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XARXA DE REFERÈNCIA EN ECONOMIA APLICADA

The Innovation and Imitation Dichotomy in Spanish firms: do absorptive capacity and the technological frontier matter?

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ABSTRACT

This paper analyses whether a firm's absorptive capacity and its distance from the technological frontier affect the choice between innovation and imitation in innovative Spanish firms. From an extensive survey of 5,575 firms during the 2004-2009 period, we found two significant results. With regard to the role of absorptive capacity, the empirical evidence shows that when innovative firms have difficulties in accessing external information and hire skilled workers, their innovative capacity is reduced. Meanwhile, with regard to distance from the technological frontier, the firms that reduce this gap manage to increase their innovative capacity at the expense of imitation. To summarise, when we studied firms' absorptive capacity and their relative position to the technological frontier in tandem, we found that the two factors directly affected firms' ability to innovate or imitate.

Key words: R&D sources, innovation and imitation strategies, absorptive capacity, technological frontier, ordered probit

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1. Introduction

The nature of innovations undertaken by firms is heterogeneous and complex and for this reason in recent times many researchers have put a great deal of effort into understanding the process of innovation at a corporate level. The modern theory of the innovation process can be traced to the ideas of Josef Schumpeter (1942), who saw innovation as the main transforming power of market economies. According to the Schumpeterian theory, entrepreneurs continually introduce new products or processes to the market, and they may enjoy considerable profits for some time, until they are displaced by subsequent successful innovators, in a process of ‘creative destruction’.

Schumpeter distinguished three steps or phases in the innovation process by which a new or superior product or process permeates the marketplace (Jaffe et al, 2003). Invention is the first step in the development of a scientifically or technically new product or process. Most inventions may be patented as a way to protect future revenue, but most inventions never develop into an innovation. The second step is innovation, which entails the commercialization of the invention. The steps of invention and innovation are carried out through a R&D process. Finally, the third step is imitation, in terms of the diffusion of innovations[1]. Innovation gradually comes to be widely available for use in the relevant applications through its adoption by firms or individuals.

Firms that specialise in developing new technologies, whether this is manufacturing new products, improving the performance of existing ones, or making production processes cheaper, have to deal with the challenge of appropriating the fruits of their labour.

Everyone knows that innovation requires experimentation, speculative investment, risk and even failure. If innovation were not associated with risk, every single firm would practise it with excellent results. Successful innovation can drive forward the existing technological frontier, giving the innovator a competitive advantage in the form of privileged knowledge of new products or new production techniques. However, innovation is also an uncertain activity that requires major investment and in many cases only offers modest benefits. The most experienced firms know when innovation needs to be given an opportunity, but they also know when to take the less glamorous but also less risky route of imitation. It is often the case that choosing an

[1] Joseph Schumpeter’s (1934, 1942) theory has been corroborated by subsequent contributions, both theoretical and empirical (see a survey in Hall et al, 2010).

R&D strategy not only entails deciding how much to invest but also deciding how, when and with whom to invest.

Even after making an important discovery, a firm would normally have to invest a great deal in developing the product. Furthermore, turning the concept of a product into a series of successful procedures and routines also involves difficulties and expense. Therefore there may be a considerable time lag between the time a valuable innovation is discovered and its conversion to commercial success.

Firms invest considerable resources in R&D activities to discover qualitatively improved products and reap the associated profits. This works as a signal to other firms – the imitators – who burst into an industry or sector with the hope of sharing the profits (with the result that the advantages of the innovator firm are rapidly eroded). This swarm of imitators means that the growth of the sector or industry where the innovation occurred is quite high for a time, although sooner or later the effects of this growth (generated by the innovation) will become exhausted and growth will slow down. When entrepreneurs are unable to appropriate all the value they create, they tend to invest less in the experimentation necessary to discover new opportunities, and consequently the process of productive diversification and development of the private sector stagnates.

A firm is following an imitation strategy when it releases a copy or adaptation of the original innovative product on the market. However, the strategy of product imitation should not necessarily be seen as a secondary strategy compared to innovation: there are situations when this is appropriate. Thus some firms make imitation their basic strategy; in other words, they wait for the launch of a new product to reach the market once any mistakes made by the innovator have been ironed out.

Imitation is a common practice among innovative firms. Indeed, who doesn't imitate? In a sample of North American manufacturing firms, Tilton (1971) found that the time lag between the initial discovery of innovations by American semiconductor manufacturers and the first commercial production run by their Japanese counterparts was on average one year. Years later, Mansfield et al. (1981) observed that at least 60% of the patents owned by a group of North American firms had been imitated during the four years after the patents were registered. And Levin et al. (1984) observed that even the leading patented innovations could be imitated within three years or more in over half the 129 lines of business examined.

Usually, the development costs incurred by the imitator are lower than those of the innovator. Mansfield et al. (1981) showed that the costs of imitations reached, on average, 65% of the costs of innovations. Meanwhile, Levin et al. (1984) observed that in 80% of the lines of business studied, the cost of making an imitation was less than 75% of the costs incurred by the firms that had developed the original innovations.

Innovation and imitation strategies are not mutually exclusive but they are subject to high levels of complementarity. Indeed, many firms successfully combine the two strategies simultaneously depending on the situation, in terms of knowledge, of each of their business units. For example, Microsoft innovates constantly with Windows (a product that some felt was an imitator of Apple's software in its early days); however, it follows an imitation strategy with the Xbox console, a market in which Sony is the leader with its Playstation, and with the Zune player in a market led by Apple's iPod.

Existing studies devote a lot of attention to making a direct comparison between innovation strategy versus imitation strategy to evaluate the differences in the performance of different firms (for example, Urban et al., 1986; Bolton, 1993; Bowman and Gatignon, 1996; Robinson and Min, 2002; amongst others). However, given that both innovation and imitation strategies are theoretically viable, we are relying on empirical evidence to predict which strategy is the most effective. In this study, we focus on firms' absorptive capacity and distance from the technological frontier.

The main objective of this work is to jointly examine how the absorptive capacity of a firm and its distance from the technological frontier determine the innovation or imitation strategies of innovative firms. The empirical results of this exercise can be used as the basis for an important set of implications that will be of great interest when it comes to designing public policies geared towards fostering entrepreneurial innovation.

This paper uses an exhaustive data source from the Spanish Technological Innovation Panel (henceforth PITEC), which brings together in a collaborative venture the Spanish National Institute of Statistics (INE) and the Foundation for Technological Innovation (COTEC). The panel obtains firm-level data and uses a collection methodology that is relatively consistent over a good number of periods. The data are taken from the Community Innovation Survey (CIS) and include information regarding innovation activities that is comparable with microdata on innovation from many other European countries. PITEC covers a broad range of sectors, and includes the activities of both manufacturing and services firms. Its principal advantage is that it allows longitudinal data to be obtained for more than 12,000 firms for the 2004-2009 period.

This study makes four main contributions. Firstly, we looked at empirical development based on four groups of firms, depending on the technological intensity of manufacturing firms (high and low technology intensity) and the knowledge intensity of service firms (knowledge-intensive services and other services). Secondly, we carried out an exhaustive study of firms' innovation and imitation strategies in relation to their absorptive capacity. Thirdly, we also analysed innovation and imitation strategies regarding their distance from the technological frontier. And finally, we used a data panel that would allow us to make a more in-depth analysis than those carried out thus far based on cross-section data.

The results show that when firms come up against barriers to accessing external information, their capacity to innovate is lessened. Similarly, the results obtained for internal absorptive capacity indicate that manufacturing firms and knowledge-intensive service firms that face greater difficulties in recruiting specialist personnel have a lower capacity to innovate. In terms of distance from the technological frontier, we found that manufacturing firms and those belonging to other service sectors closest to the technological frontier are the most likely to innovate.

The remainder of this paper is organized as follows: Section 2 makes a review of the literature; Section 3 presents the analysis model; Section 4 shows the set of data and describes the variables used in the model; Section 5 provides the empirical results, and finally Section 6 summarises the main conclusions and sets forth a political argument.

2. Conceptual Framework

Innovation and imitation strategies

With innovation strategies, firms invest a substantial amount in R&D and aims to be the first to bring their innovative products to the marketplace (Lieberman and Montgomery, 1988; Green and Scotchmer 1995). This process can benefit the firm in different ways.

For Munuera and Rodríguez (2007), the factors that determine the advantages of innovative firms can be clustered into two categories: on the one hand, those proposed by the industrial economy (at a business level) and on the other, those based on consumer behaviour theories (at a product or brand level). However, it is difficult to make an empirical division between the benefits associated with the barriers to entry and the benefits associated with consumer behaviour, as almost certainly both types of advantages are correlated (Denstadli et al., 2005).

The main argument used by Industrial Organization to justify the presence of these advantages is that of the barrier to the entry of new competitors. The existence of an entry barrier means that in order for a firm to compete effectively with the pioneer when it has no presence in a market, it needs to invest additional resources to those it would have had to invest if it had entered the market earlier. Some of the main barriers include the enjoyment of scale economies; patents or other industrial property rights; preferential access to strategic resources, and the economic cost of changing a supplier due to contractual clauses or investment in complementary assets by buyers.

With regard to consumer behaviour theories, the sources of competitive advantages are related to cognitive, affective and behavioural aspects, such as the greater probability of recognition, recall and consideration of innovative brands; the possibility of having an influence on the identification of important attributes in terms of their valuation and in establishing a product standard against which successive brands will be compared; the positive image of innovative brands and consumers' belief in them, as they achieve market recognition because they are attributed with a certain level of concern in improving their products and services; perception of the risk associated with changing a brand, and the expense involved in changing suppliers, which benefits brands that manage to get consumers to make a satisfactory trial of their product; the opportunity to choose the optimum positioning, given that if imitator brands want to differentiate themselves they are forced to adopt a lower position, etc.

However, innovation is not the only option for introducing a product. Given that there can only be one pioneer in every product market, imitation is still a viable strategy and more common than innovation (Kerin et al., 1992; Golder and Tellis, 1993; Schnaars, 1994). A firm follows an imitation strategy when it releases a product that has been copied or adapted from the original innovative product.

Although it is an unquestionable fact that imitator firms have to compete with a rival who has an advantage over them in terms of market share, they also enjoy a series of benefits that could be turned into major competitive weapons. The advantages attributed to imitators are to a large extent related to free rider behaviour. This concept does not allude to fraudulent or illegal practices but to an attempt to make profits on the back of efforts by other firms. According to Munuera and Rodríguez (2007), some of the advantages of imitator firms include the fact that the imitation strategy tends to require lower investments in basic research than their predecessors had to spend; likewise, they can save a large proportion of the considerable amounts that have to be spent on R&D by copying the original products; they can take advantage of the investment in human resources – recruitment and training – that their predecessors have made by recruiting some of their key personnel; they can benefit from the advertising investment made by the innovative firms to stimulate demand and educate buyers in the use of the new product; they have more accurate information, with fewer uncertainties, about the market potential of the product, as they are entering the market when they have already seen a positive response to marketing actions, and so on.

Absorptive capacity

Since the 1980s the interest in issues related to absorptive capacity has continued to increase. The starting point was the seminal works of Cohen and Levinthal (1989, 1990) that introduced the term in relation to innovative firms and underlined the dual nature of R&D in that it both generates new information and improves the ability of a firm to calibrate and incorporate external information. The absorptive capacity has often been interpreted as an intrinsic quality that is difficult to transfer and adapt to other contexts; however, firms' skill in identifying and incorporating external resources is born from their internal resources that facilitate change and their learning capacity. Rosenberg (1990) was the first to argue that internal R&D is necessary to understand how scientific and technological information flows from external sources into a firm.

These studies emphasize the potential synergies between internal and external knowledge. Nevertheless, Rosenberg's discussion does not deal with the multi-dimensional nature of knowledge and therefore does not fully explore the sources of these synergies. For this reason, Arora and Gambardella (1994) proposed distinguishing between two types of knowledge. The first type looks at the capacity or ability of a firm to evaluate external information, whereas the second type looks at a firm's ability to use externally generated information. Several years later, Cassiman and Veugelers (2000) and Arbussà and Coenders (2007), among others, carried out further research along these lines.

The first type of knowledge does not entail complex scientific or technological knowledge, but rather knowledge regarding the technology at user level and knowledge regarding business trends. The second type allows a firm to not only to discover technological developments and business trends, but also to integrate complex and abstract external knowledge into its activities.

Technological Frontier

The concept of distance from the technological frontier has been applied repeatedly in aggregate studies of a sectorial nature, and in recent years access to large databases at a firm level has also facilitated its use in studies devoted to analysing firms' innovation strategies. Existing studies demonstrate that the distance between a firm's position and the frontier is an important dimension when it comes to understanding the intensity and nature of the innovative patterns of industrial and service firms. However, there are certain differences between the analyses carried out at a country level and a firm level. For example, life cycle and entrance and exit strategies are less important at a country level than at a firm level. Likewise, mergers or acquisitions are not analogous at a country level.

According to several country-based studies, notably those by Vandenbussche et al. (2006) and Acemoglu et al. (2006), amongst others, rather than the technological frontier, imitation is the main growth driver of the total productivity of the factors. And when a country moves close to the frontier, it is more inclined to innovate. At a corporate level, several studies, notably those of Polterovich and Tonis (2005) and Coad (2008), show that the firms closest to the technological frontier are more likely to innovate and less likely to imitate. Firms that are technologically backward may have greater potential to imitate but need to develop their ability to absorb external knowledge. However, backwardness does not automatically translate into more innovative activities, which is why these firms need to spend time and resources on developing their internal absorptive capacity.

3. Empirical model

In this section we present the econometric methodology used in this document, knowing that the main objective of the empirical work consists of jointly examining how distance from the technological frontier and absorptive capacity determine the innovation and imitation strategies of innovative firms. The variable to be explained is hidden (or latent) to the researcher due to the impossibility of making a detailed observation of the situation of each firm.

In view of any possible bias that may be thrown up during the estimation process, the most appropriate methodology is the ordered probit. This model was developed by Aitchison and Silvery (1957) and Ashford (1959), and generalised to abnormal disorders by Gurland et al. (1960). More recently, it has been updated by Maddala (1983) and McCullagh (1980).

We have used a model based on the following specification:

$$y_i^* = \beta x_i + \varepsilon_i \qquad E[\varepsilon_i \mid x_i] = 0\,, \qquad \varepsilon_i i.n.i.d.N(0,\sigma_i^2)$$

where 'i.n.i.d' indicates that ε_i is distributed separately but not identically as a normal value.

The categories observed in y_i relate to y_i^* in accordance with the following rule:

$$y_i = \begin{cases} z_1 \; if \;\; y_i^* \in A_1 \\ z_2 \; if \;\; y_i^* \in A_2 \\ \quad\quad \cdots \\ z_m \; if \; y_i^* \in A_m \end{cases}$$

Where the series A_j form a part of space Ω of y_i^*, i.e. $\Omega = \bigcup_{j=1}^{m} A_j$ and also $A_j \cap A_k = \varnothing$ for $i \neq k$, and z_j are the discrete values comprised in Ω.

A key difference compared to linear models is that the influence of the explanatory variables on the probability of choosing the option determined by y_i (the partial derivative $\frac{dy_i}{dx_i} = \beta_k$ in the linear models) is not separate from the characteristics vector x_i.

An initial approximation to the ratio between the explanatory variables and the resulting probability is to calculate the marginal effects on the latent variable (y_i^*).

If the marginal effect expresses a change of the dependent variable caused by a unitary change in one of the independents, the others remaining constant, the estimated probit parameters reflect the marginal effect of x_{ik} on y_i in the same way as the MLP, given that $E(y*|x) = x'\beta$.

Along the lines of Vinding's study (2006), we will estimate a model where the dependent variable will be the innovative practices of the firm, and the factors related to knowledge, absorptive capacity, distance from the technological frontier and certain control variables will act as the determinants. The basic structure of the model is expressed as follows:

$$y_{i,t} = f(\beta_1 p_{i,t} + \beta_2 q_{i,t} + \beta_3 r_{i,t} + \beta_4 s_{i,t})$$

Where for each individual firm i in each period of the time t, y represents the innovative practices of the firm and p, q, r and s are the vectors in the factors related to knowledge, absorptive capacity, distance from the technological frontier, and other conventional control variables, respectively.

The categorical variable y expresses the innovative practices of the firm on an ordered scale of 0 to 2. Zero corresponds to firms that neither innovate nor imitate (non-innovating/imitating firms); the number one indicates that a firm has introduced an innovation that is new to the firm but not the market (imitator firms); and finally the categorical variable adopts value 2 when the firm has introduced a change to its products that is innovative to the market (innovative firms). In other words, the dependent variable adopts three discrete values according to the innovation intensity of the firm, $y \in (0, 1, 2)$.

In order to control the possible endogeneity problems, we have followed the proposals of Coad (2008) and Raymond et al. (2010), among others, and have applied lagged explanatory variables during the econometrics estimations, thus adopting the following model:

$$y_{i,t} = f(\beta_1 p_{i,t-1} + \beta_2 q_{i,t-1} + \beta_3 r_{i,t-1} + \beta_4 s_{i,t-1})$$

In line with the literature that in recent years has examined the incentives for firms to innovate or imitate, the results can be summarised in the following table:

Table 1: Hypothesis		
Variable	Hypothesis	Authors
Distance	Firms close to the technological frontier have more incentives to innovate and fewer to imitate.	Polterovich and Tonis (2005) Coad (2008)
Absorptive capacity	Firms with higher absorptive capacity have more incentives to innovate and fewer to imitate.	Vinding (2006)
Absorptive capacity + Distance	Firms' absorptive capacity is related to their internal resources and the environment in which they operate, and is also closely linked to their relative position with regard to the other firms involved in the market (technology distance).	

4. Data

The PITEC collates a large amount of information regarding the most important aspects of a considerable number of manufacturing and services firms. One of the advantages of the PITEC over transversal data sources from technical innovation surveys is the PITEC's temporal nature, which allows it to obtain much more accurate estimations of the progress of firms and to obtain much more robust data that better reflect the heterogeneous nature of the firms.

All things being considered, we should also highlight certain limitations that are inherent in any survey subject to the answers of a member of the firm's management personnel, in this case the R&D Manager. In this respect, the assessment of the innovative nature of a particular activity depends partly on the point of view of the person answering the survey. Nevertheless, the evidence offered by Mairesse and Mohnen (2004) suggests that subjective evaluations of innovation tend to be consistent with more objective evaluations. For the present study, it is also essential to cleanse the primary data source and to cleanse the database (treat missing values, remove excessively disparate ratios regarding the average sectorial values, etc.). After cleansing the database, the sample was reduced from 12,813 firms to 5,575 firms.

The most important operations that were taken into account throughout the cleansing process were that: *a)* the survey data should cover the 2004-2009 period; *b)* the chosen sectors should be manufacturing and services, with a distinction made between sectors with high technological intensity and sectors with low technological intensity; *c)* the sample should only include firms that have appeared in the database for at least four years; d) firms that have not undergone a merger or takeover and e) firms with ten or more employees.

Construction of the variables

Among the types of innovations proposed by Joseph Schumpeter (1934), the notion of the concept and type of innovation has changed considerably over the years. The Austrian author suggested distinguishing them according to their intensity, and believed that "radical" innovations were those that generated more disruptive changes, and "incremental" innovations were those that continually filled the process of more partial changes; and proposed a list of five types of innovations: the introduction of new products, the introduction of new production methods, the opening of new markets, the development of new sources of raw materials and materials, and the creation of new market structures.

Years later, the first edition of the Oslo Manual (OECD, 1992) highlighted the technological profile of innovations by considering innovations as product- and process-related, in spite of noting that "*Innovation activities are all scientific, technological, organisational, financial and commercial steps*". Finally, according to the third version of the Oslo Manual (OECD, 2005), along with the two types mentioned above, it considers the growing role of non-technological innovations whose sphere of application is organisational methods and distribution and marketing channels.

Along with all the different approaches to the nature of innovations, considerations about the actual requirements for defining a firm as an innovator or an imitator also vary. There is no one standard definition of an innovative firm, or what distinguishes innovation from technical change. Schmookler (1966) suggests that when entrepreneurs produce a product or service, or use a method or input that is new to that firm, they are introducing a technical change. The entrepreneur who is the first to make a technical change is an innovator.

Years later, Hall (1994) noted that the distinction between a firm that exerts a certain leadership as an innovator and the follower firms – the imitators – is ambiguous.

The Oslo Manual (OECD, 1996), which proposes the formulation and design of innovation surveys, includes technical change as well as imitation, through questions on products that are new or significantly improved upon in technological terms for the market, and products that are new or significantly improved upon in technological terms for the firm. Technical change is strongly attributed to the production of goods, and using the same definition can fail to capture the majority of service-related innovations unless we take the definition of innovations a step further on.

Along the lines of previous studies by Loof and Heshmati (2006) and Vinding (2006), amongst others, we have defined innovations as goods and services that are: (i) new or substantial improvements to the market, or (ii) new or substantial improvements to the firm only. To be specific, in line with Vinding (2006) we believe that a firm has imitated if it has introduced a product/service that is new to the firm only, and that a firm has innovated if it has introduced a product/service that is new to the market.

Table 2 shows the number of firms by type of innovation and sector for the 2004-2009 period:

Table 2: Number of firms by type of innovation and sector (2004-2009)

	High-tech industries	Low-tech industries	Knowledge-intensive services	Other Services	Total
Does not imitate/innovate	1,052 (54.85%)	1,729 (70.14%)	340 (49.93%)	446 (87.28%)	3,595 (63.98%)
Imitates	472 (24.61%)	445 (18.05%)	137 (20.12%)	43 (8.41%)	1,097 (19.68%)
Innovates	394 (20.54%)	291 (11.81%)	204 (29.96%)	22 (4.31%)	911 (16.34%)
Total	1,918 (100.00%)	2,465 (100.00%)	681 (100.00)	511 (100.00%)	5,575 (100.00%)

Source: PITEC
Note: The figures in brackets represent the percentage of firms in the sector that belong to each innovation type.

We can see that virtually 45% of high technology intensity manufacturing firms imitate or innovate. In contrast, this drops to 30% in low technology intensity manufacturing firms. In terms of knowledge-intensive services we can see that 50% of their firms imitate or innovate; however, in the other services, only 13% of the firms imitate or innovate.

Among the knowledge-related factors, we considered the intensity of internal R&D variable, *internal RD*, which we defined as the internal R&D expenses per employee; the intensity of external R&D variable, *external RD*, was measured as the external R&D expenses per employee and the cooperation variable, *Coop*, is a binary variable that differentiates between firms that do not cooperate (represented by 0) and those that do cooperate (represented by 1).

We considered the two types of absorptive capacity described previously: the first allows a firm to scan its immediate environment for knowledge and the second allows it to integrate knowledge generated anywhere into its own activities. Given that knowledge spillovers cannot be measured directly, we used the variables that are best suited to defining these two types of absorptive capacity.

Following on from the study by Arbussà and Coenders (2007), to study the first type of absorptive capacity, we used the responses regarding the importance of external sources of information to innovation; these sources range from market sources of information (MARKET), which include clients and competitors, to public institutions (PUBLIC), which include universities, technological centres and other public research institutions, to other sources (OTHERS), which include conferences, scientific journals, technical publications, fairs, exhibitions, etc. Given that firms' responses to these questions were subjective, we believe that they reflect not only the degree to which knowledge is available in the sector but also the degree of use and absorption by the firm. Again following on from Arbussà and Coenders (2007), as a proxy for the second type of absorptive capacity, we used the responses to the questions regarding the internal barriers that impede innovation in a firm (INTERNAL), these being: a) the lack of qualified people, b) the lack of technological information and c) the lack of market information.

Along the lines of the study by Arbussà and Coenders (2007), we built these variables using a *summated scale*. In other words, to reduce the limitations inherent in the use of individual indicators that offer a partial dimension of a complex phenomenon, in our case the absorptive capacity, this method adds the information from various categorical responses and provides an aggregate value that is more in line with the purpose of the study.

Following the example of Polterovich and Tonis (2005) and Vandenbussche et al. (2006), amongst others, we defined the distance from the technological frontier as the firm's productivity compared to the productivity of the leading firm in the sector.

We defined the size variable, *Size*, as the number of employees. The investment variable, K/L, measures the gross investment of material assets per employee. The group variable, *Group*, is a binary variable that differentiates between independent firms, (represented by 0) and those that belong to a group (represented by 1). We defined the market share variable, *MarketShare*, as the firm's sales divided by the value of the sales in its sector. We obtained the sectorial sales from the Spanish National Institute of Statistics. The age variable, *Age*, covers the years between the current financial year t and the financial year in which the firm was created.

Below, Table 3 shows the descriptive statistics of the manufacturing firms, and Table 4 shows the descriptive statistics of service firms.

Among the high technology intensity manufacturing firms, the firms that innovate spend the most on internal R&D (7,785.93 euros), on external R&D (2,458.48 euros) and are the most cooperative (40.93%). With regard to factors related to absorptive capacity, we can say that the information from the market (MARKET), from public institutions (PUBLIC) and from other sources (OTHERS) such as conferences, etc. is more important for the firms that innovate (2.25, 3.13 and 2.76 respectively). And firms that imitate are those that perceive the greatest difficulty (INTERNAL) in recruiting qualified personnel, etc. (2.77). In terms of distance, we can see that the firms that innovate are closest to the frontier (0.21). And in terms of the firm's characteristics, we can see that firms which innovate are the largest (215.60), the ones that invest the most (10,243.13 euros), the ones with the biggest market share (0.26%) and the youngest firms (26.07). In contrast, firms that imitate are most likely to form groups (40.42%).

Table 3: Descriptive statistics in 2004-2009 (Manufacturing)			
High-tech industries			
	Does not imitate/innovate	**Imitates**	**Innovates**
Factors related to knowledge			
Internal R&D	3,830.90	5,732.25	7,785.93
External R&D	803.35	1,217.91	2,458.48
Cooperation (%)	27.38	36.72	40.93
Absorptive capacity I (External factors)			
MARKINF	2.56	2.31	2.25
PUBLINF	3.32	3.27	3.13
OTHERS	2.99	2.83	2.76
Absorptive capacity II (Internal factors)			
INTHAMP	2.88	2.77	2.78
Distance-related factors			
Distance	0.20	0.20	0.21
Firm characteristics			
Size	145.50	181.79	215.60
Investment	10,186.55	10,023.77	10,243.13
Group (%)	39.80	40.42	38.12
Share Market (%)	0.17	0.21	0.26
Age	27.46	27.05	26.07
Number observations	5,972	2,546	2,307
Low-tech industries			
	Does not imitate/innovate	**Imitates**	**Innovates**
Factors related to knowledge			
Internal R&D	1,428.54	2,478.76	3,073.67
External R&D	320.64	509.90	731.01
Cooperation (%)	23.02	32.57	38.04
Absorptive capacity I (External factors)			
MARKINF	2.79	2.53	2.47
PUBLINF	3.37	3.37	3.24
OTHERS	3.10	2.96	2.83
Absorptive capacity II (Internal factors)			
INTHAMP	2.88	2.81	2.72
Distance-related factors			
Distance	0.22	0.24	0.23
Firm characteristics			
Size	156.34	137.08	150.64
Investment	11,666.68	20,174.68	13,484.29
Group (%)	34.03	34.52	34.13
Share Market (%)	0.14	0.13	0.14
Age	28.42	27.71	26.77
Number observations	9,728	2,364	1,628

Source: PITEC

Notes: Internal R&D, External R&D and Investment in euros per employee and size in employees.

Table 4: Descriptive statistics in 2004-2009 (Services)			
Knowledge-intensive services			
	Does not imitate/innovate	**Imitates**	**Innovates**
Factors related to knowledge			
Internal R&D	11,855.81	19,686.57	28,837.80
External R&D	1,134.48	1,943.39	3,272.48
Cooperation (%)	29.49	45.39	54.30
Absorptive capacity I (External factors)			
MARKINF	2.65	2.26	2.20
PUBLINF	3.19	3.07	2.85
OTHERS	2.98	2.76	2.54
Absorptive capacity II (Internal factors)			
INTHAMP	2.90	2.72	2.71
Distance-related factors			
Distance	0.21	0.19	0.19
Firm characteristics			
Size	223.54	128.07	153.34
Investment	8,328.95	14,110.30	13,597.31
Group (%)	31.33	27.23	29.58
Share Market (%)	0.19	0.29	0.34
Age	13.45	12.11	12.97
Number observations	1,899	683	1,178
Other Services			
	Does not imitate/innovate	**Imitates**	**Innovates**
Factors related to knowledge			
Internal R&D	969.78	1,958.16	6,029.48
External R&D	282.06	960.96	1,369.92
Cooperation (%)	23.85	36.08	42.93
Absorptive capacity I (External factors)			
MARKINF	2.97	2.91	2.55
PUBLINF	3.54	3.51	3.22
OTHERS	3.12	3.10	2.75
Absorptive capacity II (Internal factors)			
INTHAMP	3.23	3.04	2.83
Distance-related factors			
Distance	0.17	0.26	0.29
Firm characteristics			
Size	518.29	455.95	703.95
Investment	16,099.80	76,286.47	96,802.53
Group (%)	45.57	42.27	52.72
Share Market (%)	0.18	0.15	0.27
Age	34.91	35.23	27.03
Number observations	2,482	225	98
Source: PITEC *Notes: Internal R&D, External R&D and Investment in euros per employee and size in employees.*			

With regard to knowledge-intensive services (see table 4), we can see that the firms which innovate are those that spend the most on internal R&D (28,837.80 euros), that spend the most on external R&D (3,272.48 euros) and that cooperate the most (54.30%). With regard to the external factors of absorptive capacity, we see that the information from the market (MARKET), institutions (PUBLIC) and other sources (OTHERS) is more important for firms that innovate (2.20, 2.85 and 2.54 respectively). These firms also perceive the greatest difficulty (INTERNAL) in finding qualified personnel, etc. (2.71). Also, the firms that neither imitate nor innovate are the closest to the technological frontier (0.21). And with regard to the firm's characteristics, we can also say that firms that neither imitate nor innovate are the largest (223.54) and those most likely to form groups (31.33%). In contrast, firms that imitate invest the most in terms of capital (14,110.30 euros) and are the youngest firms (12.11). And firms that innovate are those with the biggest market share (0.34%).

In the cluster of other services (see Table 4) the innovative firms spend most on internal R&D (6,029.48 euros) and external R&D (1,369.92 euros) and are also more cooperative (42.93%). With regard to the external factors of absorptive capacity, we can see that information from the market (MARKET), from institutions (PUBLIC) and from other sources (OTHERS) is more important to firms that innovate (2.55, 3.22 and 2.75 respectively). These firms also experience greater difficulty in finding qualified personnel, etc. (2.83). With regard to distance, we can see that the firms which innovate are closest to the frontier (0.29). And in terms of the firm's characteristics, we can say that firms that innovate are the largest (703.95), those that invest the most (96,802.53 euros), those that are most likely to form groups (52.72%) and those with a bigger market share (0.27%). These firms are also among the youngest (27.03).

5. Results

This section discusses the most important results obtained using the ordered probit model in the four sector groupings used. Table 5 shows the model's estimates for high technology intensity manufacturing firms. Among the factors relating to knowledge, only the internal R&D expenses and cooperation are significant. In contrast, the external R&D expenses are not significant. With regard to the sign, we can say that an increase in any of these three variables decreases the probability of not imitating/innovating, or imitating, but increases the probability of innovating. Furthermore, the marginal effects show that an increase in the intensity of internal R&D notably increases the probability that a firm will innovate, while cooperation in R&D projects with other partners does not have a particularly high impact on the probability of innovating.

Table 5: Ordered probit estimation of the factors that determine R&D strategy (High-tech industries)

	Model		Marginal effects for the model		
	Coefficients	**Standard deviation**	**Does not imitate/innovate**	**Imitates**	**Innovates**
Factors related to knowledge					
Internal R&D	9.6900***	1.5800	-3.5500	-0.0426	3.6000
External R&D	2.1400	1.7200	-0.786	-0.0094	0.7950
Cooperation	0.0932***	0.0356	-0.0341	-0.0006	0.0346
Absorptive capacity I (External factors)					
MARKINF	-0.0397**	0.0208	0.0145	0.0002	-0.0147
PUBLINF	-0.0670***	0.0227	0.0246	0.0003	-0.0249
OTHERS	-0.0600***	0.0243	0.0220	0.0003	-0.0222
Absorptive capacity II (Internal factors)					
INTHAMP	0.0516**	0.0235	-0.0189	-0.0002	0.0191
Distance-related factors					
Distance	0.1894*	0.1057	-0.0694	-0.0008	0.0702
Firm characteristics					
Size	0.1351***	0.0351	-0.0495	-0.0004	0.0501
Investment	0.1470	0.3210	-0.0538	-0.0006	0.0545
Group	-0.2052***	0.0350	0.0754	0.0002	-0.0757
Share Market	-0.0045	0.0243	0.0017	0.0001	-0.0017
Age	-0.0045***	0.0008	0.0017	0.0001	-0.0017
Sectorial dummies	Yes				
Time dummies	Yes				
Number observations	4,173				

Source: PITEC
Notes: Internal R&D, External R&D and Investment in euros per employee and size in employees.
****Significant at 1%; **significant at 5%; *significant at 10%*

The results revealed by the factors that determine the absorptive capacity of a firm are very interesting, given that both the factors associated with the external absorptive capacity and those associated with the internal absorptive capacity are meaningful. The negative values of the parameters corresponding to external absorptive capacity indicate that access to information from outside the firm is an important dimension when it comes to innovating. When there is a drop in the importance of information from the markets (MARKET), from public institutions (PUBLIC) or other possible sources of information (OTHERS), such as conferences, etc., there is an increase in the probability that the firm will not imitate/innovate or that it imitates, while the probably of innovating decreases.

With regard to the dimension associated with internal absorptive capacity, access to qualified personnel is a key factor in facilitating innovation in Spanish industrial firms. If difficulties in finding qualified personnel are lessened (INTERNAL), there is also a reduction in the probability that the firm will not imitate/innovate, or that it will imitate, while, in contrast, there is an increase in the probability that the firm will innovate. These results echo those of studies such as Vinding's (2006).

A firm's distance from the technological frontier also emerges as an important and statistically relevant dimension. Indeed, the closer that high technology intensity manufacturing firms get to the frontier, the lower the probability of not innovating/imitating and the higher the probability of innovating. In other words, the closer the firm gets to the technological frontier, the more likely it is that they will innovate to the detriment of imitation. The studies by Polterovich and Tonis (2005) on a theoretical level and by Coad (2008) on an empirical level, amongst others, have found similar results with regard to the performance of this variable.

With regard to the matrix of determining factors associated with the firm's characteristics, it is worth highlighting the fact that the size of the firm is directly related to its propensity to innovate. These results echo those of Vinding (2006), amongst others. We also found a direct relationship between investment and the propensity to innovate. On the other hand, firms that belonged to an industrial group tend to lessen their innovation effort in favour of imitation. In terms of market share, we noted that there is no clear relationship with innovation in this case, demonstrating that in Spain many firms enjoy a position of hegemony in their respective niches but on the other hand show great resistance to change and to adapting to the new rules of competition. Finally, it is worth highlighting the fact that young firms have a higher capacity for innovation than other firms.

Table 6 shows the estimates of the probit model for low technology intensity manufacturing firms. As we can see, among the factors listed for knowledge, only the internal R&D and external R&D expenses are significant. However, cooperation is not significant. An increase in internal or external R&D expenses increases the probability that firms will innovate, and, to a lesser extent, that the firm will imitate.
Among the external factors related to a firm's absorptive capacity, the only significant parameter is the one corresponding to information from

other sources (OTHERS) such as conferences, etc. Moreover, internal factors (INTERNAL) are not significant. The results in Table 6 show that when there is a drop in the importance of information from the market (MARKET), public institutions (PUBLIC) and other possible sources of information (OTHERS), such as conferences, etc., there is an increase in the probability that the firm will not undertake innovation-related activities, while the probability of imitating and, above all, innovating decrease. When low technology intensity manufacturing firms experience few barriers when it comes to finding qualified personnel, etc., (INTERNAL), then the probability of imitating and, above all, innovating increases.

Table 6: Ordered probit estimation of the factors that determine R&D strategy (Low-tech industries)

	Model		Marginal effects for the model		
	Coefficients	**Standard deviation**	**Does not imitate/innovate**	**Imitates**	**Innovates**
Factors related to knowledge					
Internal R&D	8.7300***	3.0300	-3.4700	0.6430	2.8200
External R&D	22.7000**	9.8100	-9.0200	1.6700	7.3400
Cooperation	-0.0082	0.0417	0.0032	-0.0006	-0.0026
Absorptive capacity I (External factors)					
MARKINF	-0.0252	0.0243	0.0100	-0.0019	-0.0082
PUBLINF	-0.0217	0.0279	0.0086	-0.0016	-0.0070
OTHERS	-0.0788***	0.0290	0.0313	-0.0058	-0.0255
Absorptive capacity II (Internal factors)					
INTHAMP	0.0169	0.0272	-0.0067	0.0012	0.0055
Distance-related factors					
Distance	0.1505*	0.1058	-0.0598	0.0111	0.0487
Firm characteristics					
Size	0.0293	0.0849	-0.0116	0.0022	0.0095
Investment	-0.3190	0.4310	0.1270	-0.0235	-0.1030
Group	-0.0991**	0.0420	0.0394	-0.0075	-0.0319
Share Market	-0.0496	0.0578	0.0197	-0.0037	-0.0161
Age	-0.0027***	0.0010	0.0011	-0.0002	-0.0009
Sectorial dummies	Yes				
Time dummies	Yes				
Number observations	3,047				

Source: PITEC
Notes: Internal R&D, External R&D and Investment in euros per employee and size in employees.
****Significant at 1%; **significant at 5%; *significant at 10%*

According to Table 6, the closer the relative position of an individual firm to the frontier, the more the probability of it imitating or innovating increases. Moreover, this probability will be higher in the case of firms that innovate. The studies by Polterovich and Tonis (2005) on a theoretical level and by Coad (2008) on an empirical level, amongst others, found similar results with regard to the performance of this variable, although the study by Coad (2008) only analysed high technology intensity manufacturers.

In terms of the characteristics of low technology intensity manufacturing firms, we see that they behave in accordance with the values recorded in the estimates corresponding to high technology intensity manufacturers, with the exception of investment. In this case, the fact of investing more is not directly related to a greater propensity to innovate.

Table 7 shows the model's estimates for knowledge-intensive service firms. As we can see, among the factors related to knowledge, only the internal R&D expenses are significant. On the other hand, external R&D expenses and cooperation are not significant. In terms of the sign, we can say that an increase in internal R&D expenses reduces the probability of not imitating/innovating or of imitating, yet increases the probability of innovating. On the other hand, an increase in external R&D expenses or in cooperation increases the probability of not imitating/innovating or of imitating, and reduces the probability of innovating.

Among the external factors relating to absorptive capacity, the only significant one is information from other sources (OTHERS). Internal absorptive capacity is also significant. Table 7 also shows that if there is a drop in the importance of information from the market (MARKET), public institutions (PUBLIC) or other possible sources of information (OTHERS), such as conferences, etc., then there is an increased probability that the firm neither imitates/innovates, or that it imitates, while the probability that it innovates decreases. However, if the firm sees a reduction in its difficulty in finding qualified personnel, etc. (INTERNAL), then it also reduces its probability of neither imitating/innovating, or of imitating, while it increases its probability of innovating. These results are along the same lines as those for the high technology intensity manufacturing firms. We have not found any evidence in the empirical literature for knowledge-intensive services.

The distance of a firm from the technological frontier is significant. According to Table 7, we can say that the closer a firm gets to the frontier, the more it increases its probability of neither imitating nor innovating, or that it imitates and the probability of it innovating decreases. These results do not coincide with the results for manufacturing firms. We did not find any evidence for knowledge-intensive services in the empirical literature either.

In relation to the determining factors associated with the firm's characteristics, we can say that in contrast to the situation with manufacturing firms, the size of the firm is not directly related to its propensity to innovate. Nor is investment, nor the age of the firm. With regard to the effects of forming part of a corporate group, knowledge-intensive services show a positive value in the case of innovation. In other words, firms that belong to a corporate group tend to increase their innovation effort in favour of innovation. The same situation applies to firms that have a larger market share.

Table 7: Ordered probit estimation of the factors that determine R&D strategy (Knowledge-intensive services)

	Model		**Marginal effects for the model**		
	Coefficients	**Standard deviation**	**Does not imitate/innovate**	**Imitates**	**Innovates**
Factors related to knowledge					
Internal R&D	2.5500***	0.7550	-0.8070	-0.2090	1.0200
External R&D	-0.7620	5.7900	0.2410	0.0623	-0.3030
Cooperation	-0.0141	0.0698	0.0045	0.0012	-0.0056
Absorptive capacity I (External factors)					
MARKINF	-0.0099	0.0415	0.0031	0.0008	-0.0039
PUBLINF	-0.0332	0.0415	0.0105	0.0027	-0.0132
OTHERS	-0.0900**	0.0448	0.0285	0.0074	-0.0358
Absorptive capacity II (Internal factors)					
INTHAMP	0.0044*	0.0449	-0.0014	-0.0004	0.0017
Distance-related factors					
Distance	-0.5018***	0.2011	0.1588	0.0410	-0.1998
Firm characteristics					
Size	-0.1480**	0.0642	0.0468	0.0121	-0.0589
Investment	-1.0000*	0.5590	0.317	0.0082	-0.3990
Group	0.0810	0.0696	-0.0253	-0.0069	0.0322
Share Market	0.0767**	0.0336	-0.0243	-0.0063	0.0306
Age	-0.0036	0.0040	0.0012	0.0003	-0.0015
Sectorial dummies	Yes				
Time dummies	Yes				
Number observations	1,298				

Source: PITEC
Notes: Internal R&D, External R&D and Investment in euros per employee and size in employees.
****Significant at 1%; **significant at 5%; *significant at 10%*

Table 8 shows the model's estimates for other services. As we can see, among the factors relating to knowledge, only internal R&D expenses and cooperation are significant. On the other hand, external R&D expenses are not significant. With regard to the sign, we can say that an increase in internal or external R&D expenses reduces the probability of not imitating/innovating, yet increases the probability of either imitating or innovating. And an increase in cooperation increases the probability of not imitating or innovating, and decreases the probability of imitating and, above all, of innovating.

Table 8: Ordered probit estimation of the factors that determine R&D strategy (Other services)					
	Model		**Marginal effects for the model**		
	Coefficients	**Standard deviation**	**Does not imitate/innovate**	**Imitates**	**Innovates**
Factors related to knowledge					
Internal R&D	11.1000**	5.0800	-4.7000	1.5200	2.5400
External R&D	5.8100	17.5000	-2.1300	0.7980	1.3300
Cooperation	-0.3976***	0.1252	0.1450	-0.0537	-0.0914
Absorptive capacity I (External factors)					
MARKINF	-0.1088	0.0687	0.0399	-0.0149	-0.0250
PUBLINF	-0.1940**	0.0866	0.0711	-0.0266	-0.0445
OTHERS	-0.0440	0.0887	0.0161	-0.0060	-0.0101
Absorptive capacity II (Internal factors)					
INTHAMP	-0.1638*	0.0893	0.0601	-0.0225	-0.0376
Distance-related factors					
Distance	0.2717**	0.1439	-0.0996	0.0373	0.0623
Firm characteristics					
Size	0.0512	0.0368	-0.0188	0.0070	0.0117
Investment	2.7800***	1.0600	-1.0200	0.3820	0.6438
Group	0.0851	0.1462	-0.0311	0.0117	0.0194
Share Market	-0.2478**	0.1106	0.0909	-0.0340	-0.0569
Age	-0.0023	0.0017	0.0009	0.0003	-0.0005
Sectorial dummies	Yes				
Time dummies	Yes				
Number observations	403				
Source: PITEC *Notes: Internal R&D, External R&D and Investment in euros per employee and size in employees.* ****Significant at 1%; **significant at 5%; *significant at 10%*					

We can also see that among the external factors relating to absorptive capacity, the only significant one is information from public institutions (PUBLIC). Meanwhile, the internal factors (INTERNAL) are significant. Table 8 also shows that if we reduce the importance of information from the market (MARKET), public institutions (PUBLIC) and other possible sources of information (OTHERS), such as conferences, etc., then there is an increase in the probability that the firm will not imitate/innovate, while there is a decrease in the probability of the firm imitating and, above all, a decrease in the probability of it innovating. We find the same situation if we reduce the difficulty in finding qualified personnel, etc. (INTERNAL). Our understanding is that in this case the qualified personnel factor is not important for the firm to innovate.

As in the case of other services, the distance of a firm from the technological frontier is also significant. Moreover, according to Table 8, the closer a firm gets to the frontier, the more the probability decreases of it imitating/innovating, while the probability of it either imitating or innovating increases. This probability is higher in the case of innovation. This finding is similar to that of the manufacturing firms.

In relation to the firm's characteristics, we can say that as in the case of the manufacturing firms, the larger firms are those that have a greater propensity to innovate. We also noted that the firms that invest the most and those that group together the most also have this propensity. However, among the firms with a larger market share and the mature firms we did not find a direct relationship with the propensity to innovate.

6. Conclusions

The preceding literature illustrates the role of the firm's absorptive capacity when designing innovative strategies; similarly, various studies show us that the firm's relative position to the technological frontier is a key factor in whether the firm opts for one strategy or another. This work integrates in the same analysis the two approaches to reach a series of relevant results from a microeconomic perspective. The results classified the activities into four groups depending on technology intensity, and from this we derived a series of very interesting stylized facts.

The empirical results for the four industrial clusters show that factors associated with external absorptive capacity (information from the markets, public institutions or other possible sources) determine whether firms which come across barriers to accessing external information reduce their capacity to innovate. Similarly, the results from using the variable of barriers to recruiting qualified personnel, proxy to internal absorptive capacity, indicate that manufacturing firms and knowledge-intensive service firms with greater difficulties in recruiting specialist personnel experience a lower capacity to innovate.

With regard to the distance from the technological frontier, we found that this was significant for all firm types, regardless of their sector. In the case of manufacturing and other service firms, we found that the firms which were closest to the technological frontier had the highest probability of innovating. In other words, firms closest to the frontier tend to innovate more often than firms further away. However, in the case of knowledge-intensive services, the value of this parameter adopts a different sign than one might expect. In other words, knowledge-intensive service firms that have a lower initial relative productivity are not subject to the series of limitations that would discourage their commitment to innovation.

These results suggest that innovation and imitation are related to the absorptive capacity of a firm and its distance from the technological frontier, and that it is important to distinguish between manufacturing and service firms and also their technology intensity, as not every sector performs in the same way.

The empirical evidence obtained is of great interest when it comes to the evaluation and subsequent design of public policies geared towards promoting technology and technological change. These results are even more relevant in countries such as Spain where, in the current economic situation, firms are being forced to undertake offer strategies that lead to improving the level of productivity and making a firm commitment to R&D and innovation. It is therefore necessary to design different public policies geared towards fostering corporate innovation for different sectors according to the absorptive capacity of firms and their position with respect to the technological frontier.

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