC will be zero if the company declares that it does not cooperate on innovation activities. We assume that values of IC between 1 and 8 correspond to a low level of cooperation; between 9 and 16, to a medium level of cooperation; and between 17 and 26, to a high level of cooperation. The purpose of this index is to give a more precise characterisation of the intensity and quality of cooperation –the variable we use as a proxy of open innovation. The results are shown in Table 3.

*Table 3. Number of firms included in the panel by internal expenditure on R&D and cooperation activities. Only firms classified as LI.*

| | | | | R&D expenditures and cooperation on innovation | | | |
|---|---|---|---|---|---|---|---|
| | TOTAL PANEL | No R&D | R&D but No cooperation | Total | Index of cooperation: Low | Index of cooperation: Medium | Index of cooperation: High |
| Num. of firms | 11,182 | 5780 | 2997 | 2405 | 1349 | 709 | 347 |

Data: PITEC 2008. Own elaboration

Tables 4 and 5 show the main features of the selected firms. They refer to the size of firms by number of employees, their geographical location, the type of company (public, private, etc.), their technological level, average revenue and their location in a technology centre and membership of a group of companies. Table 5 shows the same results as Table 4 in percentage terms.

*Table 4. Main features of the firms included in PITEC.*

| | TOTAL (LI) | No internal R&D | Internal R&D but No coop. | Internal R&D and coop. in innovation | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Total | Low Index of coop. | Medium Index of coop. | High Index of coop. | Index of coop. |
| Total | 11,182 | 5780 | 2997 | 2405 | 1349 | 709 | 347 | 9.1 |
| 1 - 9 employees | 1,312 | 763 | 296 | 253 | 189 | 53 | 11 | 6.8 |
| 10 - 49 employees | 4,125 | 2021 | 1281 | 823 | 506 | 238 | 79 | 8.2 |
| 50 - 99 employees | 1,515 | 623 | 544 | 348 | 182 | 107 | 59 | 9.8 |
| 100 - 249 employees | 1,718 | 842 | 445 | 431 | 230 | 122 | 79 | 9.7 |
| 250 and more employees | 2,512 | 1531 | 431 | 550 | 242 | 189 | 119 | 10.9 |
| Madrid | 2083 | 1213 | 472 | 398 | 199 | 125 | 74 | 10.2 |
| Catalonia | 2682 | 1209 | 966 | 507 | 279 | 150 | 78 | 9.2 |
| Andalusia | 739 | 444 | 159 | 136 | 78 | 44 | 14 | 8.5 |
| Other regions in Spain | 5678 | 2914 | 1400 | 1364 | 793 | 390 | 181 | 8.9 |
| Public | 214 | 111 | 33 | 70 | 32 | 19 | 19 | 11.2 |
| Private without foreign capital | 9284 | 4874 | 2532 | 1878 | 1114 | 554 | 210 | 8.6 |
| Private and <10% foreign capital | 123 | 59 | 32 | 32 | 12 | 9 | 11 | 11.5 |
| Private and foreign capital between 10% and 50% | 248 | 101 | 85 | 62 | 30 | 23 | 9 | 10.3 |
| Private and >50% foreign capital | 1196 | 619 | 302 | 275 | 145 | 77 | 53 | 9.6 |
| Research association and other research institution | 117 | 16 | 13 | 88 | 16 | 27 | 45 | 16.1 |
| High technology | 803 | 113 | 305 | 385 | 148 | 129 | 108 | 11.9 |
| Medium technology | 5264 | 3029 | 1186 | 1049 | 615 | 285 | 149 | 9.0 |
| Low technology | 5115 | 2638 | 1506 | 971 | 586 | 295 | 90 | 8.3 |
| Average size (# employees) | 324 | 341 | 223 | 409 | 334 | 435 | 647 | - |
| Average revenue (K€) | 78,277 | 65,825 | 58,928 | 132,317 | 97,447 | 148,971 | 233,852 | - |
| Local markets | 1309 | 1052 | 137 | 120 | 67 | 39 | 14 | 8.7 |
| National markets | 3337 | 2102 | 694 | 541 | 330 | 154 | 57 | 8.5 |
| EU markets | 2073 | 1068 | 540 | 465 | 260 | 137 | 68 | 9.3 |
| Non-EU markets | 204 | 84 | 62 | 58 | 37 | 15 | 6 | 8.4 |
| EU and others | 4259 | 1474 | 1564 | 1221 | 655 | 364 | 202 | 9.5 |
| No Science Park | 10,692 | 5675 | 2868 | 2149 | 1233 | 631 | 285 | 8.9 |

| | TOTAL (LI) | No internal R&D | Internal R&D but No coop. | Internal R&D and coop. in innovation | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Total | Low Index of coop. | Medium Index of coop. | High Index of coop. | Index of coop. |
| On a Science Park | 490 | 105 | 129 | 256 | 116 | 78 | 62 | 11.2 |
| The firm is not a member of a group | 6705 | 3580 | 1921 | 1204 | 727 | 341 | 136 | 8.6 |
| The firm is a member of a group | 4477 | 2200 | 1076 | 1201 | 622 | 368 | 211 | 9.7 |

Data: PITEC 2008. Own elaboration.

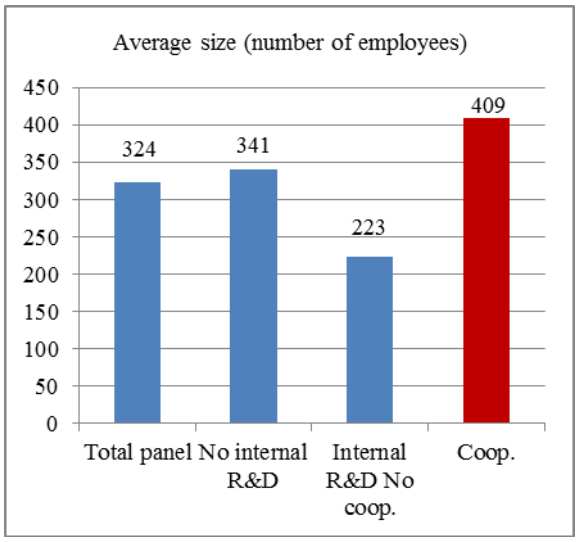
*Table 5. Main features of the firms included in PITEC (percentages).*

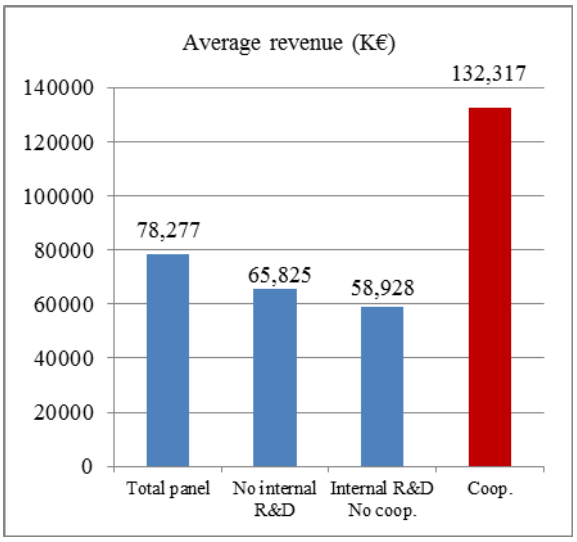
| | TOTAL | No internal R&D | Internal R&D but No coop. | Internal R&D and coop. on innovation | | | |
|---|---|---|---|---|---|---|---|
| | | | | Total | Low Index of coop. | Medium Index of coop. | High Index of coop. |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| 1 - 9 employees | 11.7% | 13.2% | 9.9% | 10.5% | 14.0% | 7.5% | 3.2% |
| 10 - 49 employees | 36.9% | 35.0% | 42.7% | 34.2% | 37.5% | 33.6% | 22.8% |
| 50 - 99 employees | 13.5% | 10.8% | 18.2% | 14.5% | 13.5% | 15.1% | 17.0% |
| 100 - 249 employees | 15.4% | 14.6% | 14.8% | 17.9% | 17.0% | 17.2% | 22.8% |
| 250 and more employees | 22.5% | 26.5% | 14.4% | 22.9% | 17.9% | 26.7% | 34.3% |
| Madrid | 18.6% | 21.0% | 15.7% | 16.5% | 14.8% | 17.6% | 21.3% |
| Catalonia | 24.0% | 20.9% | 32.2% | 21.1% | 20.7% | 21.2% | 22.5% |
| Andalusia | 6.6% | 7.7% | 5.3% | 5.7% | 5.8% | 6.2% | 4.0% |
| Other regions in Spain | 50.8% | 50.4% | 46.7% | 56.7% | 58.8% | 55.0% | 52.2% |
| Public | 1.9% | 1.9% | 1.1% | 2.9% | 2.4% | 2.7% | 5.5% |
| Private without foreign capital | 83.0% | 84.3% | 84.5% | 78.1% | 82.6% | 78.1% | 60.5% |
| Private and <10% foreign capital | 1.1% | 1.0% | 1.1% | 1.3% | 0.9% | 1.3% | 3.2% |
| Private and foreign capital between 10% and 50% | 2.2% | 1.7% | 2.8% | 2.6% | 2.2% | 3.2% | 2.6% |
| Private and >50% foreign capital | 10.7% | 10.7% | 10.1% | 11.4% | 10.7% | 10.9% | 15.3% |
| Research association and other research institution | 1.0% | 0.3% | 0.4% | 3.7% | 1.2% | 3.8% | 13.0% |
| High-level technology | 7.2% | 2.0% | 10.2% | 16.0% | 11.0% | 18.2% | 31.1% |
| Medium-level technology | 47.1% | 52.4% | 39.6% | 43.6% | 45.6% | 40.2% | 42.9% |
| Low-level technology | 45.7% | 45.6% | 50.3% | 40.4% | 43.4% | 41.6% | 25.9% |
| Local markets | 11.7% | 18.2% | 4.6% | 5.0% | 5.0% | 5.5% | 4.0% |
| National markets | 29.8% | 36.4% | 23.2% | 22.5% | 24.5% | 21.7% | 16.4% |
| EU markets | 18.5% | 18.5% | 18.0% | 19.3% | 19.3% | 19.3% | 19.6% |
| Non-EU markets | 1.8% | 1.5% | 2.1% | 2.4% | 2.7% | 2.1% | 1.7% |
| EU and others | 38.1% | 25.5% | 52.2% | 50.8% | 48.6% | 51.3% | 58.2% |
| No Science Park | 95.6% | 98.2% | 95.7% | 89.4% | 91.4% | 89.0% | 82.1% |
| On a Science Park | 4.4% | 1.8% | 4.3% | 10.6% | 8.6% | 11.0% | 17.9% |
| The firm is not a member of a group | 60.0% | 61.9% | 64.1% | 50.1% | 53.9% | 48.1% | 39.2% |
| The firm is a member of a group | 40.0% | 38.1% | 35.9% | 49.9% | 46.1% | 51.9% | 60.8% |

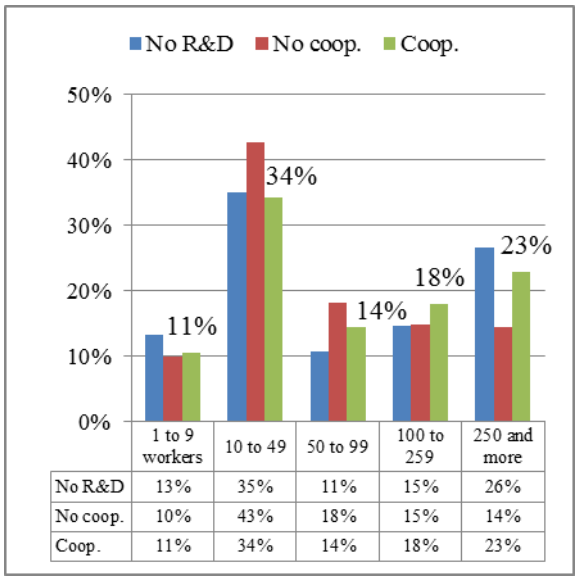
Data: PITEC 2008. Own elaboration.

The following shows the information contained in tables 4 and 5 in graph format (see figures 4 and 5).

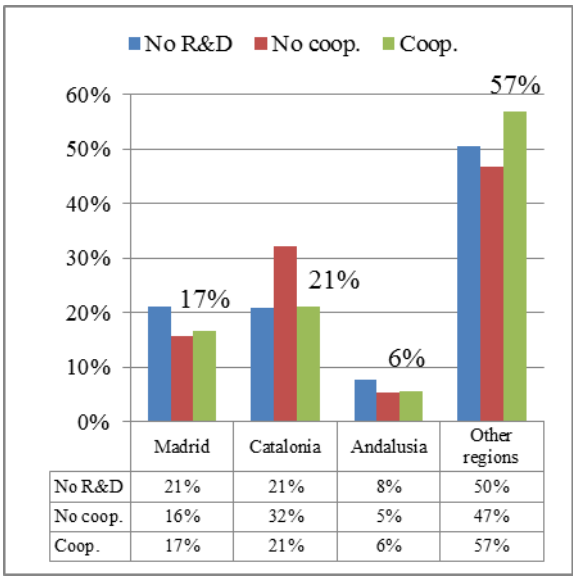
*Figure 4: Main features of the firms included in PITEC.*




| | 1 to 9 workers | 10 to 49 | 50 to 99 | 100 to 259 | 250 and more |
|---|---|---|---|---|---|
| No R&D | 13% | 35% | 11% | 15% | 26% |
| No coop. | 10% | 43% | 18% | 15% | 14% |
| Coop. | 11% | 34% | 14% | 18% | 23% |

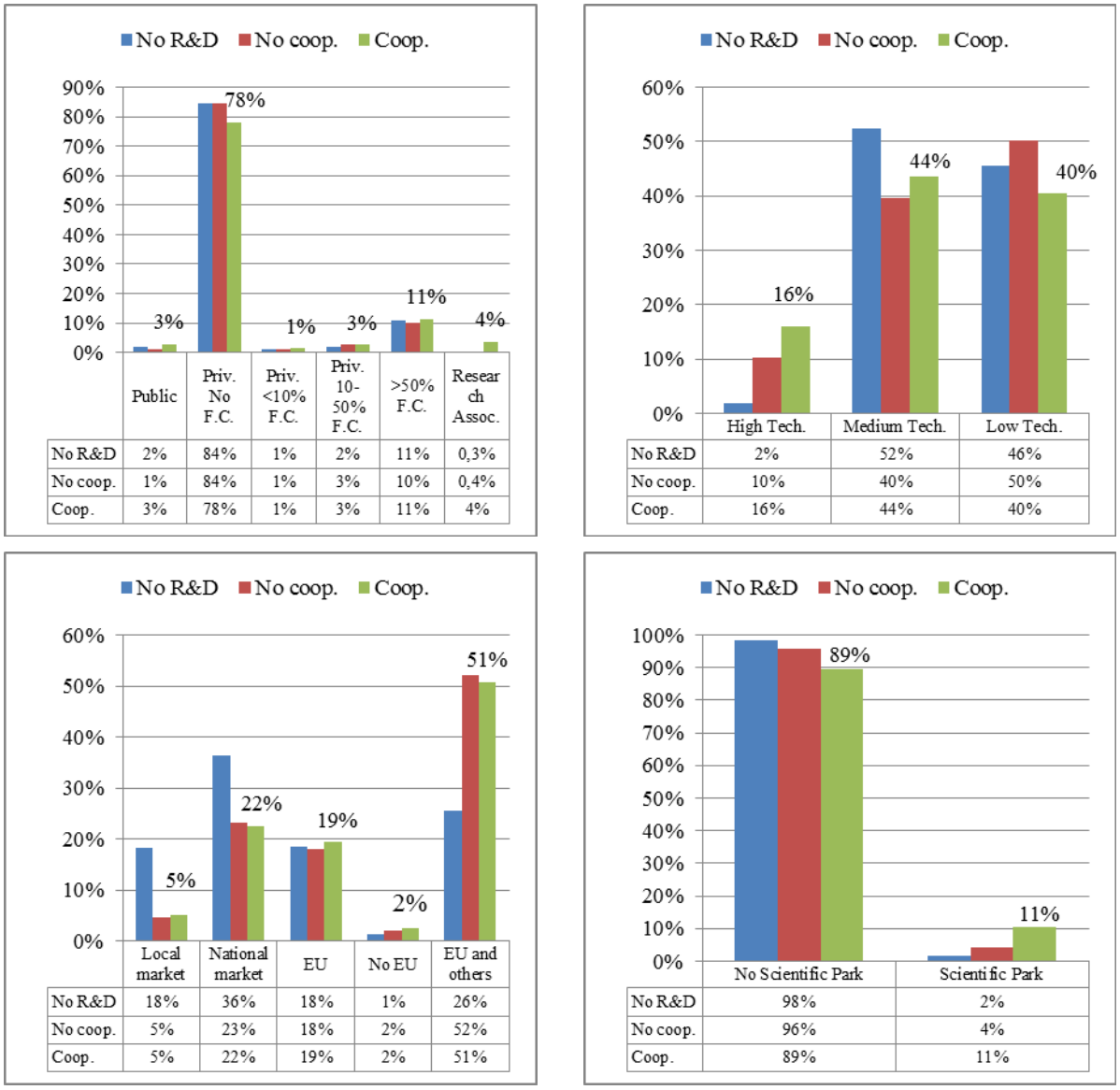



| | Madrid | Catalonia | Andalusia | Other regions |
|---|---|---|---|---|
| No R&D | 21% | 21% | 8% | 50% |
| No coop. | 16% | 32% | 5% | 47% |
| Coop. | 17% | 21% | 6% | 57% |

Data: PITEC 2008.

Firms that cooperate on innovation activities are characterized by the fact that they are larger than the rest. On average, they have more than 400 employees and revenues of more than 130 million euros. In relation to the location of the firms' head offices, there is a smaller presence of such firms in Madrid, Catalonia and Andalusia, contrary to what might be expected. More specifically, 57% of cooperating companies have their head offices outside these regions.

*Figure 5: Main features of the firms included in PITEC (Cont.).*




F.C.: Foreign Capital.Data: PITEC 2008.

As far as ownership is concerned (Fig. 5 above left), of the firm considered private, foreign capital firms are predominant -more than 75% in all cases. However, the main difference is the weight of research associations in firms that cooperate on innovation, since this type of 'firm' represents 4% of cooperating firms and almost 0% of firms that do not carry out internal R&D or, if they do, they do not cooperate on innovation.

Depending on the type of sector and on their technological level, most sectors are, on average, classified with a medium level of technology. More specifically, 52% of companies that do not have R&D expenses and 44% of the companies that cooperate on innovation are to be

found in this type of sector. However, firms that have R&D expenses but that do not cooperate on innovation are to be found mostly in low technology sectors. One important differential feature is that firms that cooperate on innovation are concentrated in a greater proportion in high technology sectors. Thus, while 16% of firms that cooperate on innovation correspond to this typology, only 2% of the firms that do not carry out R&D activities and 10% of the firms that have R&D expenses do not cooperate on innovation.

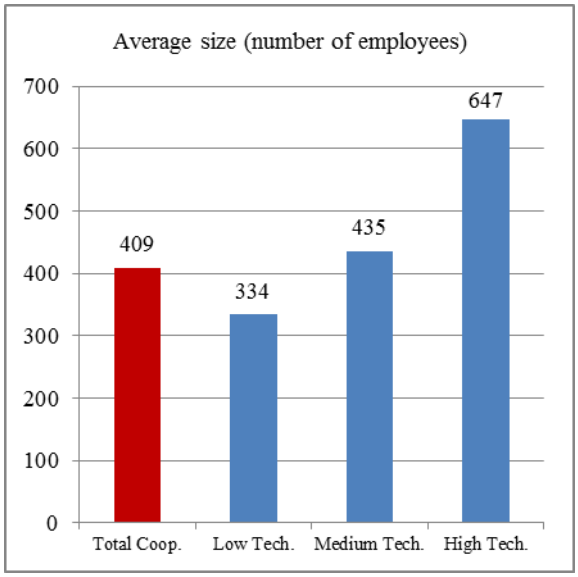
In relation to the market on which firms operate, those that cooperate on innovation are characterized by the fact that they are proportionally more focused on external markets: EU or non-EU countries. The percentage of firms that focus without distinction on European markets or other countries is higher in firms with R&D expenses; however the percentage is slightly higher in firms that do not cooperate on innovation (52%) than in those that do cooperate (51%).

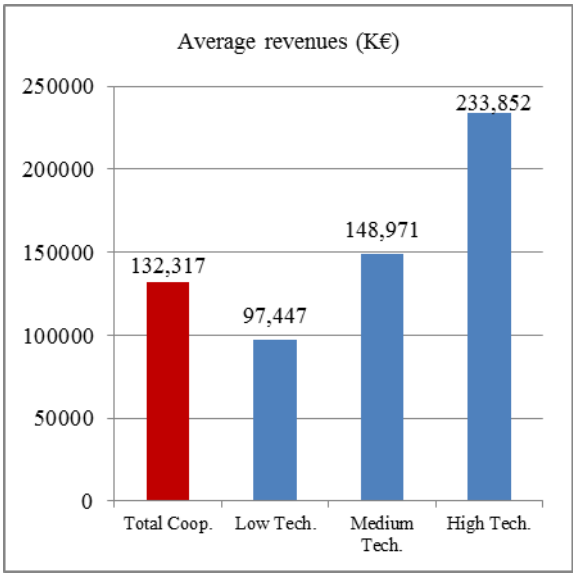
Regarding the location of the firms, most of the companies under analysis are not in a science or technology park. In fact, more than 85% of firms are not. However, it should be noted that the percentage of firms that cooperate on innovation that are located in a Science or Technology Park (11%) is higher than that of firms that do not have R&D expenses (2%) and those that do not cooperate on innovation (4%).

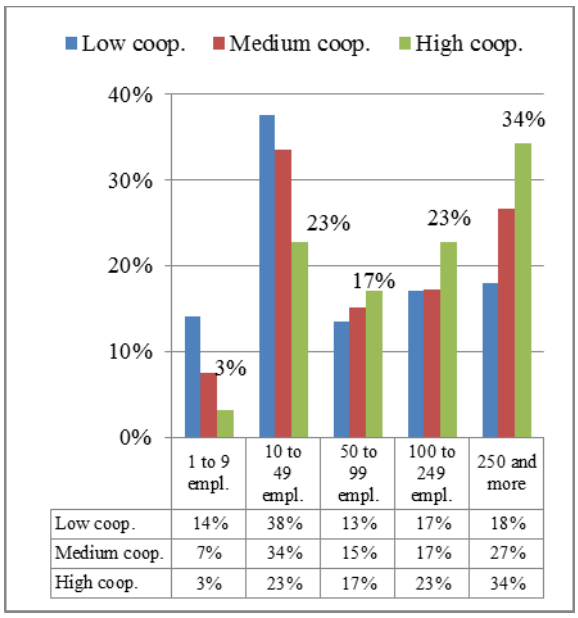
Finally, depending on whether or not the firm is a member of a group, firms that are not members of a group account for most of the firms that do not have R&D expenses or that carry out internal R&D but do not cooperate on innovation. Consequently, the proportion of firms that do cooperate is higher among firms that are members of a business group.

Figures 6a and 6b show the main features of firms that cooperate on innovation, classified according to cooperation intensity. Cooperation intensity is defined from the index of cooperation defined above.

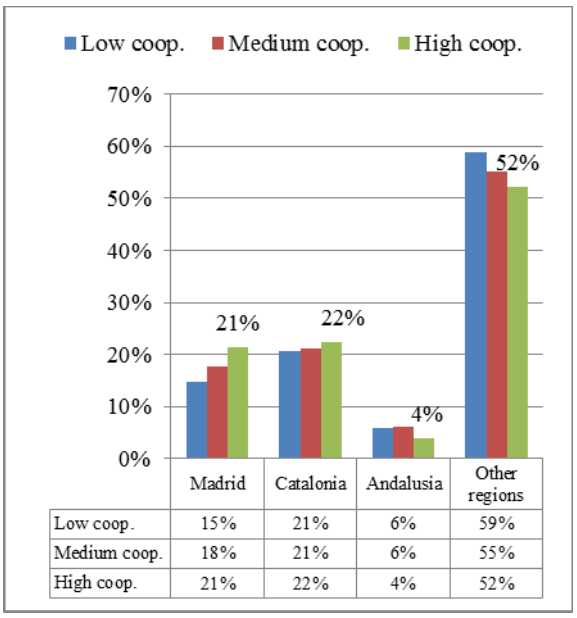
*Figure 6a. Main features of firms that cooperate on innovation, classified by cooperation intensity.*



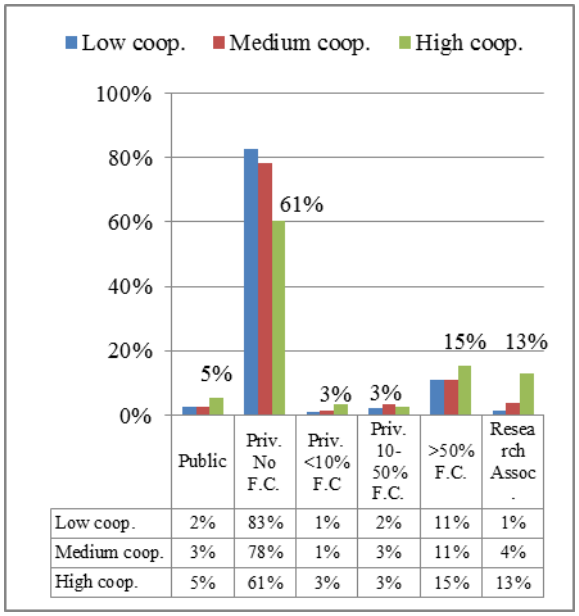

| | 1 to 9 empl. | 10 to 49 empl. | 50 to 99 empl. | 100 to 249 empl. | 250 and more |
|---|---|---|---|---|---|
| Low coop. | 14% | 38% | 13% | 17% | 18% |
| Medium coop. | 7% | 34% | 15% | 17% | 27% |
| High coop. | 3% | 23% | 17% | 23% | 34% |



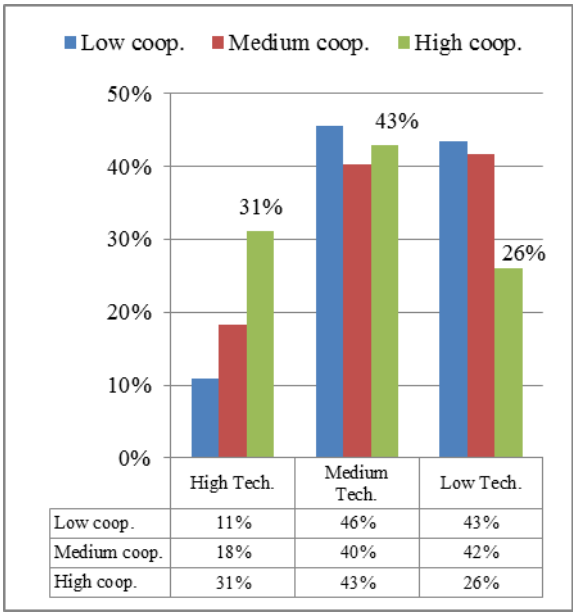

| | Madrid | Catalonia | Andalusia | Other regions |
|---|---|---|---|---|
| Low coop. | 15% | 21% | 6% | 59% |
| Medium coop. | 18% | 21% | 6% | 55% |
| High coop. | 21% | 22% | 4% | 52% |

Notes: 'empl': employees.

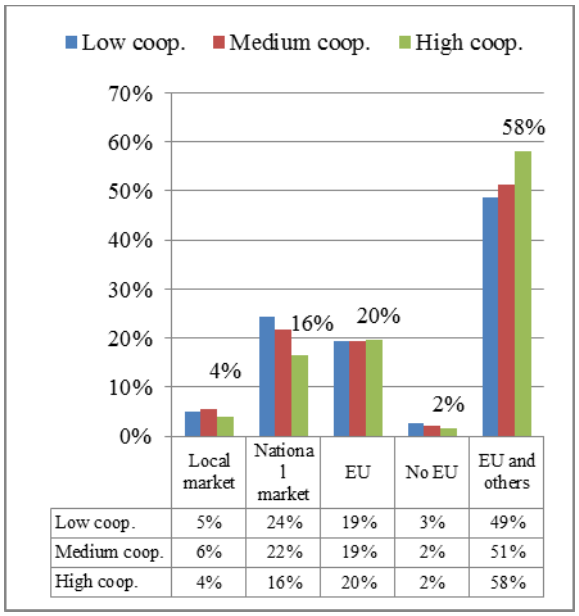
*Figure 6b. Main features of firms that cooperate on innovation, classified by cooperation intensity (cont.).*



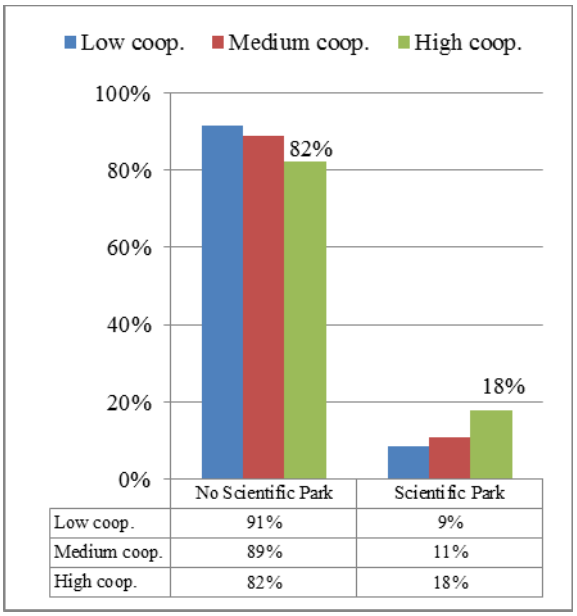

| | Public | Priv. No F.C. | Priv. <10% F.C | Priv. 10-50% F.C. | >50% F.C. | Research Assoc. |
|---|---|---|---|---|---|---|
| Low coop. | 2% | 83% | 1% | 2% | 11% | 1% |
| Medium coop. | 3% | 78% | 1% | 3% | 11% | 4% |
| High coop. | 5% | 61% | 3% | 3% | 15% | 13% |




| | High Tech. | Medium Tech. | Low Tech. |
|---|---|---|---|
| Low coop. | 11% | 46% | 43% |
| Medium coop. | 18% | 40% | 42% |
| High coop. | 31% | 43% | 26% |



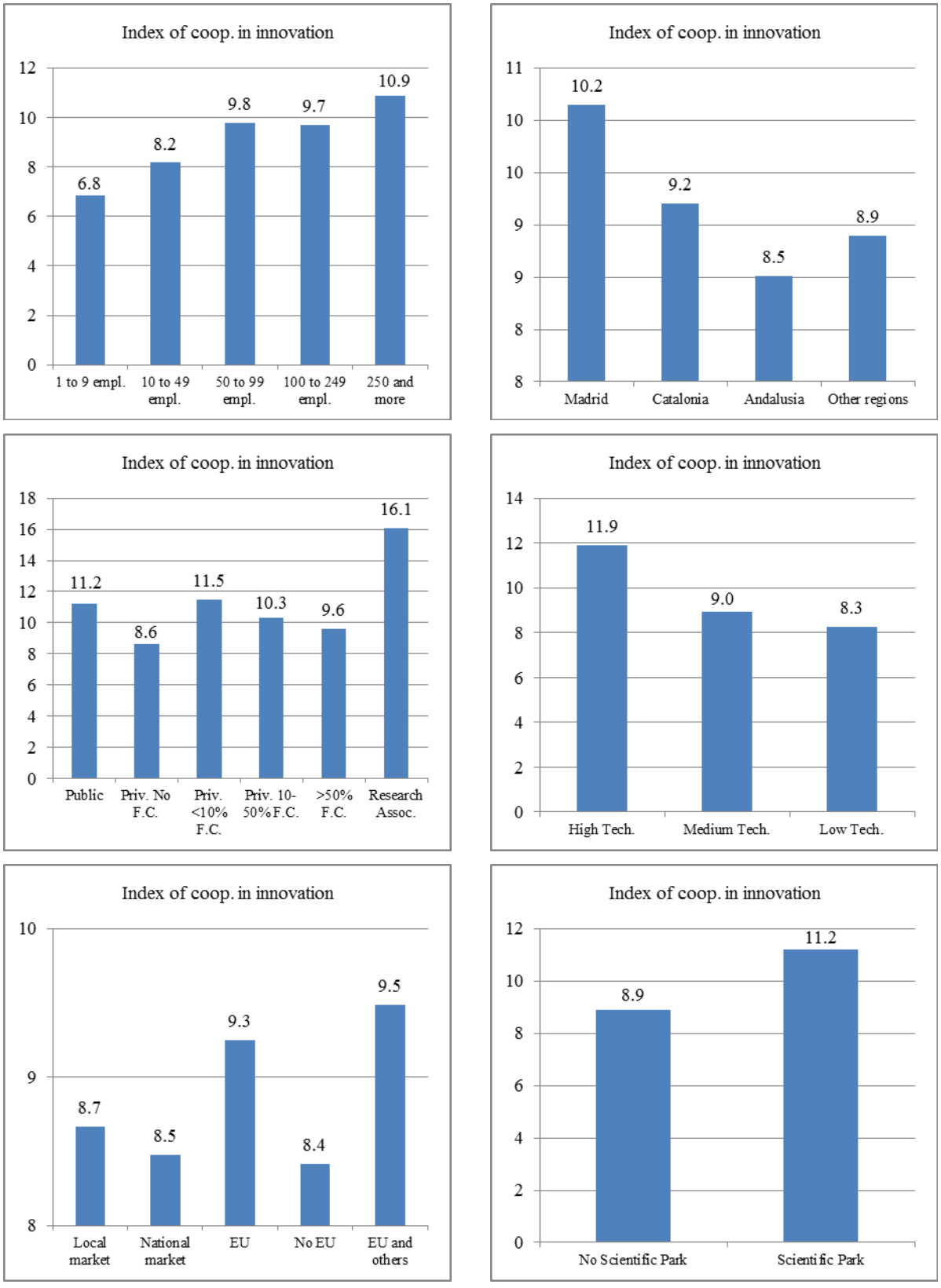

| | Local market | National market | EU | No EU | EU and others |
|---|---|---|---|---|---|
| Low coop. | 5% | 24% | 19% | 3% | 49% |
| Medium coop. | 6% | 22% | 19% | 2% | 51% |
| High coop. | 4% | 16% | 20% | 2% | 58% |




| | No Scientific Park | Scientific Park |
|---|---|---|
| Low coop. | 91% | 9% |
| Medium coop. | 89% | 11% |
| High coop. | 82% | 18% |

Notes: F.C.: Foreign Capital.

*Figure 7: Index of cooperation on innovation.*




Data: PITEC 2008. Own elaboration.

From the index of cooperation on innovation, which refers only to firms that cooperate on innovation and carry out internal R&D activities, we can conclude the following:

1. Firms with a high index of cooperation are larger in terms of both number of employees and revenues.
2. Firms with a high index of cooperation on innovation are more numerous in Madrid and Catalonia; however, the highest percentage of enterprises in any case is located outside these regions and Andalusia.
3. Firms with a high index are more numerous in private enterprise, with more than 50% of foreign capital, and among research associations. However, most of the firms are national private companies.
4. Firms with a high index of cooperation are more numerous in high technology sectors, although most firms are to be found in medium technology sectors.
5. Firms that focus on external markets (Europe and other countries) have a higher index of cooperation on innovation than firms that focus on national and local markets.
6. Although most companies are not located in a Science or Technology Park, the presence of companies with a high index of cooperation on innovation is higher among the small group of companies that are located in said parks.
7. Firms with a high index of cooperation on innovation are more numerous among companies that are members of a group.

## 3.3 Econometric model

Having defined the main characteristics of the different types of firms in the panel, we can now estimate the probability of a firm being cooperative and, more specifically, the probability of a firm being highly cooperative.

In order to achieve this objective, we have estimated three different econometric models: the first model considers all the firms included in PITEC and reveals the determining factors for the firm to be a R&D firm. In this case, the endogenous variable $Y_1$ is a binary variable that takes the value of 1 if the firm carries out internal R&D and 0 if it does not.

A second model estimates the probability of a firm being cooperative. In this second model, we again consider the entire panel of firms, taking into account that there are at least three

types of firms: firms that do not carry out internal R&D; firms that do not cooperate (that carry out internal R&D activities); and firms that do cooperate (that also carry out internal R&D). In this case the endogenous $Y_2$ variable can take three different $j$ values: $j=0$ if the firm does not carry out internal R&D; $j=1$ if the firm carries out internal R&D but does not cooperate on innovation; and $j=2$ if the firm cooperates on innovation activities.

Finally, the third model estimates the probability of a firm being highly cooperative –the case of firms with a high probability of being an open innovator. In this case, the sample under analysis considers only the set of firms that carry out internal R&D. The endogenous variable in this case, $Y_3$, can take four possible $j$ values: $j=0$ if the firm carries out internal R&D but does not cooperate on innovation; $j=1$ if the firm is a low-level cooperative firm; $j=2$ if the firm is a medium-level cooperative firm; and $j=3$ if the firm is high-level cooperative firm. This classification is based on the index of cooperation given in sub-section 3.2.

The three models that are estimated can be summarised with the following three expressions:

| | |
|---|---|
| Model 1: | $\Pr(Y_1=1 \mid X_{ki})$ |
| Model 2: | $\Pr(Y_2=1 \mid X_{ki})$ |
| | $\Pr(Y_2=2 \mid X_{ki})$ |
| Model 3: | $\Pr(Y_3=1 \mid X_{ki})$ |
| | $\Pr(Y_3=2 \mid X_{ki})$ |
| | $\Pr(Y_3=3 \mid X_{ki})$ |

where $X_{ki}$ is the vector of $X_k$, independent variables for each firm $i$, and includes the firm's size, a dummy variable that indicates whether or not the firm is member of a business group, another dummy variable that indicates whether or not the firm is located in a Science and Technology Park, the firm's market, the firm's property, the sector in which the firm operates and the region in which the head office is located.

As all our endogenous variables are categorical variables, the methodology used here consists of estimating discrete choice models. In the first case, as $Y_1$ is a binary variable, we estimate a logit model. For models 2 and 3, as $Y_2$ and $Y_3$ are categorical variables with more than two possible alternatives, we estimate two multinomial models.

## 3.4 Discussion

We now present the results of the econometric analysis explained in the previous section. The results are given in Table 6. The first two columns refer to the logit estimation of *Model 1*, which estimates the probability of a firm being a R&D firm. Columns three and four refer to the multinomial estimation of *Model 2*, which estimates the probability of a firm being a cooperative firm, assuming as the reference category "Being a Non-R&D Firm". The last two columns of Table 6 show the results of the multinomial estimation of the probability of a firm being a high-level cooperative firm (*Model 3*), considering as the reference category "Being a Non-Cooperative Innovation Firm". For all the models, we show the odds ratio for each variable and their level of significance.

The odds ratio shows that firms that are members of a business group are clearly more likely to have R&D expenses and to cooperate on innovation activities. More specifically, the probability of investing in internal R&D is 1.3 times higher for firms that are members of a business group (*Model 1*). Furthermore, the probability of a firm being cooperative is 1.8 times higher for firms included in a business group when we compare cooperative firms with firms that do not carry out R&D (*Model 2*). If we focus exclusively on firms that invest in R&D, we can observe that being a member of a business group has a significant and positive effect on the probability of a firm being a high-level cooperative firm (*Model 3*), with an odds ratio of 2.4 with regard to non-cooperative firms.

Being located in a Science or Technology Park also has a highly positive effect on the probability of a firm investing in R&D and being a cooperative firm. The probability of a firm being a R&D cooperative firm is 4.4 times higher when the firm is located in a Science and Technology Park (*Model 2*). This variable also has a positive effect on the probability of a firm being a high-level cooperative firm. In this case, compared to non-cooperative firms, firms that are located in a Science and Technology Park have a probability that is 2.8 times higher than firms located elsewhere. *Model 3* shows that the maximum odds ratio is reached for high-level cooperative firms, which indicates that the effect of being in a Science and Technology Park is particularly positive for high-level cooperative firms.

*Table 6. Logit and Multinomial estimations.*

| | **MODEL 1 (Logit)** | | **MODEL 2 (Multinomial)** | | | | **MODEL 3 (Multinomial)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference: Non-R&D Firms | | Reference: Non-R&D Firms | | | | Reference: Non-Cooperative Innovation Firms | | | | | |
| | Probability of being a R&D Firm | | Probability of being a R&D Non-cooperative innovation firm | | Probability of being a R&D Cooperative innovation firm | | Probability of being a LOW-level cooperative innovation firm | | Probability of being a MEDIUM-level cooperative innovation firm | | Probability of being a HIGH-level cooperative innovation firm | |
| | Odds ratio | | Odds ratio | | Odds ratio | | Odds ratio | | Odds ratio | | Odds ratio | |
| Firm size: 1 to 9 employees | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | |
| 10 to 49 employees | 1.23 | *** | 1.34 | *** | 1.07 | | 0.65 | *** | 1.14 | | 1.70 | |
| 50 to 99 employees | 1.40 | *** | 1.60 | *** | 1.15 | | 0.51 | *** | 1.16 | | 2.63 | *** |
| 100 to 249 employees | 1.03 | | 1.04 | | 1.01 | | 0.73 | ** | 1.48 | ** | 3.54 | *** |
| 250 employees and more | 0.72 | *** | 0.64 | *** | 0.80 | ** | 0.73 | ** | 2.25 | *** | 5.32 | *** |
| Member of a business group | 1.30 | *** | 1.01 | | 1.79 | *** | 1.70 | *** | 1.77 | *** | 2.44 | *** |
| Located on a Science and *Technology Park* | 3.24 | *** | 2.26 | *** | 4.39 | *** | 1.77 | *** | 2.19 | *** | 2.85 | *** |
| Market: European and non-European countries | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | |
| Local market | 0.12 | *** | 0.13 | *** | 0.11 | *** | 0.80 | | 1.01 | | 0.56 | * |
| National market | 0.31 | *** | 0.34 | *** | 0.29 | *** | 0.93 | | 0.91 | | 0.63 | *** |
| European Union market | 0.48 | *** | 0.48 | *** | 0.48 | *** | 1.04 | | 1.08 | | 0.92 | |
| Other non-EU countries | 0.67 | *** | 0.64 | *** | 0.71 | * | 1.25 | | 1.05 | | 0.76 | |
| Private firm without foreign capital | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | |
| Public firm | 2.19 | *** | 1.36 | | 3.15 | *** | 2.16 | *** | 2.04 | ** | 5.29 | *** |
| Private firm with foreign capital < 10% | 0.93 | | 0.87 | | 1.01 | | 0.77 | | 1.05 | | 2.68 | *** |
| Private firm with foreign capital (10% to <50%) | 1.18 | | 1.34 | * | 1.01 | | 0.71 | | 0.89 | | 0.64 | |
| Private firm with foreign capital (more than 50%) | 0.74 | *** | 0.82 | * | 0.68 | *** | 0.88 | | 0.72 | ** | 0.88 | |
| Research associations | 2.61 | *** | 0.78 | | 4.88 | *** | 2.65 | *** | 6.11 | *** | 20.77 | *** |
| Low-level Tech sector | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | |
| High-level tech sector | 6.44 | *** | 5.20 | *** | 8.43 | *** | 1.15 | | 1.90 | *** | 4.14 | *** |
| Medium-level tech sector | 1.12 | *** | 1.01 | | 1.30 | *** | 1.31 | *** | 1.23 | ** | 2.20 | *** |
| Head Office: Rest of Spain | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | | Ref. | |
| Madrid | 0.78 | *** | 0.93 | | 0.62 | *** | 0.65 | *** | 0.55 | *** | 0.84 | |
| Catalonia | 1.04 | | 1.36 | *** | 0.70 | *** | 0.51 | *** | 0.84 | | 0.59 | *** |
| Andalusia | 0.75 | *** | 0.84 | * | 0.65 | *** | 0.77 | * | 0.00 | *** | 0.51 | ** |
| Intercept (coefficient instead of odds ratio) | 1.41 | *** | -0.22 | | -0.52 | | -0.52 | *** | -2.00 | *** | -4.10 | *** |
| Case num | 11,182 | | 11,182 | | | | 5402 | | | | | |
| Pseudo R2 | 0.22 | | 0.22 | | | | 0.15 | | | | | |

* Significant at the level of 90%, ** 95%, *** 99%.

In relation to the market in which the firm operates and considering the largest regional market, i.e. firms operating in both European and non-European markets, *Model 1* shows that any firm with a smaller geographical market is less probable to invest in R&D. It follows that the larger the geographical scope of a firm, the greater its probability of carrying out R&D activities.

This is confirmed when we look at the probability of a firm being a firm that cooperates on innovation (*Model 2*) with an adequate statistical level of significance. If we focus exclusively

on firms that carry out R&D (*Model 3*), we see that the variable market ceases to be statistically significant to explain the differences in the probability of a firm being a firm with a high, medium, or low level of cooperation on innovation. In other words, the market on which the firm focuses does not reveal whether the level of cooperation will be high, medium or low. In *Model 3*, none of the estimated odds ratios are statistically significant.

Considering the type of firm and taking into account firms without private foreign capital, the probability of a firm carrying out R&D is higher in public firms and research associations (*Model 1)*. However, the probability of a firm carrying out R&D is lower in private firms with more than 50% foreign capital. The same result applies when we look at the probability of a firm being a firm that cooperates on innovation (*Model 2*), although the effect is greater in all 3 cases. Thus, the type of firm (by ownership) is the key for discriminating the type of cooperation. Public firms and agencies and research consortia are more likely to be highly cooperative (in relation to non-cooperative firms) with odds ratios of 5.3 and 20.7, respectively.

Being a firm in a high technology sector has a strong impact on the probability of a firm being one that carries out R&D (*Model 1*). This probability is 6.4 times higher than if it were in a low-level technology sector. This effect is more important when we estimate the probability of a firm being a firm that cooperates on innovation (*Model 2*); in this case the odds ratio is 8.4. Being a medium-level technology firm also increases the probability of cooperation, although at a much lower level. Finally, the type of sector in which the firm operates also affects the probability of it being a high-level cooperative firm (*Model 3*).

The probability of investing in R&D against firms with head offices in a Spanish Region other than Madrid, Catalonia or Andalusia is only important in the case of Catalonia, but the difference between these regions and 'the rest of Spain' is not statistically significant (*Model 1*). When we distinguish between the non-R&D firms, R&D firms that do not cooperate and R&D firms that cooperate, we see that the probability of cooperation is always higher in any region other than Madrid, Catalonia or Andalusia. This result is particularly important because, a priori, we might expect that being located in an economically dynamic region with a higher level of industrial activity (such as Madrid and Catalonia) would contribute to cooperation on innovation. However, the results point to the opposite. Moreover, this effect is maintained when we focus our analysis on firms that carry out R&D (*Model 3*). Thus, firms

whose head offices are located outside Madrid, Catalonia or Andalusia are more likely to be highly cooperative.

Finally, the size of the enterprise seems to have a positive effect on the probability of carrying out R&D (*Model 1*), since the probability of carrying out R&D activities increases with the number of employees. However, this variable seems to show nonlinear behaviour because firms with more than 250 employees have a lower probability of carrying out R&D than firms with 1 to 9 employees. This behaviour is maintained when we consider the probability of a firm being cooperative (Model 2). The effect of the size of the firm on the probability of it being highly cooperative (Model 3) is unquestionable: the larger the firm, the greater the probability of it being highly cooperative (where we consider only R&D firms).

## 4. Concluding remarks

The main aim of this work is to identify open innovation practices in innovative Spanish firms. For this purpose, we have analysed PITEC panel data on innovative firms. The first question that arises is that it is not evident which variables (from those included in statistical surveys) allow us to identify indicators of open innovation within a system of innovation. The main difficulty of this type of work is the need for proposing previously appropriate indicators that allow us to profit from this kind of database. In answer to these questions, we posed a brief methodological reflection in section 2 and proposed the analysis of the innovation links between Spanish firms and other agents within the system of innovation as a means for identifying open innovation practices. As a proxy for these links, we have employed the patterns of cooperation of innovative Spanish firms: cooperation links would perform the role of 'proxies' to open innovation practices.

This methodological decision has allowed us to 'depict' the profile of the innovation links of innovative Spanish firms involved in open innovation practices. This profile would correspond to a characterization of an open innovator firm. Thus, we have shown that innovative Spanish firms involved in open innovation are more numerous in high-level technology sectors; these firms are larger than the other firms within the system of innovation; there are proportionally more open innovator firms located in Madrid and Catalonia than in the rest of the country; they are more numerous among private firms (mainly national firms

with a low proportion of foreign capital) and public firms and research associations; focused on external markets; and frequently located in Science and Technology Parks.

It is very important to point out a serious limitation of this study: it is a static analysis. We have employed only firms that refer to 2008. Notwithstanding this limitation, this study allows to analyze (and fix) the profile and main features of innovative Spanish firms and the probability of their being (or their propensity to being) open innovator firms. Overcoming this limitation is a line for future work.

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## Notes

[1] FECYT is the Spanish Foundation for Science and Technology (http://www.fecyt.es) and Cotec is a Foundation for Technological Innovation (http://www.cotec.es/).

[2] See http://icono.fecyt.es/05%29Publi/AA%29panel/bdPITEC_June2010_ing.pdf (accessed February 2011)

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## Key terms & definitions

*Open innovation*: this consists of the intentional use of knowledge to impulse internal innovation and, at the same time, to expand markets by allowing the external use of innovation

*Systemic innovations*: these are innovations that require significant adjustments to different parts of the system within which they are developed

C*ollaborative links*: these links are representative of systemic innovation practices.

*Index of cooperation*: this is a weighted sum of the different level in the intensity of cooperation derived from the different types of agent.

*Open innovator firm*: this is a firm that carries out internal R&D and cooperates with the innovative agents within the system of innovation.