Working Papers. Department of Economics, University of Girona
Num. 15, pp. 1-28.
ISSN 1579-475X

Innovation strategies in the presence of technology markets: evidence from Spanish innovative firms*

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Girona, July 2005

Abstract

The development of markets for technology has eased the acquisition of technology and reshaped the innovation strategies of firms that we classify as producers of innovations or as imitators. Innovative activities of firms include research, acquisition of technology and downstream activities. Within an industry, firms producing innovations tend to conduct more research and downstream activities than those imitating innovations. Acquisition of technology is equally important for both. To implement innovation strategies, firms producing innovations require both the capability to scan the external environment for technology and the capability to integrate new technology. Firms producing innovations require both, while firms imitating innovations require scan capabilities only.

Keywords: Innovation, R&D, technology acquisition, appropriability, absorptive capacity.
JEL classification: L22, O32.

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* Acknowledgements are due to Nicolas Boccard and one anonymous reviewer of the EURAM conference who read preliminary versions of this paper. The database was obtained with the financial support of the Department of Business Economics & Management, University of Girona.
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1. Introduction

1.1. Changes in the attributes of knowledge

Arora and Gambardella (1994) and Arora *et al*. (2001) argue that increased knowledge about a phenomenon makes it possible to explain it in a more general and abstract manner; this is, to articulate it. When knowledge becomes articulable it changes from tacit to codified; this has two implications: codified knowledge can be partitioned and it can be used in a variety of contexts -as opposed to tacit knowledge that is was firm-specific. This change opens up the possibility for the transfer of knowledge and its trade.[1]

In the past two decades, advances in communications and computer capabilities have contributed to the increased articulation and codification of knowledge, thus making it more amenable to be transferred across organisations and giving rise to markets for technology.

1.2. Innovation and imitation strategies

The development of markets for technology has influenced firms' innovation strategies by widening the range of innovation activities available to them. For instance, firms may now buy technologies that were not available to them before; firms may also choose to acquire technologies in the market even if they could develop them at home and specialise in the production of new knowledge or in its commercialisation. Overall, the rapid growth of markets for technology has lead many firms to rethink their innovation strategies, with a growing importance of strategies based on monitoring external technology developments and acquiring technology. The extent to which knowledge and technologies can be partitioned, and hence traded, differs across industries. The empirical literature has long established the importance of industry effects on the research activity's decisions of firms (see Cohen and Levin, 1989, for a review). Within an industry, there are also differences across firms reflecting the choice of innovation strategy by managers. The focus in this study is on intra-industry differences, although inter-industry effects are also accounted for.

We study how markets for technology influence firms' innovation strategies through a classification of firms as innovators or as imitators. Innovators are firms that produce knowledge that is new whereas imitators only produce knowledge, if any, already existing in the market or the industry. This classification has been used extensively in the literature to study intra-industry differences.

For instance, within the industrial organisation approach, Katz and Shapiro (1987) and Amir and Wooders (2000) are examples of innovation models that study the

[1] Polanyi (1966), Nelson and Winter (1982), and Winter (1987) contributed to the classification of the attributes of knowledge that make it more or less difficult to transfer.

roles of innovators and imitators in an industry. Katz and Shapiro (2001) introduce the effects of licensing and imitation on development incentives in the literature on the R&D rivalry and examine the conditions under which R&D competition between two firms takes the form of a "waiting" game, in which the imitator firm benefits form its' rivals development of the innovation; as opposed to a "race" game to be the innovator (and winner) firm. Amir and Wooders (2000) construct a model that characterises an ex ante symmetric duopoly where an innovator / imitator configuration emerges under imperfect appropriability of R&D. In their model, the innovator is the more R&D intensive firm (where intensity might refer to R&D strategy, lab type and size, and the composition of R&D).

Historical and organizational characteristics of firms can also account for differences within an industry (Röller and Sinclair-Desgagné, 1996). According to the evolutionary (or historical) approach (Nelson and Winter, 1982), the world is too complex to be fully comprehended. This would necessarily lead to try-out some processes before knowing whether they are beneficial or not, hence explaining persistent differences across firms (as in Lipmann and Rumelt, 1982). Fagiolo and Dosi (2003) classify the innovation strategies of firms into innovator and imitator roles using the evolutionary approach.

Another approach, that of organizational studies, argues that organizational rigidities in firms make corporate change slow and imitation of organizational capabilities difficult resulting in firms' heterogeneity (see for instance Teece, 1980 and Simon, 1978). This approach has also been adopted to study innovation / imitator roles relating those to the tacit / codified dimension of knowledge. Thus, Kogut and Zander (1992) show that to the extent that tacit knowledge is embedded in organizations in a given industry, imitation will be made more difficult, favouring innovators in that industry. On the contrary, an increasing codification of technology will enhance its transfer and hence the potential for imitators.

1.3. Firms' characteristics

The transfer of knowledge, besides changes in some of its attributes that render it transferable, requires also some capabilities on the part of the firm that is to receive it. Specifically, it requires the capability to scan the environment for knowledge generated in the industry or elsewhere, and to integrate such knowledge into the firms' know-how. These constitute the aspects described by Arora and Gambardella (1994b) of what was first named absorptive capacity by Cohen and Levinthal (1989). Also, the size of the firm, as suggested in Katz and Shapiro (2001) and Amir and Wooders (2000), and whether it belongs to a conglomerate or it is an independent firm, have consequences on the strategies of innovators and imitators. The direction of the size effects may depend on industry conditions (as the appropriability regime) and / or the nature of innovations (major or minor, i.e. allowing large or small cost reductions).

This paper examines how innovation strategies differ between innovators and imitators both within and between industries and looks at the firms' capabilities that allow them to conduct these strategies in the presence of markets for technology, focusing on the type of absorptive capacity that the different strategies require. It uses a statistical methodology (multilevel logit models for complex samples) that allows us to disentangle industry and firm-specific effects, hence explaining the relationship between innovation strategies and firm characteristics.

Section 2 defines the variables involved and the relationships established in the literature. Section 3 deals with the sample, the choice of indicators, the preliminary analyses, the clustering of innovation activities to form meaningful components of innovation strategies and the formulation of multilevel logit models for complex samples. Section 4 presents the results of models predicting the different components of innovation strategies from the dimensions of absorptive capacity and other variables, testing for the existence of differences between innovator and imitator firms. Section 5 concludes.

2. Theory and hypotheses

2.1. Appropriation instruments

We have explained that the development of markets for technology owes to the increased transferability of knowledge as it changes from tacit to codified knowledge. An additional requirement to the development of these markets is the appropriability of the knowledge being traded, by which firms having produced the knowledge receive the returns generated by it. As first pointed out in Arrow (1962), the involuntary leakage of knowledge from the organisation producing it (or spillovers) could endanger the appropriation of the rents from innovation[2].

To protect the results of their research activities, firms can invest in appropriation instruments. We distinguish between producers of innovations and imitators in an industry based on their use of instruments for appropriating the returns from innovation.

Teece (1986) identifies several dimensions for the appropriability of the returns from innovation: nature of technology, strength of property rights regime, complementary assets, ease of replication and ease of imitation. Different combinations of these dimensions correspond to different appropriability regimes. Appropriation regimes vary across industries and so does the efficiency of appropriation instruments. Appropriation instruments fall within two categories: legal and strategic.

Among the group of legal instruments are patents, trademarks, and copyrights (see Mansfield (1986) on the effectiveness of patents in different industries). Among the strategic instruments are investments in complementary assets, such as marketing, sales effort and customer service, secrecy and lead time, or the relative complexity of products. In some industries, strategic instruments may be more effective means of appropriating the returns of a firm's R&D results (see for instance Levin *et al.*, 1987.)

[2] See De Bondt (1996) for a review of the effects of spillovers on the research decisions of firms.

Besides differences across industries and appropriation regimes, the use of appropriation instruments obviously varies with the innovation strategy of the firm: firms that produce more innovations and firms that produce innovations that are easier to imitate are more likely to use appropriation instruments. This link between innovation strategy and use of appropriation instruments is for instance studied in Cassiman, Pérez-Castrillo and Veugelers (2002) that classifies firms' innovation activities between activities dedicated to the creation of knowledge (whether applied or basic research) and activities dedicated to the protection of knowledge (or investment in appropriation instruments.) Firms conducting basic R&D invest in protection activities to avoid outgoing spillovers.

We assume that firms that invest resources in the protection of knowledge, whether these are legal instruments or strategic instruments of appropriation, are those that produce innovations (as opposed to imitators.)

2.2. Innovation strategies of firms

Following the OECD Oslo Manual (OECD, 1994), the range of innovation activities that a firm undertakes includes both R&D and non-R&D activities. Non-R&D activities include acquisition of technology and downstream activities.

There are various approaches in the literature to explaining how firms make decisions about the innovation activities that they undertake.

The transaction costs approach studies whether it is best for a firm to develop in-house technology or to acquire it in the market; that is, treats the internal and external innovation activities as substitutes. When the production of knowledge and technology exhibits increasing returns, it can be produced more efficiently by a specialised firm. On the other hand, firms can choose to develop own technology, which will better fit the own needs. With lower transaction costs arising from changes in the attributes of knowledge, technology acquired in the markets increasingly substitutes technology developed at home. The extent of the substitution effect will obviously depend on the range of technologies available in the market, which will vary across industries and also among technologies. Veugelers and Cassiman (1999) study the industry and firm-specific effects that influence the innovation strategies of firms and distinguish between internal (make) and external (buy) technology sourcing. They find that the majority (73%) of firms in their sample combine internal and external activities rather than concentrating on only one type.

Another strand of the literature considers the various innovation activities of firms as complementary. Complementarity between internal and external R&D activities through the role of absorptive capacity is explained in Cohen and Levinthal (1989)[3]: internal R&D creates the capacity to assimilate and exploit external R&D.

[3] More recently, Arora and Gambardella (1994) study the complemetarity between internal and external R&D activities, and find two sources of complementarity that correspond to the capacity to scan and to integrate external knowledge (that is, two categories of absorptive capacity.)

Complementarity may also apply to the relationship between R&D and non-R&D activities. In another study, Cassiman and Veugelers (2002b) look at the complementarity between innovation activities that include own R&D, acquisition of technology on the markets and cooperation at R&D level. They find that own R&D and external technology sourcing are complementary activities: a firm combining them is more likely to produce innovative output than if it were to concentrate on either. In another study, Cassiman and Veugerlers (2000) analyse firms' choices between internal and external innovation activities, further distinguishing between types of external technology acquisition, which can be in embodied in an asset. The embodied category includes hiring new personnel and acquiring parts of other firms or equipment. The disembodied category includes licensing agreements and R&D contracting (outsourcing). Their results hint in the direction of complementarity among the various technology acquisition types.

Complementarity among innovation activities of firms may also refer to downstream non-R&D activities. Levinthal and March (1993) classify the innovation activities of firms between exploration and exploitation activities; exploration activities are related to developing (R&D) or acquiring new knowledge (acquisition of technology) whereas exploitation activities are related to downstream activities. They find that a balance between exploitation and exploration activities is desirable. Similarly, Teece (1986) argues that firms producing innovations, absent a market for a technology, must invest in specialised / co-specialized assets in order to extract profits from the technology. These assets may include competitive manufacturing facilities, marketing and after-sales support.

The role of the non-R&D activities in the innovation process has grown with the surge of markets for technology (Arora *et al.*, 2001). Teece (1998) recognises that the appearance of markets for technology has eroded some traditional sources of competitive advantage, the technology that is traded in the market can no longer be unique to a firm and hence cannot be a source of competitive advantage. Nowadays, competitive advantage can arise from the unique combinations of physical, social and resource allocation structure that firms provide so that the knowledge of individuals in an organisation can be shaped in a manner that is unique to that firm and that will influence its success. Innovation strategies are key since what matters more nowadays is not the ownership of knowledge assets and assets complementary to them –which can be increasingly acquired in the market–, but the combination of these knowledge assets with other assets needed to create value.

To sum up, with the surge of markets for technology, we can expect that firms substitute part of their internal innovation activities by acquisition of technology in the markets. Whereas the acquisition of technology in the market can be more efficient than developing it at home whenever there are increasing returns to its production, technology developed at home may be more fitted to the own needs. Acquisition of technology does not produce innovations that are exclusive or new to an industry and thus can not result in a competitive advantage per se; rather –if the firm seeks to have a competitive advantage– acquisition of technology can be combined with R&D activities that are capable of producing innovations that are new to an industry, or can be combined with downstream activities to adapt them to own market or clients needs. We label "innovation strategy" the combination of these activities by a firm and seek to explain how managers make decisions about them. Specifically, having assumed that we can distinguish between innovators and imitators in an industry according to their use of appropriation instruments (innovators invest in legal and / or strategic protection instruments and imitators do not), we hypothesize that innovators and imitators will differ in the composition of their innovative activities with innovators investing more in R&D activities (Hypothesis 1, for instance, as in Amir and Wooders, 2000, see Table 1 for a complete list of all hypotheses that are tested in Section 4)[4].

We also hypothesize that, due to the gains from specialization that explain the surge of markets for technology, acquisition of technology is important for both innovators and imitators (Hypothesis 2 in Table 1; Arora et al., 2001 and Teece, 1998). We also hypothesize that there is a positive correlation between R&D and downstream activities, as suggested for instance in Teece (1986), and we hypothesize that innovators will invest more in both R&D and downstream activities (Hypothesis 3 in Table 1).

2.3. The absorptive capacity of firms

To implement their choice of innovation strategy, firms require absorptive capabilities. In their seminal paper, Cohen and Levinthal (1989) first introduced the term absorptive capacity by pointing out at the dual role of R&D as a producer of new information as well as an enhancer of a firm's ability to learn from already existing information. In their model, absorptive capacity is a function of the R&D intensity of a firm and of the ease of learning of the knowledge to be assimilated, which vary across industries.

More recently, Kamien and Zang (2000) relate the absorptive capacity of firms to their R&D approaches, that is, to firms' innovation strategies rather than industry effects. They distinguish between firms with a basic (non-firm-specific) R&D approach and firms with a narrow (firm-specific) R&D approach. Different absorptive capacities correspond to the two R&D approaches.

Arora and Gambardella (1994b) suggest two dimensions of absorptive capacity distinguishing between the ability to evaluate information (or scientific capabilities) and the ability to utilize information (or technological capabilities) and find support for both in the biotechnology sector. Also Cassiman and Veugelers (2000) find evidence of two dimensions of absorptive capacity on an empirical paper on Belgian manufacturing firms, where they distinguish between firms' abilities to scan the market for technology and to absorb the technology acquired. Two categories of absorptive capacity, corresponding to the absorption of applied and basic research are also studied in an empirical paper (Lim, 2004), where the author finds evidence for two types of

[4] Amir and Wooders (2000) develop a model of R&D competition with one-way spillovers that yields equilibrium with an R&D innovator and an R&D imitator. In their model, R&D decisions of firms are strategic substitutes and imitator firms are less intense in R&D, where R&D intensity might account for R&D strategy, lab type and size, and the composition of R&D.

absorptive capacity (for absorbing applied and basic knowledge and for absorbing applied knowledge only) in the electronics and the pharmaceutical industries.

Some other models have broken the link between the production of own R&D activities and the absorptive capacity of firms. For instance, Hammerschmith (1999) separates a firm R&D activities between those dedicated to producing new knowledge and those enhancing absorptive capacity. A related idea can be found in Cassiman et al. (2002). We have mentioned that the authors model the relationship between a firm's knowledge flows and its innovation activities which can be of three types: basic research, applied research and intellectual protection. In their model, investment in basic research represents investment in absorptive capacity that can not lead to innovations outputs *per se* unless combined with investments in applied research.

Variations in the modelling of absorptive capacity, from one category to two, from being a by-product of own R&D to not being linked to the production of own R&D, and from varying according to industry characteristics to being related to a firm's innovation strategy, suggest changes in absorptive capacity that may have accrued with the development of markets for technology. Teece (1998) points out that in today's business environment, firms' require dynamic capabilities to achieve and maintain a competitive advantage; where dynamic capabilities involve receiving and interpreting messages about new markets and new technologies. The reception and interpretation of these messages will be shaped by a firm's own knowledge. The process extends to identifying relevant external technology and bringing it into the firm.

Following this literature, we assume that there are two types of absorptive capacity that are relevant to the firm in the presence of technology markets: the capability to scan the external environment for new technology and the capability to integrate new external knowledge into its innovation process.

The capability to scan the external environment does not involve complex scientific or technological knowledge, but knowledge about technology at user level and knowledge on business trends. We hypothesize that this capacity is significant to all innovation activities of firms (R&D, acquisition of technology and downstream activities; Hypothesis 4). With regards to R&D and acquisition of technology, knowing the range of technologies available in the market and understanding technological trends are necessary before a firm can decide appropriately between developing R&D and/or acquiring the technology in the market. With regards to the significance of this type of absorptive capacity for downstream activities, Teece (1998) points out that to successfully commercialise knowledge it is necessary to understand the nature of knowledge and the manner in which it can be bought or sold. In sum, the capability to scan the external environment is necessary to understand the business a firm is in and to produce at least as efficiently as competitors. Since it does not necessarily involve production of innovations, we hypothesize that this type of absorptive capacity is important to all firms performing innovation activities, whether they are innovators or imitators (Hypothesis 5).

The second type of absorptive capacity allows a firm not only to find out about technological developments or business trends, but to integrate external complex, not embodied knowledge into its own activities. We expect this type of absorptive capacity to be relevant for R&D activities (Hypothesis 6) since the more complex type of knowledge that corresponds to these activities requires pre-existing expertise in the area to successfully integrate it. Since we have before hypothesized that innovator firms will be more likely to conduct R&D activities, we expect that the effect will be larger for innovator firms (Hypothesis 7).

2.4. Size

The existing literature is not conclusive on the sign of the relationship between size and innovation activities. Levinthal and March (1993) note that large firms tend to favour exploitation (downstream activities) over exploration (R&D and acquisition of technology) activities. One reason for this is that incentives to exploration activities are harder to provide in larger, more rigid organisations. Thus, according to this view, small firms should invest more in exploration activities than large firms. In the same direction, Stiglitz and Weiss (1981) in a model of credit rationing in markets with imperfect information where interest rates act as an incentive mechanism, show that increasing the rate of interest may increase the relative attractiveness of riskier projects, i.e. projects with higher probability of bankruptcy. Hence, according to this view, small firms, with fewer assets at stake, may be more willing to perform riskier (R&D) activities. On the other hand, in industries where appropriability is low, small firms may lack the financial resources to invest in the complementary activities necessary to exploit R&D outputs in-house: Nelson (1959) argues that large firms which possess the resources to invest in complementary assets, have greater incentives to invest in developing new technologies. If this view is correct, large firms should be investing more in R&D activities than small firms. However, the surge of markets for technology in recent years may have eased the commercialisation (licensing) of R&D outputs by small firms lacking the financial resources to exploit them. Nevertheless, capturing the rents from innovation may continue to be difficult for small firms due to the inefficiency of contracts for technology and to their lower bargaining power (Arora *et al.*, 2001). Also in recent years, some small start-ups have been successful in attracting funds in financial markets to invest in downstream activities (but consequently growing in size). We thus hypothesize that the effect of size on R&D activities will change depending on the industry (Hypothesis 8).

One way to reconcile the too rigid structure of large organizations for R&D activities, and the lack of resources of small firms to invest in complementary assets to appropriate the results from R&D activities, is the spin-off of new R&D ventures from big corporations. As a consequence of this, firms belonging to a conglomerate should be more likely to perform R&D (Hypothesis 9). However, the management of corporate ventures is not trouble free (see Arora *et al.*, 2001, for more details).

Taking into account the innovation / imitation strategies of firms, Katz and Shapiro (1987)'s model suggest that major innovations will be developed by industry leaders (large firms) only in those industries where imitation is difficult. This is in accordance with findings in the empirical literature (for instance, Mansfield, 1981). For minor innovations, their model suggests that industry leaders (large firms) will be the innovators, regardless of the appropriation regime. In Amir and Wooders (2000) the innovator (the more R&D intensive firm) and the imitator firm differ in size.

Innovation activities

Hypothesis 1 Firms using appropriability instruments (innovators) have a higher probability of investing in R&D than firms not using appropriability instruments (imitators.)
Hypothesis 2 Acquisition of technology is important for both innovator and imitator firms
Hypothesis 3 Producers of innovations are more likely to conduct downstream activities than imitators. Downstream activities can serve to appropriate results of innovation (are complementary to research activities).

Firms' organisational characteristics 1: Absorptive capacity

Hypothesis 4 The capability to scan the external environment is important for performing R&D, acquiring technology in the market, or conducting downstream activities.
Hypothesis 5 The capability to scan the external environment is important for both innovator and imitator firms.
Hypothesis 6 The capability to integrate external knowledge is important for performing R&D
Hypothesis 7 The importance of the capability to integrate external knowledge for performing R&D is higher for innovator firms.

Firms' organisational characteristics2: Size and Group

Hypothesis 8 The effect of size is industry specific.
Hypothesis 9 Firms belonging to a conglomerate are more likely to perform R&D activities.

Table 1: Hypotheses

3. Data and Methods

3.1. Sample

We work with innovation data from the Technological Innovation Survey to firms in Spain. This survey is part of the European CIS program and contains information on the innovation (R&D and other innovation activities) decisions of firms, the factors that influence their capability to innovate and innovation outputs.

The data in the survey refer to the period 1998-2000, and include both firms in manufacturing and services[5]. The representative sample includes 11778 firms, of which we select innovative firms only -those that have reported a positive amount spent on at least one innovation activity during the year 2000-, being left with 3767 observations[6].

[5] Kaiser (2002a), Brouwer and Kleinlnecht (1997) and Sirilli and Evangelista (1998) are examples of studies of innovative activity in the service sector.
[6] This selection is in line with other studies, for instance, Veugelers (1997), Cassiman and Veugelers (2000), Cassiman and Veugelers (2002a).

Sample weights are used throughout because firms were selected with unequal probabilities in the sample.

3.2. Variable construction and exploratory analyses

Grouping variable: Production of innovation / imitation

To explore the relationship between innovation strategy and innovation output, we assume that firms that are first to come up with innovations invest in appropriation activities to protect the rents from innovation. Appropriability conditions vary across industries and so does the appropriability instruments that are more suitable: in some instances, legal protection is effective, in other instances, strategic measures are more useful. The questionnaire included a list of legal (patents, design, copyrights and trademarks) and strategic (secrecy, complexity of the product design and lead time) instruments of protection. We construct the binary variable PROTECT that assigns a value of "1" to those firms that have used at least one of the appropriation instruments in the questionnaire and "0" otherwise. The percentage of innovators in the sample is 38.2% and that of imitators is 61.8%.

Since throughout our analysis we control for industry effects, we are left out with differences in innovation strategies among firms within an industry; and by splitting the sample between those that use appropriation instruments to limit outgoing spillovers and those that do not, we separate firms that produce innovations from firms that imitate those. This is done in order to make it possible for the determinants of the innovation strategy to differ between innovator and imitator firms.

Dependent variables: Innovation strategies of firms

According to the Oslo manual, innovation is both what is new to an industry and what is new to a firm, even when it is no new to the market. The questionnaire included a battery of "yes-no" questions asking about whether the firm had carried out a list of innovative activities during year 2000, both R&D and non-R&D activities. R&D activities are:
a) internal (IntRD)
b) contracted externally (ExtRD)

Non-R&D activities are:
a) acquisition of machinery and hardware (Machi)
b) acquisition of technology such as patents, licenses and software (Techno)
c) design, trial production and tooling-up (Trial)
d) market research (Market)

Table 2 shows the proportion of firms answering that made some expenditure on the different types of innovation activity.

	IntRD	ExtRD	Machi	Techno	Trial	Market
% yes	37.2	17.4	73.4	29.2	19.9	28.3

Table 2: Percentages of yes answers to different types of innovation expenditure

Table 2 only shows the distribution of each innovation activity separately. Clustering innovation activities will help us simplify our models predicting the occurrence of these activities. In order to find groups of activities which are conceptually complementary and actually done together by a substantial number of firms, we estimate the relationships between all possible pairs of binary variables indicating if the firm carried out the different innovation activities. The Pearson's ϕ statistic (square root of the coefficient of mean square contingency, measure of association for 2×2 contingency tables) was used. For 2×2 tables it is bounded between -1 and +1 and thus interpreted like an ordinary correlation (see Table 3).

	IntRD	ExtRD	Machi	Techno	Trial	Market
IntRD	1	.179	-.225	-.012	.119	.129
ExtRD	.179	1	-.036	.050	.020	.109
Assets	-.225	-.036	1	.142	-.101	-.004
Techno	-.012	.050	.142	1	.072	.149
Trial	.119	.020	-.101	.072	1	.255
Market	.129	.109	-.004	.149	.255	1

Table 3: Association between the different types of expenditure (Pearson's ϕ)

Taking into account the conceptual similarity of activities, the type of knowledge that they involve and the largest positive ϕ coefficients, we classify these activities into three groups: the first group refers to exploration activities that involve tacit (not codified) knowledge; the second group refers to exploration activities that involve codified (whether tangible or intangible) knowledge; the third group of innovative activities refers to exploitation activities, that is, activities that lead to the deployment and use of the knowledge assets in the other two categories.

a) Activities in the first group include *internal* (IntRD) and *external* (ExtRD) *R&D*; that is, exploration activities conducted in or outside the firm that are undertaken in a systematic manner with the aim to acquire the knowledge necessary to develop new or improved products and / or processes. 44.9% of firms perform at least one of these activities[7].
b) activities in the second group (*acquisition of technology*) also belong to the exploration category and include the acquisition of embodied technology such as

[7] For evaluation of absorptive capacity purposes, it could be of interest to analyse firms conducting external R&D and performing no internal R&D, separately. The percentage of firms in this situation is small (7,6%). These firms tend to be imitators (73,8% are, whereas for the whole of the sample the percentage of imitators is 61,8%), tend to belong to a conglomerate (28,2% versus 21,8% for the whole of the sample) and there are few small firms (only 17,6% of them are in the first quartile of sales.)

machinery and equipment (Machi) for the development of new or improved products and/or processes; and the acquisition of disembodied technology or knowledge (Techno) comprising rights to use patented and not patented innovations, licences, know-how, trademarks, and software. 78.3% of firms perform at least one of these activities.

c) Activities in the third group include *downstream (or exploitation) activities*, namely investments in design and other technical procedures to the deployment of innovations (Trial), and internal and external marketing activities to introduce new or improved products in the market (Market). These two items measure activities that are complementary to R&D or to acquisition of technology. 38.0 % of firms perform at least one of these activities.

Three binary variables (coded as "1" for firms performing at least one of the activities in the group and "0" otherwise) were constructed to act as dependent in our models.

Appendix 1 shows the percentages of firms conducting these activities within each industry, together with the percentage of innovator (as opposed to imitator) firms. Industries with fewer than 50 firms are omitted. The results show an enormous heterogeneity across industries regarding the grouping and dependent variables, which makes it necessary to take industry into account in the analysis.

Summated scales: Absorptive capacity, size and confounding variables

A set of variables are constructed from the sum of sets of unidimensional items in the questionnaire. Summated rating scales (e.g. Spector, 1992) are often used to increase measurement reliability when an unobservable concept (e.g. absorptive capacity), assumed to be unidimensional, is measured by multiple indicators.

We use two groups of variables to measure the two types of absorptive capacity hypothesized in the previous section: the first type of absorptive capacity allows a firm to scan or monitor the external environment and the second type corresponds to a more sophisticated absorptive capacity that will allow a firm to integrate into its own activities general knowledge developed elsewhere. We label these AC-I and AC-II, respectively.

The literature on absorptive capacity does not deal satisfactorily with how much innovation activity and of what kind is needed to absorb external knowledge. The fact that knowledge spillovers can not be measured directly[8], added to the various characterisations of absorptive capacity that we have sketched in the previous section, makes the choice of indicators a delicate issue. From the range of data available, we constructed the variables that fitted best the definitions of the two types absorptive capacity explained above.

To proxy for the first type of absorptive capacity (AC-I), we use the answers to the questions about the main external sources of information used by innovative firms; from market information sources (summated scale MARKINF) including a) customers

[8] See Griliches (1992) for a review of the ways in which spillovers can be proxied.

and b) competitors; from public institutions (summated scale PUBLINF) including c) Universities and d) technological centres and other public research institutions; from other sources (summated scale CONFINF) including e) congresses, meetings and professional magazines and f) fairs and exhibitions.

Cassiman and Veugelers (2000), working with the equivalent European Commission's CIS data set for Belgian firms, measure the scanning capabilities of firms with a variable that captures how important publicly available external information is to the innovation activities of firms. The construction of their variable is similar to ours. Also working with data from the same European Commission's CIS program on German firms, Kaiser (2002a) proposes a measure of the absorptive capacity of a firm that results from the interaction between the innovation intensity of firms (innovation expenditures scaled by sales) and the spillover pools, these latter measured by the responses to the questions on the importance of certain external information sources for innovation for a firm. Since the answers to these questions already involve a judgement on the firms' part, we feel that they reflect not as much the extent to which knowledge is available in a sector but its actual use and absorption by the firm.

To proxy for the second type of absorptive capacity (AC-II) we use the answers to the following questions about internal factors that hamper a firm's innovation activity, (summated scale INTHAMP) a) Lack of qualified personnel b) lack of information on technology and c) lack of information on markets.

R&D personnel, existence of own R&D department and expenditures on R&D activities are other proxies used in the literature to measure this type of absorptive capacity. For instance, the presence of a permanent R&D activity in the firm as a proxy for this type of absorptive capacity is used in Veugelers (1997), in Cassiman and Veugelers (2000) and in Cassiman and Veugelers (2002a). These data are not available for the Spanish case.

Data on internal factors that hamper innovation are also used in Veugelers and Cassiman (1999) to study a firm's decision to innovate and to acquire technology externally. Kaiser (2002b) uses proxy variables that summarise factors hampering innovative activity to measure spillover knowledge flows.

Other proxies for absorptive capacity, like number of patents or publications, only make sense for some industries. For instance, Lim (2000) uses publication data to distinguish between absorptive capacity for basic and for applied research. His study is restricted to the pharmaceutical and electronic industries

The next summated scale used in the analysis (summated scale SIZE) is intended to capture the effect of firm size on the innovation strategies of firms and is constructed from the number of employees and sales volume quartiles within the industry. This means that a firm with a high summated score is a large one when compared to the industry median.

Other factors that hamper a firm's innovation activity, even if not of direct relevance to the hypotheses that we want to test, must also be included in the analysis as confounding variables, because if omitted, the estimates of the effects of the relevant variables could be biased. These other factors include economic issues hampering innovation (summated scale ECOHAMP): a) excessive economic risk, b) innovation costs too high, and c) lack of appropriate financing sources; and other issues hampering innovation (summated scale OTHHAMP), a) insufficient flexibility of norms and regulations and b) lack of demand for new products or services. These variables have been reported as significant in the literature. Veugelers and Cassiman (1999) observe that firms that find high risk and high costs to be an obstacle to innovation are actually more likely to innovate. Also the lack of opportunities to innovate and the perception of the need for innovation, are found significant issues in the firms' decisions to innovate. Kaiser (2002b) includes the answers to the "economic" and "other" issues hampering innovation to obtain variables to proxy for spillovers.

The summated scales computed and the items included are summarized in Table 4.

Reliability of a summated rating scale is usually computed as Cronbach's α (Cronbach, 1951) under the assumption that items are at least tau-equivalent. This assumption is often violated as it implies that all items have equal true variances and that all errors are uncorrelated. If the tau-equivalence assumption is violated, α is a lower bound for reliability in the absence of error correlations (Novick and Lewis, 1967; Raykov, 1997) but if measurement errors are correlated, it can even happen that α overestimates true reliability (e.g. Raykov, 2001a). Unfortunately, empirical studies do not usually perform any test of the tau-equivalence assumption when applying α.

Confirmatory factor analysis (CFA) models can accommodate unequal true variances and error correlations and are thus a much more general framework to reliability measurement. The remaining assumptions can be tested with a number of goodness of fit indices (Bollen and long, 1993) and the failure to reject these assumptions can be interpreted in terms of validity (Batista-Foguet et al. 2004). CFA models constitute a particular case of structural equation models (e.g. Bollen, 1989; Raykov and Marcoulides, 2000; Batista-Foguet and Coenders, 2000). Once the CFA model has been estimated, reliability of a summated rating scale SRS_i computed from the items y_j loading on the same factor η_i can be computed with the formula given by Raykov (2001b).

The CFA model specified the indicators and dimensions indicated above and their reliabilities are shown in Table 4. Its goodness of fit was excellent (Bollen's comparative fit index 0.974, Tucker and Lewis index 0.962, Steiger's Root mean square error of approximation 0.022). Given the reduced number of items in each of the scales, the obtained reliabilities can be considered to be good.

Most of the questions were answered in a 4-point ordinal categorical scale from "not used" or "not relevant" to "highly important" (the size indicators were actually grouped in quartiles) and are appropriate for factor analysis models (Coenders, et al. 1997) but cannot be considered to be normally distributed. The sampling design used in this study can be considered to be cluster sampling (e.g. Thompson, 1992) as individual firms are nested within industries. Under this design, cases corresponding to the same cluster (industry, in our case) are dependent. In addition, sample weights are needed because firms were selected with unequal probabilities. Corrections to fit indices for non-normal complex samples are available in M*plus*3.11 (Muthén & Muthén, 2004) which is the program we used for estimation.

Dimension	reliability	Items
Importance of market information sources (MARKINF)	0.613	• Customers • Competitors
Importance of public information sources (PUBLINF)	0.720	• Universities • Research centres
Importance of conferences fairs and journals as information sources (CONFINF)	0.732	• Conferences and journals • Fairs
Internal issues hampering innovation (INTHAM)	0.811	• Personnel qualification • Lack of technological information • Lack of market information
Size (SIZE)	0.843	• Employment • Sales
Economic issues hampering innovation (ECOHAMP)	0.795	• Risk • Costs • Financing
Other issues hampering innovation (OTHHAMP)	0.645	• Regulations • Lack of demand

Table 4: CFA dimensions, scale reliabilities and indicators

Binary explanatory variable: belonging to a conglomerate

The variable CONGLOM is a binary variable distinguishing between independent firms (78.2% of the sample, coded as 0) and those belonging to a conglomerate (21.8 % of the sample, coded as 1).

Missing data and outlier treatment

3488 out of 3767 responses to the "yes-no" questions on innovative activities were complete. Since answers to these questions were used to construct the dependent variables in this article and we saw no reasonably accurate way of imputing responses, missing values were dropped. The remaining variables in the study had virtually no missing data, and only two further cases were eliminated for this reason.

6 outliers were detected with extreme Mahalanobis distances to the mean vector of the variables analyzed in this article and were also eliminated. The final usable sample size is thus 3480.

3.3. Model specification and estimation

A logit model with random effects for complex samples was used to predict each of the three binary dependent variables indicating innovation strategic profile (R&D activities, technology acquisition and downstream activities). Logit models constitute a standard statistical tool for predicting a binary dependent variable for a set of numeric and binary predictors. The probability that firm i in industry j will perform a particular type of innovative action (π_{ij}) undergoes the logistic transformation and is related to the set of explanatory variables:

$$\ln\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)=\beta_0+\beta_1 x_{1ij}+\beta_2 x_{2ij}+\cdots+\beta_k x_{kij} \qquad (1)$$

As our data are hierarchical in nature (firms are nested within industries), a multilevel Logit model is required (e.g. Goldstein, 1995:77-111). In such a model, random intercepts account for industry heterogeneity. Equation 2 is identical to equation 1 except by the fact that the β_{0j} intercept has an industry subindex and is thus assumed to vary across industries around a expected value β_0. A random intercept plays an analogous role to a complete set of industry specific binary variables. One of the main advantages of using a random intercept is greater parsimony, as only two parameters are to be estimated, β_0 and Var(β_{0j}) no matter how large the number of industries is. Another advantage is that not all industries are needed; a representative sample of them is enough, thus making this formulation to be specially suited for cluster samples.

$$\begin{aligned}&\ln\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)=\beta_{0j}+\beta_1 x_{1ij}+\beta_2 x_{2ij}+\cdots+\beta_k x_{kij}\\&\beta_{0j}\rightarrow N(\beta_0,Var(\beta_{0j}))\end{aligned} \qquad (2)$$

The model can be extended to include random slopes as well. Some or all of the slopes may differ across industries thus showing different importance of some or all the predictors in different industries. A random slope plays an analogous role to a complete set of interaction terms between the predictor and industry specific binary variables. Equation 3 shows such a model when only x_1 has a random slope.

$$\begin{aligned}&\ln\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)=\beta_{0j}+\beta_{1j} x_{1ij}+\beta_2 x_{2ij}+\cdots+\beta_k x_{kij}\\&\beta_{0j}\rightarrow N(\beta_0,Var(\beta_{0j}))\\&\beta_{1j}\rightarrow N(\beta_1,Var(\beta_{1j}))\end{aligned} \qquad (3)$$

Besides, in a sample with unequal probabilities of selection like ours, sampling weights must also be taken into account. When computing point estimates, an individual with a weight equal to say 2, counts as if it was repeated twice in the sample. Most statistical programs perform well this adjustment to point estimates. What is less widely understood is that standard formulae for computing standard errors fail to work in this situation, even if weights are normalized to a unit average. Adjustments to standard errors are performed by M*plus*3.11, which is the program we use throughout with the maximum likelihood option.

All explanatory variables described in the previous section were used. As argued before, we assume that the determinants of innovation profile may change between innovator firms who have a lot of innovations to protect and imitator firms that have no innovations to protect. Therefore, an interaction term was included between PROTECT and all other variables. The summated rating scales were mean centred in order to prevent collinearity with the iteration terms (Li et al., 1998; Irwin and McClelland, 2001) and to make the main effect of the PROTECT variable to be interpreted as the effect for a firm with the mean level of the summated scales which does not belong to a conglomerate. The main effects of all other variables refer to an imitator firm which does not protect innovation.

A model with all random coefficients would imply too much computational burden. Thus, a model was fitted with only a random intercept to get the mean effect and random intercept estimates. Then slope variances were introduced one by one to check their significance. For the significant ones, the estimated variance was recorded as well as the individual effects for each industry.

4. Results

4.1. R&D activities

Table 5 shows the estimates for the first dependent variable described in Section 3.2, R+D activities, which belong to the exploration category. Standard errors and t-values are included to assess the statistical significance and the standardized estimate to assess predictor importance.

As expected, firms that protect innovations are more likely to conduct Exploration-R&D activities than firms that are imitators (significant PROTECT main effect).

As regards AC-I, the use of information from public institutions and from specialised meetings and media tends to increase R&D activities to a similar extent for both imitators and innovators (significant main effect and non significant interaction), whereas the use of information from market sources (suppliers, clients and competitors) only increases R&D activity for the innovator group (main effect close to zero and significant positive interaction). These results provide partial support for hypotheses 4 and 5.

As regards AC-II, the existence of internal issues hampering innovation increases innovators' propensity to do R&D activities (significant positive interaction effect PROTECT×INTHAMP combined with a main effect of INTHAMP close to zero). Veugelers and Cassiman (1999) observe that firms that find lack of technological information to be an obstacle to innovation are actually more likely to innovate; that is, the questionnaire seems to capture awareness to obstacles existing when one is actually carrying out R&D activities rather than effectiveness in blocking innovative purposes. We also use this interpretation in our proxy for AC-II. Under this interpretation, our finding provides support to hypotheses 6 and 7.

	$\hat{\beta}$	s.e.	t*	stand. $\hat{\beta}$
Mean effects				
INTERCEPT	0.310	0.078	**3.962**	
CONGLOM	0.595	0.066	**9.049**	0.122
SIZE	0.458	0.055	**8.299**	0.210
INTHAMP	-0.005	0.040	-0.124	-0.002
MARKINF	-0.060	0.043	-1.387	-0.028
PUBLINF	0.435	0.068	**6.433**	0.149
CONFINF	0.139	0.031	**4.512**	0.065
ECOHAMP	0.221	0.053	**4.176**	0.109
OTHHAMP	0.074	0.034	**2.214**	0.034
PROTECT	0.997	0.085	**11.691**	0.240
PROTECT×CONGLOM	-0.666	0.169	**-3.936**	-0.095
PROTECT×SIZE	0.129	0.078	1.661	0.042
PROTECT×INTHAMP	0.184	0.066	**2.789**	0.049
PROTECT×MARKINF	0.331	0.095	**3.479**	0.091
PROTECT×PUBLINF	-0.039	0.104	-0.375	-0.009
PROTECT×CONFINF	-0.084	0.076	-1.112	-0.023
PROTECT×ECOHAMP	-0.254	0.061	**-4.161**	-0.074
PROTECT×OTHHAMP	-0.178	0.064	**-2.784**	-0.050
Effect Variances				
INTERCEPT	0.649	0.169	**3.839**	
SIZE	0.133	0.057	**2.340**	
MARKINF	0.091	0.042	**2.168**	
PROTECT×INTHAMP	0.394	0.179	**2.205**	

Table 5: Results for predicting the probability of carrying out R&D activities
* Boldfaced if significant (α=5%)

Within the group of imitators (main effects), both SIZE and CONGLOM have significant coefficients, indicating that larger firms and firms belonging to a conglomerate are more likely to conduct R&D activities. Within the group of innovators, larger firms are more likely to conduct R&D activities, while the CONGLOM effect is cancelled out in the case of innovators (positive main effect and negative interaction of about the same size). The results thus partly support Hypothesis 9.

As regards the intercept variance, its high statistical significance shows that firms in different industries will have different probabilities of performing R&D activities, for given values of all the variables in the model. A list of industries with higher and lower propensities to carry out R&D activities is in Appendix 1.

As regards effect variances, the effect of size and the use of market information have a significantly different effect across industries both in the innovator and imitator group. For internal factors hampering innovation the industry differences occur only for the innovator group. The significant variance of the effect of size may be related to the differences in the sign of the effect of size reported in the literature. In 12% of the studied industries the effect of size was actually negative, thus fully supporting Hypothesis 8. The largest positive size effects are for the traditional industries with a low technological component (shoes, hospitality, wholesale trade, wood and cork, construction, automobile repair) to whom a large size may allow to invest in complementary assets to appropriate the results from R&D. It may also suggest a low degree of specialisation in the production of knowledge and technology, corresponding to their low complexity. The negative size effects are for industries with a high technological component (software, computers, electronics), where smaller firms may benefit from their lower organizational rigidities. It may also indicate that the specialisation on the production of knowledge and technology increases with the technological component of the industry, in response to its growing complexity.

The results were compared to that of a traditional logit analysis (Table 6) assuming constant intercept and slopes across industries and simple random sampling (thus ignoring weights and within industry dependence). Ignoring within industry dependence and weights biases both estimates and standard errors. The differences between Table 5 and Table 6 are really sizeable and would lead to markedly different theoretical interpretations, as many coefficients are significant in one analysis and fail to be so in the other.

	$\hat{\beta}$	s.e.	t*	stand. $\hat{\beta}$
Mean effects				
INTERCEPT	0.242	0.066	**3.692**	
CONGLOM	0.688	0.114	**6.055**	0.159
SIZE	0.236	0.053	**4.452**	0.114
INTHAMP	0.087	0.076	1.145	0.034
MARKINF	0.043	0.058	0.741	0.019
PUBLINF	0.614	0.078	**7.822**	0.242
CONFINF	-0.019	0.058	-0.333	-0.009
ECOHAMP	0.131	0.064	**2.035**	0.059
OTHHAMP	0.053	0.071	0.736	0.022
PROTECT	1.270	0.106	**11.999**	0.300
PROTECT×CONGLOM	-0.432	0.182	**-2.378**	-0.083
PROTECT×SIZE	0.062	0.085	0.728	0.020
PROTECT×INTHAMP	-0.063	0.119	-0.528	-0.017
PROTECT×MARKINF	0.140	0.091	1.532	0.042
PROTECT×PUBLINF	0.007	0.120	0.056	0.002
PROTECT×CONFINF	0.136	0.094	1.436	0.039
PROTECT×ECOHAMP	-0.035	0.102	-0.343	-0.010
PROTECT×OTHHAMP	-0.052	0.111	-0.469	-0.015

Table 6: Results of a standard Logit model with fixed effects under the assumption of simple random sampling for R&D activities

* Boldfaced if significant (α=5%)

4.2. Acquisition of technology

With regards to the second dependent variable which is acquisition of technology, also within the exploration category, Table 7 shows that there is no significant difference in the likelihood of doing it between innovators and imitators. This is consistent with the view that assets acquired in the market can not be a source of competitive advantage, hence, cannot distinguish between producers of innovations and imitators. Hypothesis 2 is thus supported.

As hypothesized (Hypotheses 6 and 7), no absorptive capacity to integrate innovations (AC-II) is needed to acquire technology in the market.

However, the capability to scan the external environment for technology (AC-I), in the form of information from specialised meetings and media, increases the probability of acquiring technology for both imitators and innovators and to a greater extent for the latter. Information from public institutions is significant only for imitators, but with a negative sign. This could be due to the bridge between the basic type of knowledge that is characteristic of public institutions and the applied knowledge that is traded in the market. Unexpectedly, information from market sources is found not significant in the analysis. Partial support for Hypotheses 4 and 5 is thus provided.

Smaller firms and firms not belonging to a conglomerate are more likely to acquire technology in the market both if they are innovators and imitators. This seems to be is in line with markets for technology providing firms with access to technologies that were not available to them before.

	$\hat{\beta}$	s.e.	t*	stand. $\hat{\beta}$
Mean effects				
INTERCEPT	-1.429	0.060	**-23.764**	
CONGLOM	-0.343	0.112	**-3.060**	-0.076
SIZE	-0.134	0.048	**-2.787**	-0.066
INTHAMP	0.033	0.062	0.538	0.016
MARKINF	-0.064	0.051	-1.255	-0.032
PUBLINF	-0.206	0.062	**-3.335**	-0.076
CONFINF	0.106	0.035	**3.042**	0.054
ECOHAMP	0.062	0.063	0.983	0.033
OTHHAMP	-0.407	0.068	**-5.983**	-0.199
PROTECT	-0.194	0.115	-1.678	-0.050
PROTECT×CONGLOM	0.299	0.174	1.714	0.046
PROTECT×SIZE	0.114	0.072	1.578	0.040
PROTECT×INTHAMP	0.238	0.127	1.879	0.068
PROTECT×MARKINF	-0.160	0.085	-1.891	-0.048
PROTECT×PUBLINF	0.278	0.095	**2.934**	0.071
PROTECT×CONFINF	0.217	0.087	**2.496**	0.064
PROTECT×ECOHAMP	-0.005	0.127	-0.037	-0.001
PROTECT×OTHHAMP	0.332	0.071	**4.670**	0.100
Effect Variances				
INTERCEPT	0.210	0.066	**3.159**	
INTHAMP	0.097	0.045	**2.164**	
MARKINF	0.258	0.090	**2.860**	
OTHHAMP	0.256	0.128	**2.000**	
PROTECT×INTHAMP	0.217	0.102	**2.134**	

Table 7: Results for predicting the probability of carrying out acquisition of technology

* Boldfaced if significant (α=5%)

As regards the intercept variance, its high statistical significance shows that firms in different industries will have different probabilities of acquiring technology. The percentage of firms acquiring technology within each industry is displayed in Appendix 1. Unlike the case is for R&D and downstream activities, technology acquisition seems to be important for all industries, as in no industry is the percentage of firms acquiring technology lower than 58%. As regards effect variances, the effect of internal and other factors hampering innovation and the use of market information have a significantly different effect across industries both in the innovator and imitator group.

4.3. Downstream activities

The third dependent variable corresponds to the downstream (exploitation) activities, that is marketing and technical procedures and preparations for carrying out innovations. Firms producing innovations invest significantly more often in downstream activities than imitators. This suggests that despite the growth of technology markets, investments in complementary assets continue to be an important means to appropriating the results from innovation (Hypothesis 3 is supported).

The presence of internal factors hampering innovation reduces the probability of performing downstream activities only for imitators.

On the other hand, the capability to scan the external environment for technology is significant. Specifically, the more the information from markets is used, the higher the probability of carrying out downstream activities both for innovators and imitators (the effect is smaller for innovators but still sizeable). The more the information from fairs and conferences is used, the higher the probability of carrying out downstream activities but only for imitators. This may indicate capability to scan product and service markets rather than markets for technology only. Support is thus provided for hypotheses 4 and 5.

Finally, belonging to a conglomerate tends to increase the probability of carrying out downstream activities but does so only for imitators.

The results in Table 8 bear more resemblance to those in Table 5 than to those in Table 7. Actually, the ϕ coefficients in Table 3 suggest that downstream activities are more strongly related to R&D activities than to acquisition of technology.

As regards the intercept variance, its high statistical significance shows that firms in different industries will have different probabilities of performing downstream activities. As regards effect variances, the effect of internal and other factors hampering innovation and the use of market and other sources of information have a significantly different effect across industries both in the innovator and imitator group.

	$\hat{\beta}$	s.e.	T*	stand. $\hat{\beta}$
Mean effects				
INTERCEPT	0.941	0.062	**15.286**	
CONGLOM	0.346	0.096	**3.602**	0.072
SIZE	-0.087	0.047	-1.859	-0.041
INTHAMP	-0.084	0.038	**-2.209**	-0.038
MARKINF	0.407	0.038	**10.565**	0.193
PUBLINF	0.059	0.072	0.811	0.021
CONFINF	0.169	0.044	**3.813**	0.081
ECOHAMP	0.021	0.040	0.527	0.011
OTHHAMP	0.406	0.032	**12.632**	0.188
PROTECT	1.135	0.087	**13.011**	0.280
PROTECT×CONGLOM	-0.546	0.114	**-4.786**	-0.079
PROTECT×SIZE	0.213	0.074	**2.892**	0.071
PROTECT×INTHAMP	0.152	0.067	**2.259**	0.041
PROTECT×MARKINF	-0.141	0.065	**-2.185**	-0.040
PROTECT×PUBLINF	-0.084	0.120	-0.701	-0.020
PROTECT×CONFINF	-0.225	0.077	**-2.924**	-0.062
PROTECT×ECOHAMP	0.037	0.052	0.712	0.011
PROTECT×OTHHAMP	-0.313	0.059	**-5.291**	-0.090
Effect Variances				
INTERCEPT	0.172	0.092	1.871	
INTHAMP	0.202	0.079	**2.558**	
MARKINF	0.282	0.123	**2.293**	
CONFINF	0.170	0.054	**3.170**	
OTHAMP	0.091	0.041	**1.983**	
PROTECT×OTHHAMP	0.248	0.115	**2.160**	

Table 8: Results for predicting the probability of carrying out downstream activities
* Boldfaced if significant (α=5%)

5. Conclusions

In the presence of markets for technology, managers must adapt their innovation strategies to maintain the competitive advantage of the firm. Technology available in the market can in many instances substitute efficiently R&D developed at home. To maintain a competitive advantage, firms can produce new knowledge not available in the markets or adapt it to suit their own needs or those of their clients. A combination of investment in R&D, acquisition of technology and downstream activities that is particular to a firm will allow it to obtain a competitive advantage. We classify the possible set of combinations into two categories of innovation strategies: innovators and imitators. Innovators are firms producing new knowledge and tend to invest more in R&D than imitators. Imitators acquire technology in the market or produce at home technology that is already available elsewhere. They are found to invest less in R&D activities. Both innovators and imitators acquire technology in the market, pointing at the benefits of specialisation in the production of knowledge and technology. Innovators invest more in downstream activities than imitators, suggesting complementarity between R&D and downstream activities. In order to implement their innovation strategies, firms must have capabilities in the form of absorptive capacity. Absorptive capacity can be of two types: the capability to scan the environment for new technologies, and the capability to integrate complex and disembodied knowledge. Scan capabilities are found to be significant for both imitators and innovators and for all types of innovation activities, whereas only innovators require absorptive capability of the second type and they require it mostly for R&D activities. Larger firms and firms belonging to a conglomerate tend to carry out more R&D and less acquisition of technology.

The propensity to carry out any of the innovation activities varied a lot across industry. More remarkably, the effect of the explanatory variables also did. For instance, size was found to have a positive effect on R&D in some industries and a negative effect in some others.

To be able to derive empirically testable hypotheses from the literature, we have had to neglect some important aspects of the references used. Overall, the results are in line with those previously found in the literature, albeit we produce them in more detail and using a statistical methodology that makes it possible to distinguish within and between industry differences and to produce proper inferences in complex sample designs. The use of this methodology is far more than a statistical refinement, as the results and their interpretation do substantially change when comparing them to those obtained with standard logit models. Due to the difficulties in the measurement of spillovers in general, and absorptive capacity in particular, the evidence that we provide is not conclusive, but provides a starting point for further research in this direction.

Our findings suffer from three limitations or lines for further research. First, this study was limited to the variables available at the Technological Innovation Survey. More work is needed to identify firm characteristics generating absorptive capacity and how to measure it empirically, as well as other possible confounding variables. Besides, internal factors hampering innovation showed signs of endogeneity (as those carrying out more R&D actually found the most hampering factors) and appropriate instrumental variables would also be welcome. Second, more empirical work is also needed to check the robustness of the results outside its temporal and spatial framework and to evaluate the dynamic effects of growing markets for technologies on innovation strategies of firms. Finally, both additional theoretical and empirical work is needed to understand how managers make decisions on the combination of innovation activities that firms undertake, given the wider range of options that have become available in recent years. Some of this work could be of qualitative nature, involving in-depth interviews of the managers themselves or case studies of particularly illustrative firms.

Appendix 1: Industry heterogeneity according to the grouping and dependent variables

	Number of firms in the sample	Innovator %	R&D activities %	Acquisition of technology %	Downstream activities %
Food and drinks	271	41	47	74	43
Miscellaneous textiles	127	42	39	85	30
Clothing (textiles and furs)	50	35	46	79	48
Wood and cork products	83	22	47	76	20
Pulp, paper and paperboard	64	46	53	80	30
Publishing and printing services	117	33	28	91	31
Chemicals	156	56	74	58	39
Pharmaceutical products	74	76	90	64	35
Rubber and plastic products	112	55	59	69	33
Non-metallic mineral products	140	38	45	82	35
Metallurgic ferrous products	57	58	58	61	38
Metal products (except machinery and equipment)	193	43	39	80	34
Mechanical machinery and equipment	173	59	67	64	39
Electrical machinery and equipment	91	54	57	71	51
Optical instruments and surgical equipment	56	65	76	84	66
Motor vehicles	99	70	80	64	55
Furniture	114	54	33	82	56
Other manufactures	70	66	75	68	61
Building	80	24	45	86	29
Wholesale	92	28	24	84	39
Transportation	50	29	26	86	53
Other transportation and travel agencies	56	07	48	79	26
Financial intermediation	91	31	45	62	52
Software	92	62	92	71	58
Other computer related activities	51	37	74	73	48
Research and development	66	74	97	60	44
Architecture and engineering services	66	35	60	74	34
Other activities	73	27	29	93	25
Other collective health services	86	17	33	85	36

Industries with fewer than 50 cases were dropped as their results would be too much sample dependent.

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