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TECHNOLOGIES IN SPANISH MANUFACTURING FIRMS**

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FIRM BOUNDARIES AND INVESTMENTS IN INFORMATION TECHNOLOGIES IN SPANISH MANUFACTURING FIRMS

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Abstract

The objective of this paper is to analyse the relationship between information processing needs and capabilities. We explore the consequences of variations in the vertical and horizontal boundaries of the firm on investments in information technologies. Contrarily to the existing literature, which postulates that less vertical integration implies more investments in information technologies, we argue that concurrent sourcing increases the likelihood of investing in the stock of information technologies. We also maintain that the type of technology analysed has to be taken into account when relating it to firm limits. In particular, we show that beyond-firm technologies are positively related with outsourcing, but diversification only has an influence on the technologies that are used internally. Our hypotheses are tested on a panel of Spanish manufacturing firms, offering general support to our arguments.

Keywords: vertical integration, horizontal boundaries, information processing needs, technology adoption, manufacturing.

JEL classification: O33, M15.

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1.- Introduction

The literature on management relates the information processing needs of firms and their information processing capabilities. From the works of Galbraith (1974) and Tushman and Nadler (1978) different papers have used this framework to determine the optimal design of organizations. The basic idea is that organizations are information processing systems that must cope with different degrees of uncertainty (Tushman and Nadler, 1978). The sources of uncertainty that organizations are facing may be internal or external and they critically determine the amount and the type of information processing mechanisms that an organization needs to develop. Therefore, under this perspective the optimal design for organizations is based on the concept of fit.

The application of the information processing needs-capabilities framework is far from being limited to the understanding of firm structure. Given that the information processing needs and capabilities of firms are partially dependent on the investments that firms perform in information technologies, a natural extension of this framework is their study. Our objective in this paper is to examine whether firm boundaries are related to investments in information technologies through the unbalance that they may create within organizations. In our model, the information processing needs and capabilities of firms are determined by their vertical and horizontal limits. The degree of vertical and horizontal integration is critical when understanding the needs of firms to communicate with external providers of resources and the cost of coordinating the activities performed inside and outside the firm.

The arguments that we use in this paper can be mainly divided into two groups. First, we take advantage of recent developments on concurrent sourcing (Parmigiani, 2007; Puranam, Gulati and Battacharya, forthcoming) to argue that investments in technologies used for managing internal transactions do not reach their maximum when firms are vertically desintegrated, as the literature has argued (Dewan, Michael and Min, 1998). Contrarily, we maintain that the obtention of the complementarity advantages generated by concurrent sourcing (Puranam et al., forthcoming) create the highest level of information processing needs. Therefore, firms following this strategy require more internal investments in information technologies to combine internal and external flows of information, than firms that are either vertically integrated or desintegrated.

Second, extant research seems to assume a direct relationship between the boundaries of the firm and investments in the stock of new technologies. This omits the fact that the gap between information processing needs and capabilities may have different characteristics and may require different technologies to be closed. A particularly useful distinction is that of in-firm and beyond-firm technologies (Powell and Dent-Micallef, 1998). The first type includes those technologies that are used within the firm, whereas the second group consists of technologies that are used for managing interorganizational relationships. With this distinction in mind, we show that whereas investments in in-firm technologies are related to both the vertical and horizontal limits of the organization, this does not happen regarding beyond-firm technologies. The reason is that modifications in the vertical boundaries of the firm may potentially reduce its size, making the relationship between internal and external activities necessary. This increase in the interrelations between the firm and the market is not evident in the case of diversification or refocusing and, therefore, it does not necessarily motivate the adoption of beyond-firm technologies. Diversification, however, increases the variety of tasks that the firm is involved in and, consequently, increases the need to invest in information technologies that are used to manage internal flows of information. We also argue that this effect is specially important for firms that present higher degrees of related diversification, provided that the main benefits of this strategy stem from the tight coordination of close activities that generate synergies. Firms that engage in related diversification present a higher inter-unit task interdependence and have to compensate for the higher uncertainty that subunits face. Therefore, the fact that coordination costs are higher in firms with related diversification explain why they should have a higher stock of in-firm technologies.

To test our hypotheses we have chosen a representative sample of manufacturing firms operating in Spain. The data collected provides us with information on the horizontal and vertical boundaries of around 2,000 organizations that are followed over time. In our model, these two dimensions determine the information processing needs and capabilities of organizations. The sample also includes information on the investments that firms perform in information technologies (in-firm technologies) and on the adoption of certain types of technologies that are mainly used for interorganizational communication (beyond-firm technologies). These data are used as a measure of the information processing capabilities of organizations. Provided the

different nature of the data on information technologies, we perform separate analysis. On the one hand, we estimate the total investment that firms incur in information processing equipment and relate it with both concurrent sourcing and diversification. The censored nature of the dependent variable makes the use of a Tobit model necessary. On the other hand, we test the relationship between outsourcing and diversification, and the use of beyond-firm technologies. We expect to find that those firms that outsource more (i.e., with lower information processing capabilities) are more likely to be using interorganizational communication technologies. As explained above, diversification should not show any significant relationship with technology adoption in this case. The use of a multivariate probit allows us to analyse the information available on several technologies in an integrated way.

This paper contributes to the literature in two ways. First, we explain the investments in information technologies as a function of the vertical and horizontal limits of the firm. In doing so, we differentiate ourselves from similar papers that have tackled the relationship between firm boundaries and investments in information technology (see, for example, Dewan et al., 1998). On the one hand, extant research has considered the two extreme forms that firms use to organize transactions in the vertical chain, the market and the hierarchy. This has led researchers to posit that the relationship between vertical integration and information technology investments is negative (see, for example, Dewan et al., 1998). However, we argue that the reasoning leading to that conclusion omits the existence of an intermediate form that combines these two, namely, concurrent sourcing. Recent research (Parmigiani, 2007, p. 304) has shown that concurrent sourcing cannot be understood just as a middle point in the continuum between making and buying, but as a independent discrete choice. This suggests that this intermediate form of governance has its own characteristics and its own costs, being them not just a function of the percentage of vertical integration achieved. This idea leads us to develop a rationale for the existence of an inverted U-shaped relationship between vertical integration/outsourcing and the stock of investments in information technologies, which is tested in the paper.

On the other hand, we show that the assumption that diversification is always related to investments in *all* the types of new technologies may be erroneous. When firms diversify they increase their internal information processing needs, which makes them to invest in the stock of information technologies that are use to manage *internal*

tasks. However, this does not necessarily mean an increasing need of those technologies that are used for managing interorganizational relationships. We show that this is the case when considering investments in beyond firm technologies. Finally, in our analyses we control for the impact that other factors, as the stability of the market or the modifications in the products that the firm sells, may have on the amount of information that the firm needs to process.

Second, we provide additional evidence on the relationship between firm boundaries and investments in information technology. This evidence is much needed, given the conflicting results that are present in existing research. For example, regarding the vertical dimension, some empirical studies have found that the speed of adoption of new technologies is lower for non-vertically integrated firms (see, for example, Forman and Gron, 2011, and Gertner and Stillman, 2001). These findings are not only at odds with the postulates of the framework used here, but also with the prevailing view that developments in information technologies have allowed firms to reduce their limits (Forman and Goldfarb, 2006). An explanation to these results may be that they focus on single industries (Forman and Goldfarb, 2006). By choosing a sample integrated by firms operating in different markets we are able to check whether this is the reason for the inconsistency. Apart from this, we are not aware of any paper testing the possibility that concurrent sourcing may be the option that uses information more intensively.

The rest of the paper is structured as follows. The following section starts by presenting the information processing needs-capabilities framework. We then move into the development of the four hypotheses that are subsequently tested. Section three describes the model, the data, the variables and the methodology that is used to test them. Section four presents the results and relates them to the existing empirical evidence. The final section concludes and discusses the major implications of this paper.

2.- A framework for understanding information processing needs and information processing capabilities

Our main argument in this paper is that we can use the information processing needs-capabilities framework in order to understand the investments that firm perform in new technology. Under this framework, organizations are understood as information processing systems (Tushman and Nadler, 1978). The amount of information that a firm has to process depends on the external and internal sources of uncertainty that it has to

confront. Externally, an organization has to cope with the unpredictability that surrounds the obtention of inputs, the use of the technology or the changes in the tastes of consumers, to name just a few. Internally, the firm has to be effective at solving the coordination problems imposed by the division of labor and the different challenges associated to the activities that it has to perform. As Tushman and Nadler (1978), we consider that this uncertainty depends on three factors: (1) the characteristics of the tasks that the firm has to perform, specially whether the task is simple and rutinary or not, (2) the predictability of the environment in which each of the units develop their activities and (3) the interdependence between the different tasks. More complex, less rutinary activities that are surrounded by a changing environment and that need to be tightly coordinated generate higher information processing needs.

The information processing needs of an organization have to be matched by its information processing capabilities (Tushman and Nadler, 1978; Benasou and Venkatraman, 1995). These capabilities are mainly determined by two factors. First, the organizational structure of the firm, that has the role of collecting environmental information and processing the internal data that is necessary for performing the activities. Second, the investments of firms in information technologies (Benasou and Venkatraman, 1995), on which we focus on this paper. The information processing capabilities of firms increase with the adoption of information technologies that help the firm to collect and manage the information required for producing and selling its products and services.

In this paper, we view investments in information technologies as a way to correct the unbalance between the information processing needs and capabilities of firms. In our model, the need to invest in information technologies is related to the horizontal and vertical boundaries of firms. The choice of the products and the customers to whom the firm will offer these products is one of the main decisions that managers have to take. This choice results in the delineation of the vertical and horizontal limits of the firm: the vertical scope is determined by the number of activities that are made in-house, whereas the horizontal scope is determined by its line of products.

Both the vertical and the horizontal limits of the firm are critical at understanding the information processing-needs and capabilities of firms. First, we propose that the simultaneous use of the market and the hierarchy (i.e., concurrent sourcing), increases the incentives of firms to invest in the stock of information technologies. This is due to

complexities introduced by the need to produce an integrated management of both sources (Mols et al., forthcoming; Parmigiani, 2007). We also argue that firms that outsource a higher proportion of their transactions have a higher need of investing in interorganizational communication technologies. The reason is that not using a firm's organizational structure to govern the transactions lowers its information processing capabilities. Second, we maintain that diversification increases the information processing needs of firms by augmenting the complexity and the variety of the tasks performed and coordination costs. However, diversification should not be necessarily related to the adoption of technologies that are used for interorganizational communication, given that they do not contribute to the processing of internal information.

2.1. Outsourcing, information processing needs and investments in technology

The literature has traditionally argued that vertical integration leads firms to invest less in information technologies (see, for example, Dewan et al., 1998). In this section we add two qualifications to this hypothesis in order to build a more nuanced and realistic assessment of the relationship. In order to do this, we first focus on the increasing information processing needs that the use of concurrent sourcing imposes on firms, and analyse the incentives to invest in in-firm technologies. Then, we move into the consideration of the reduction of organizational structure that takes place when firms vertically desintegrate and analyse the consequences in terms of the need to adopt beyond-firm technologies to manage external links.

On the one hand, the literature on information systems has maintained that the way in which firms govern transactions may affect the intrafirm information processing needs and capabilities, determining a firm investment in information technologies. The forms of governance traditionally analysed have been the market and the hierarchy. However, the literature on management has recently focused on the analysis of situations in which firms use a combination of both¹. This is what the literature has termed as concurrent sourcing and, in our view, its consideration in the context of in-

¹ Bradach and Eccles (1989) use the term “plural governance forms” and they take place when “distinct organizational control mechanisms operate simultaneously for the same function by the same firm”. Other studies have reflected the existence of the simultaneous use of the market and the hierarchy under different names such as “tapered integration” (Harrigan, 1986), plural governance (Heide, 2003) or concurrent sourcing (Parmigiani, 2007).

firm information technology investments has clear implications on the relationship that we are analysing.

To understand why concurrent sourcing may increase the information processing needs of the firm more than the use of the other two extremes, we have to analyse its advantages (Puranam et al., forthcoming; Mols et al., forthcoming). The preference of firms for the use of concurrent sourcing may be mainly explained in terms of (1) incentive and (2) knowledge complementarities. On the one hand, incentive complementarities are due to the competition that the simultaneous use of both sources may create between external and internal suppliers. First, the use of internal sources produces a credible threat on external suppliers that the firm may integrate backwards. Second, when firms produce internally, they collect information that may be used for controlling and monitoring external providers. The information may be also used to discipline the activities that are developed internally and for performance evaluations (Mols et al., forthcoming). On the other hand, knowledge complementarities are created through the combination of the external knowledge on the resources and capabilities of suppliers with the one that the firm possesses. This complementarity arises thanks to collaboration of suppliers and the firm. For example, the plural form provides the firm with a more complete knowledge on the state of the technology, given that it potentially relates the firm with a diverse set of suppliers (Mols et al., forthcoming).

All of these advantages are based on the intensive use of internal and external information, and on their combination. In the words of our theoretical model, they create interdependencies between the internal and the external activities. When firms use concurrent sourcing a complex management process emerges, given that both governing systems must be managed simultaneously (Mols et al., forthcoming; Parmigiani, 2007). In fact, the increased complexity that arises through the combination of two distinct forms of governance is recognised as one of the main costs of plural sourcing (Mols et al., forthcoming, p. 10). This complexity results in higher information processing needs than those stemming from using only the market (and certainly, and we concur in this with the literature, from using the hierarchy).

Therefore, the advantages of concurrent sourcing in reducing information asymmetries (Heide, 2003) and learning from the combination of internal and external sources of knowledge increases the information processing needs of firms above those of the two competing forms of governance. We do not have any prediction of the

amount of outsourcing that should be necessary to produce the maximum incentives for investing in in-firm technology. However, it seems sensible to expect that both the market and the hierarchy should be important in order to generate enough complexity in the managing process. Therefore, our first hypothesis maintains that:

Hypothesis 1. Outsourcing has an U-inverted influence on investments in in-firm information technologies, such as that firms with a moderate use of concurrent sourcing are the ones with the highest stock

On the other hand, to our knowledge the literature has generally considered investments in information processing capabilities, without taking into account the different types of technologies that firms may adopt. However, the distinction between technologies that are used within firms (in-firm technologies) and those used beyond their limits (beyond-firm technologies) seems important. It is important because the relationship between the boundaries of the firm and the adoption of the different technologies available in the market may be different. In particular, we argue that outsourcing is unequivocally and positively related to the adoption of beyond-firm technologies. As argued below, this relationship is specific of the vertical limits of the firm and we do not have any reason to suspect that beyond-firm technologies should also be related to the horizontal boundaries of organizations.

To understand the positive relationship between outsourcing and the adoption of beyond-firm technologies we focus our attention on the organizational structure of firms or, in other terms, the type of subunit structure that a firm uses in order to cope with the uncertainty of the environment (Tushman and Nadler, 1978). As mentioned above, the organizational structure has the role of collecting environmental information and processing the internal data that is necessary for performing the activities. Researchers have offered arguments in favor of the proposition that different organizational structures have different capacities for effective information processing (Tushman and Nadler, 1978). However, we are interested in the reduction of information processing capabilities that the firm experiences when it reduces its vertical limits. In particular, our main argument is that the absence of an organizational structure reduces the information capabilities of firms. This creates an unbalance between information processing needs and capabilities that has to be corrected through the use of certain information technologies, specifically, the ones that serve to establish

interorganizational links between the firm and the stages of the vertical chain that are performed externally.

For our purposes, a firm can manage the production process of a given product internally or it can outsource a given proportion of it. If the full production process is performed internally, the firm benefits from the information processing capabilities that are provided by its organizational structure. More precisely, they benefit from different mechanisms such as rules and procedures, task forces, teams, integrating roles or liaison roles (Galbraith, 1978 and Thusman and Nadler, 1978) that provide the firm with the necessary infrastructure to manage the transaction.

The situation just described is very different when a firm decides to externalize all or, at least, a part of the activities. The absence of an organizational structure means that the organization is not able to use intraorganizational mechanisms in order to manage a given transaction. Thus, processing capabilities may be improved through the use of other mechanisms, such as investments in information technologies (Bensaou and Venkatraman, 1995, pp.1475). Investments in information technologies may be useful for the firm both before and after the transaction takes place, improving the communication and helping in the coordination of the interorganizational activities. For example, they may be used to coordinate all the activities related to searching, communicating and establishing contracts between agents (Malone, Yates and Benjamin, 1987; Clemons, Reddi and Row, 1993). Additionally, they improve the ability of firms to perform other tasks that take place after this and that have to do with ordering, billing, making transportation arrangements or confirming payments (Wang and Benaroch, 2004; Lucking-Reiley and Spulber, 2001).

The coordination advantages described above are not only obtained thanks to the establishment of links through which firms exchange information about different variables such as price, quality, or delivery conditions (Malone et al., 1987; Clemons et al., 1993), but also because these technologies reduce the complexities, and thus the costs, associated with communication and coordination between firms. Information technology facilitates the specification of the characteristics of the externalised production in a language that is understandable for all parties (Blois, 1986). This reduction of complexity is obtained thanks to the codification of information and to formalization (Argyres, 1999), which makes it easier the transference of knowledge and of the details of the transaction between organizations. Another important advantage of

codified information is that it facilitates the management of inter-firm dependences and the right combination of the externalized activities with those that are performed in house (Bardhan, Whitaker and Mithas, 2006). Codification is important because it helps reducing coordination costs by limiting the independence of suppliers and by minimizing the number of errors (Atallah, 2002). This, in turn, makes quality controls technologically feasible (Blois, 1986) and allow to adress incentive and cognitive conflicts (Mani et al., 2010).²

In summary, our second hypothesis reflects the fact that organizational structure and interorganizational communication technologies are, at least within the information processing needs and capabilities framework, substitutes.

Hypothesis 2. Firms that outsource production at a higher extent of are more likely to invest in beyond-firm information technologies than those firms that outsource less

2.2. Diversification, information processing needs and investments in technology

The diversification level of a firm accounts for the extent to which it simultaneously operates in distinct lines of business. Through diversification, firms can take out excess capacity in resources or production factors, which can not be sold efficiently in the market (Dewan et al., 1998). Despite economic benefits stemming from the sharing of these resources between different lines of business, diversification increases internal coordination requirements and, consequently, its information processing needs. Diversification not only increases internal coordination costs because of the coordination of the resources between different lines of business, but also because the need to manage more activities within more complex structures. However, diversification has little effect on external coordination costs. In this sense, through diversification the firm increases firm activities and, unlike vertical integration, there is no need to obtain the product in the market (Hitt, 1999; Dewan et al., 1998). Hence, diversification increases internal coordination requirements, but it has little effect on the external ones. To account for the increase in information processing needs diversified firms demand information technologies investments as a way to increase their information processing capabilities and reducing internal coordination costs (Hitt 1999;

² Incentive conflict assumes the existence of possible opportunistic behaviour. This conflict affect firms' motivation to process information accurately. Cognitive conflicts assumes the lack of a common communication language and therefore, the lack of a shared understanding.

Dewan et al., 1998; Gurbaxani and Whang 1991). Contrarily to the second hypothesis and similarly to the first, in this case we focus on in-firm information technology investments, given that they can be used to coordinate the different activities that it performs. Therefore, our third hypothesis can be written as follows:

Hypothesis 3. More diversified firms are more likely to invest in in-firm information technologies that facilitate intrafirm coordination

The distinction between related and unrelated diversification is also helpful for understanding the information processing needs of firms. To understand the difference that may arise, we have to clarify the nature of the economic benefits that firms obtain with both types of diversification. When firms engage in related diversification they seek to obtain economic benefits through the sharing of resources between related lines of business. However, the benefits of unrelated diversification mainly stem from the exploitation of internal capital markets (Hill, 1988; Hill and Hoskisson, 1987; Teece, 1982). In other words, the information processing needs created by related diversification are much more important than the ones of unrelated diversification and, therefore, the importance of increasing the information capabilities of firms is also different. When the type of diversification is related, firms use investments in in-firm information technologies to coordinate different lines of business, obtaining economies of scope as the coordination and control of sharing resources between different lines of business improve (Tanriverdi, 2006; Clemons and Row, 1991). However, the benefits of unrelated diversification stem from sharing financial resources in business units that are not related to each other. That is, the sharing of resources in related diversification creates more interdependences within firms and therefore, more needs to coordinate than unrelated diversification (Shin, 2006; Hitt, 1999; Dewan et al., 1998; Hill and Hoskisson, 1987). Due to the reduction in coordination costs achieved through information technologies investments and the greater need to reduce the costs of interdependences in related diversification firms, the demand for in-firm information technologies investments should be greater in those firms with a relatedly diversified strategy (Hitt, 1999; Dewan et al., 1998).

Hypothesis 4. Those firms with related diversification are more likely to invest in in-firm information technologies that facilitate intrafirm coordination than the ones with unrelated diversification

Regarding the relationship between a firm horizontal boundaries and investments in interorganizational communication technologies, whereas diversification increases the likelihood of investing in information technologies that facilitate intrafirm coordination, we do not expect them to be related to the use of technologies that are conceived for external communication (beyond-firm). The reason is that, in this case, diversification is not unambiguously related with an increase in the interorganizational information processing needs or a reduction in the interorganizational information processing capabilities of firms. In other words, firm boundaries are expected to be related to investments in information technologies. However, the types of investments taken into account should be considered at the time of understanding the relationship between them. Although econometric theory precludes us from enunciating a hypothesis in which we expect no causal relationship, we control for diversification in the model that explains the adoption of interorganizational communication technologies.

3.- Empirical Analysis

3.1. Sample description

The data set used in the empirical analysis is the Survey of Business Strategies (ESEE), which is conducted by the Spanish Ministry of Industry since 1990. This data source provides information about firms' characteristics and strategies belonging to the Spanish manufacturing sector. Although the survey is not specific for studying investments in information technologies, the questionnaire includes a set of questions regarding (1) the use of several technologies that facilitate interorganizational transactions (beyond-firm technologies) and the (2) investments that the firm performs in information processing technologies (in-firm technologies).

In order to test our hypotheses we have performed two analysis. The first one helps us testing Hypotheses 1, 3 and 4. Given that these hypotheses are based on internal coordination costs we have calculated an indicator that picks up the investments in in-firm technologies that help to manage them. This indicator is the stock of information technology, which is based on both the firm's investments in information processing equipments and the external expenses in information technology training. Combining this information we calculate the stock in information technologies using the perpetual inventory method for the first component (information processing equipment)

and a three year capitalized valued for the training expenses. In order to homogenise the time reference of the two analyses we have calculated this variable in the years 2002 and 2006. For this analysis we have an incomplete panel of 2,480 firms and 3,576 observations. The sample size for this analysis is different than the second one mainly due to the need for available data that the calculation of the perpetual inventory method requires.

The second analysis allows us to test hypothesis 2. It maintains that outsourcing reduces the use of the hierarchy, weakening the information processing capabilities of firms and increasing the need to use beyond-firm technologies. The data also offers information on the use of ebusiness. More precisely, the questionnaire includes information about the use of supplier to business (S2B), business to business (B2B) and business to consumer technologies (B2C). From this set of technologies we choose those that facilitate interorganizational communication, namely, S2B and B2B. The data set also provides information on the use of Computer Aided Design (CAD).³ The use of CAD is justified by the fact that they improve the codification and the formalization of the transactions that are developed with other organizations. Following Hypothesis 2, we cannot expect that B2C is explained by vertical integration, given that this technology is designed to communicate with consumers and it is not related to the outsourcing practices of firms. However, it may offer a reference point to be compared with the results obtained for the other ebusiness technologies. Taking into account all these four technologies means that our analysis is limited to the years 2002 and 2006 and to an incomplete panel of 2,520 firms and 3,624 observations.

3.2. Variable description and Measurements

Dependent variables

Investments in in-firm information technology stock. The measure of information technology stock combines investments in information processing equipment with a capitalized value of information technology expenses and it is used to test Hypotheses

³ Although CAD could be understood as an in-firm technology, some authors (see for example Blois, 1986) have also considered that this technology can also be used to standardize interorganizational communication.

1, 3 and 4. Among these expenses we consider the ones in computer and information technology training.

The stock of investments in information processing equipment has been used because it seems a more stable and suitable indicator than the annual information technology investment, which is more sensitive to short-term fluctuations in firm performance. It has been constructed using the perpetual inventory method, using with the investments in information processing equipment (IPE_t) from 1994 to 2006. In accordance with Linchtenber (1995), the annual depreciation rate (δ) is assumed to be 15% and in order to approximate the first year value a presample growth rate of 5% has been considered.

Regarding, the capitalized value of information technologies training, we follow Dewan and Kraemer (2000), Dewan et al. (1998) and Dewan and Min (1997), by assuming that computer and information technology training (T) create an asset whose service life is three years. Therefore, we have calculated a three year capitalization of computer and information technology training using a depreciation rate, δ_1 , of 33%. The combination of both dimensions, the stock of investments in information processing equipment and the three year capitalized valued of information technologies training, is obtained through the following specification of information technologies stock:

$$IT_t = (1 - \delta) * IT_{t-1} + IPE_t + \sum_{k=0}^2 (1 - \delta_1)^k * T_{t-k}$$

We take the natural logarithm of this variable as the final measure of the stock of IT.

Investments in beyond firm technologies. As explained above, for testing Hypothesis 2 we have considered four technologies. Two of them are necessary to perform supplier and interfirm transactions, i.e., supplier to business and business to business. Along with these technologies, we also consider one technology that facilitates supplier transactions (CAD) and an ebusiness technology that is not clearly related to the outsourcing of production that we are studying (B2C). We codify the use of these technologies through four dummy variables that take a value of 1 if the firm uses the technology, and zero otherwise.

Independent variables

Vertical integration. We use the percentage of finished products or tailored components manufactured by a third-party over total purchases as a proxy of the firm's vertical integration. This measure indicates the importance of production externalization and out of the four dimensions of vertical integration established by Harrigan (1986), it makes reference to the breadth of the production stage.

Diversification. To clarify whether there are differences in the use of information technology between firms with different degrees of diversification we use a dummy variable that takes the value one when the firm is not diversified. Similarly, in order to analyse the differences in the use of information technologies that depend on the type of diversification, i.e. related and unrelated, we use a dummy variable that identifies the firms with unrelated diversification.

Control Variables

The models that we estimate also include a set of control variables affecting the decision to adopt a given technology and the total investments that the firm performs. Along with some variables affecting the information processing needs or capabilities, the model includes other variables directly related to the adoption of technology, according to diffusion theory.

Diversification/Vertical integration. We include diversification and vertical integration as a control variable in both analysis. The argument that supports their inclusion is that, given the limited coordination capacity of firms, both dimensions could be conceived as substitutive (Zhou, 2011). For example, the firm could outsource activities in order to free up coordination capacity to carry out other activities such as diversification.

Market stability. As commented, predictability of the environment is one factor to take into account when the information processing needs are being analyzed. Those activities developed in instable markets generate higher information processing needs (Premkumar, Ramamurthy and Saunders, 2005) and, as a consequence, they can increase the need to invest in all the types of information processing equipment. To control for this effect we have included a dummy variable taking the value 1 when all the markets served by the firm are characterized as stable, and zero otherwise. Therefore, we expect the sign of this variable to be negative in all the analysis.

Product stability. Information processing needs could also be affected by the characteristics of the tasks developed by the firm. In order to control for the information processing needs generated by the activities whose description varies over time we have included a dummy variable that takes a value of 1 when the firm does not change its product offering, and zero otherwise. We expect this variable to have a negative and significant sign in all the estimations.

Business group. The corporate status of the firm, that is, whether the firm is part or not of a larger business group, could also affect the likelihood of investing in information technologies. Baptista (2000) argues that the effect of this variable could be ambiguous. On one hand, independent firms could have a higher flexibility, which favours adoption. On the other hand, firms belonging to a business group could have a better access to financial resources and benefit from information sharing among group members, experiencing less uncertainty. To control for this effect, we include a dummy variable that takes a value of 1 when the firm belongs to a larger business group, and zero otherwise.

Foreign capital. This variable indicates the possession of a part of the capital by foreign investors. The inclusion of this variable is justified by the fact that foreign parent companies often transfer new technology to domestic affiliates (Hollestein and Woerter, 2008). We include a dummy variable taking a value of 1 if the presence of foreign capital in the focal firm is higher than 30%, and zero otherwise. This threshold has been used by other empirical studies studying manufacturing firms (see, Merino and Salas, 1995, 1996).

Export intensity. The literature on the diffusion of new technologies suggests the importance of taking into account the presence of the firm in international markets when the adoption of technologies is analyzed. Export-oriented firms use information technologies mainly to find information about the latest market trends and for the coordination of activities with foreign partners (Lal, 1999, 2002). They may also invest in information technologies to confront the higher levels of competition that are present in international markets. Therefore, we expect a positive relationship between a firm's export orientation and information technologies adoption. Export intensity is measured by the ratio of total exports to sales.

Firm size. Previous studies that analyse the diffusion of innovations have related the size of the firm and the adoption of new technologies. These studies establish a

positive relationship between the two variables, offering reasons such as the possibilities to obtain economies of scale or the improved access to resources achieved by large firms (Astebro, 2002; Karshernas and Stoneman, 1993; Romeo, 1975). Regarding information technologies adoption, Battisti, Canepa and Stoneman (2009) argue that this variable could pick up several firm characteristics that justify the positive relationship between size and information technologies adoption. These characteristics include efficiency, management abilities, past innovations or variations in the costs of acquiring the new technology, and scale economies. Size is measured by the number of employees working for a given firm (in thousands) and according to previous literature (Battisti et al., 2009; Hollestein and Woerter, 2008; Hollestein, 2004; Bertschek and Fryges, 2002) we expect a positive sign on the accompanying coefficient.

R&D intensity. This variable is included to recognize the influence of absorptive capacity in increasing the likelihood of adopting new technologies. The inclusion of this variable accounts for the fact that the likelihood of adopting new technology not only depends on the amount of available information but also on a firm's ability to assimilate and apply it to commercial ends (Cohen and Levinthal, 1990). Therefore, we consider that those firms that present higher ratio of R&D expending to sales have a higher capacity to value information and they are more likely to invest in technology.

Market Concentration. Market structure has been traditionally linked to the degree of innovation and to the incentives of firms to invest in a given technology. However, the direction of its influence has been ambiguous in most of the cases (Reinganum, 1981). We build a concentration measure that uses the market shares of the four largest firms in every industry to construct a concentration ratio (CR₄).

Industry variables. Other industry features, apart from market concentration, could also affect the likelihood of adopting a given technology. To control for them, we include 19 dummy variables in order to capture the differences between the 20 industries identified in the survey.

Time variables. In order to control for the higher likelihood of adoption that may be induced by the learning-by-contact process, i.e. epidemic effect, we also include a dummy variable that takes the value 1 in 2002. This variable also picks up any other temporal effect related to the investments in technology.

Tables 1 and 2 offer some descriptive statistics and correlations on the variables of interest for both the samples used in the first and second analysis.

		S2B			B2B			B2C			CAD		
		Mean		z	Mean		z	Mean		z	Mean		z
		Yes	No		Yes	No		Yes	No		Yes	No	
		760	2864		285	3339		190	3434		1388	2236	
P. Externalization		11.189	8.063	-6.075***	11.812	8.455	-3.327***	11.902	8.543	-2.417**	11.897	6.746	-12.943***
Export propensity		0.253	0.173	-10.885***	0.271	0.183	-7.781***	0.219	0.188	-2.702***	0.251	0.152	-12.868***
Firm size		0.318	0.195	-11.251***	0.491	0.197	-11.321***	0.390	0.211	-5.265***	0.306	0.168	-13.551***
M. Concentration		40.847	39.919	-1.299	41.066	40.032	-1.858*	40.915	40.070	-1.394	40.320	39.974	-1.204
R&D intensity		0.012	0.005	-13.518***	0.010	0.007	-8.147***	0.011	0.007	-4.492***	0.011	0.004	-14.619***
		S2B			B2B			B2C			CAD		
		Yes	No	χ^2	Yes	No	χ^2	Yes	No	χ^2	Yes	No	χ^2
Market Stability	Yes	330	1509	20.444***	124	1715	6.480**	85	1754	2.896*	638	1201	20.561***
	No	429	1354		161	1624		105	1680		750	1035	
Product Stability	Yes	559	2314	19.182***	211	2662	5.174**	146	2727	0.724	1003	1870	67.381***
	No	201	550		74	677		44	707		385	366	
Business group	Yes	345	946	40.036***	163	1128	62.752***	86	1205	8.124***	603	688	59.990***
	No	415	1918		122	2211		104	2229		785	1548	
Foreign capital	Yes	170	476	13.549***	97	549	55.485***	46	600	5.581***	310	336	31.219***
	No	590	2388		188	2790		144	2834		1078	1900	
No Diversification	Yes	645	2548	9.626***	248	2945	0.350	163	3030	1.028	1190	2003	12.081***
	No	115	316		37	394		27	404		198	233	
Unrelated Diversification	Yes	60	189	1.576	21	228	0.120	15	234	0.329	135	114	28.664***
	No	700	2675		264	3111		175	3200		1253	2122	

Table 2. Correlations between all the independent variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
P. Externalization (1)	1									
No Diversification (2)	-0.013	1								
Un. Diversification (3)	0.023	-0.739	1							
Market Stability (4)	-0.053	0.011	-0.031	1						
Product Stability (5)	-0.078	-0.009	0.002	0.083	1					
Business Group (6)	0.019	0.015	-0.020	-0.026	-0.009	1				
Foreign capital (7)	0.006	0.017	-0.046	-0.020	-0.002	0.506	1			
Export propensity (8)	0.063	-0.006	-0.006	-0.080	-0.047	0.336	0.330	1		
Firm size (9)	-0.007	-0.050	0.001	-0.007	-0.051	0.317	0.289	0.202	1	
Market Concentration (10)	-0.023	0.064	-0.021	0.008	0.0164	0.069	0.006	0.048	0.101	1
R&D intensity (11)	0.116	-0.007	0.009	-0.041	-0.077	0.147	0.106	0.184	0.160	0.059

3.3. Methodology

Provided the different nature of our dependent variables, we use two different methodologies for the independent test of Hypothesis 1, 3 and 4, on the one hand, and Hypothesis 2, on the other. The first analysis uses a tobit model in order to account for the censored nature of the investments in information technologies. Similarly, the limited nature of the adoption of new technologies suggests using a multivariate probit model to test Hypotheses 2. At the same time, it controls for the potential correlation arising between the adoption of the different technologies analysed. Both methods are briefly described in the two following subsections.

First analysis: diversification and investments in information technologies

Regarding the first analysis, and given that the variable “stock in information technologies” has a censored distribution (the lower threshold is a value of 0) a tobit regression was chosen. The general model is specified as follows (Greene, 2008):

$$\begin{aligned}y_i^* &= x_i\beta_i + \varepsilon_i \\y_i &= 0 \text{ if } y_i^* \leq 0 \\y_i &= y_i^* \text{ if } y_i^* > 0\end{aligned}$$

where y^* is a latent variable that is a function of a group of exogenous variables and, ε , the error term, which is normally distributed with mean 0 and variance σ_ε . The observed values, y , depend on the value of the latent variable for values greater than 0, and are censored at 0 otherwise.

Second analysis: vertical boundaries and the adoption of interorganization technologies

The second analysis studies the impact of production outsourcing on the adoption of three e-business technologies and computer aided design. As explained above, we use a multivariate probit model to achieve this. Its advantage is that it allows the estimation of the equations corresponding to each of the technologies at the same time. This recognizes the possibility that the adoption of all of them may not be independent. The relation between them may be justified in terms of common factors (for example, firm characteristics) affecting the propensity to adopt or by the presence of systems formed by two or more technologies. Although the model does not distinguish between the two potential sources of correlation, their existence would render a separate

estimation as inefficient. We estimate this model through the method proposed by Capellari and Jenkins (2003).

4.- Results

Table 3 shows the results of the estimation of a tobit model on the 3,576 observations available. It is used to test for Hypotheses 1, 3 and 4. The first column of table 4 present the results of the estimation of a simple model that only includes the control variables. Columns 2 and 3 present the results of a augmented model that allow us to test Hypothesis 1 and 3 (column 2) and Hypothesis 4 (column 3). All the three models are globally significant as shown by the value of the LR Chi-2. Furthermore, the analysis of the comparison of the models reveals that model 2 is preferred to models 1 and 3.

Hypothesis 1 maintained that when firms use concurrent sourcing they present higher investments in in-firm information technologies than when they use either the market or the hierarchy. This suggests a quadratic influence of product externalization on the stock of IT. The results show that product externalization has an U-inverted influence on the stock of information technologies, supporting hypothesis 1. In other words, firms with a higher degree of vertical integration and those that rely intensively in the market invest in information technologies less money than those firms that make a simultaneous use of both the market and the hierarchy. Taking model 2 as the reference, the maximum investment in information technologies takes place when firms outsource approximately a 52% of their production.

Hypothesis 3 argued that firms with higher degrees of diversification have higher information processing needs and will invest more in in-firm information technologies. Column 2 adds one additional variable, whether the firm is diversified or not, that allows us to test this. The coefficient of the variable identifying those firms with no diversification is negative and significant. This means that, as predicted by Hypothesis 2, diversified firms are more likely to use in-firm information technologies.

Finally, Hypothesis 4 argued that those firms with related diversification have higher information processing needs and will invest more in information technologies than those firms with unrelated diversification. Column 3 shows the estimation results of the augmented model that includes the variable that identifies the firms presenting

unrelated diversification. This variable has a negative and no significant sign, which indicates that the type of diversification has no effect on the use of information technology. The variable capturing whether the firm is diversified, however, maintains the significance and sign previously obtained and the one measuring product externalization still suggests the inverted U-shaped influence of outsourcing in the stock of IT.

The results of the preferred model provide us with important information about the effect of the control variables on the stock of in-firm information technologies. This model reveals that all the control variables, with the exception of market structure, have a significant effect on the use of information technology. Specifically, the results indicate that market and product stability are negatively related to investments in new technologies, as suggested by our model. They also show that those firms that have higher levels of export intensity, larger size, that belong to a business group and have foreign investors in their capital are more likely to use information technologies. All these results are consistent with our expectancies and with previous research in the literature of diffusion.

A possible drawback of our results on the relationship between the boundaries of the organization and investments in the stock of information technology is that is that the survey is not explicit on whether the latter could include the adoption of beyond-firm technologies. As argued (and tested below), these technologies should play a minor role in the case of managing a diversified corporation. Similarly, it could be maintained that these technologies could be related to the degree of vertical integration, affecting our conclusions on the relationship outsourcing-stock of in-firm information technologies. In order to address this potential shortcoming we re-estimated all the three models without including those firms that are using supplier to business, business to business and consumer to business technologies. We did not exclude the firms using CAD because this technology is not unambiguously related with one of the dimensions (vertical or horizontal).

Table 3. Tobit estimates on the investments that firms perform in information technologies

Dependent variable	IT Stock	IT Stock	IT Stock	IT Stock	IT Stock	IT Stock
No Diversification		-0.807*** (-3.57)	-0.987*** (-2.94)		-0.790*** (-2.81)	-1.057** (-2.46)
Unrelated Diversification			-0.312 (-0.73)			-0.442 (-0.82)
Production externalization	0.043*** (3.94)	0.042*** (3.83)	0.042*** (3.86)	0.055*** (4.06)	0.054*** (3.98)	0.054*** (4.00)
Production externalization²	-0.0004*** (-2.84)	-0.0004*** (-2.73)	-0.0004*** (-2.75)	-0.0007** (-3.38)	-0.0006** (-3.31)	-0.0007** (-3.34)
Market Stability	-0.539*** (-3.67)	-0.534*** (-3.64)	-0.537*** (-3.66)	-0.480** (-2.70)	-0.476** (-2.69)	-0.479** (-2.70)
Product Stability	-0.498*** (-2.70)	-0.507*** (-2.75)	-0.506*** (-2.75)	-0.481** (-2.09)	-0.489*** (-2.13)	-0.493*** (-2.14)
Year 2002	1.301*** (8.63)	1.314*** (8.73)	1.314*** (8.73)	1.449*** (8.04)	1.458*** (8.10)	1.458*** (8.10)
Integrated in a business group	2.020*** (10.79)	2.034*** (10.88)	2.039*** (10.90)	2.174*** (9.29)	2.189*** (9.37)	2.198*** (9.40)
Foreign capital	0.984*** (4.28)	1.013*** (4.42)	1.007*** (4.39)	0.919*** (3.10)	0.945*** (3.19)	0.938*** (3.17)
Export propensity	2.835*** (9.02)	2.844*** (9.06)	2.839*** (9.05)	2.844*** (7.22)	2.864*** (7.28)	2.859*** (7.26)
Firm size	1.432*** (10.03)	1.392*** (9.74)	1.386*** (9.69)	1.320*** (7.26)	1.276*** (7.01)	1.264*** (6.92)
Market concentration	0.007 (0.59)	0.007 (0.68)	0.007 (0.68)	0.006 (0.41)	0.007 (0.51)	0.007 (0.51)
R&D intensity	18.249*** (4.59)	18.440*** (4.64)	18.475*** (4.65)	25.373*** (4.52)	25.605*** (4.57)	25.640*** (4.57)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	7.296*** (10.11)	8.043*** (10.72)	8.222*** (10.41)	6.879*** (7.97)	7.601*** (8.45)	7.875*** (8.21)
No. Observations	3576	3576	3576	2683	2683	2683
Test comparison (models 2, 3 vs. 1)	---	12.72***	6.63***	---	7.92***	4.30**
Test comparison (models 3 vs. 2)	---	---	0.53	---	---	0.67
VIF (max/mean)	6.96/2.84	6.97/2.78	6.98/2.81	6.70/2.69	6.70/2.64	6.71/2.68
LR χ^2	1041.65***	1054.35***	1054.88***	761.10***	769.00***	769.68***

***, **, *: Variable statistically significant at the 1%, 5% or 10%, respectively. T-ratios in parentheses

Columns 4 to 6 present the estimations over the restricted sample. The number of observations is reduced from 3,576 to 2,683. The estimates show very similar results both for the variables of interest and for the control variables. Diversified firms invest more in in-firm information processing equipment than non-diversified firms, with the distinction between related and unrelated diversification not being relevant. The coefficients corresponding to the degree of production externalization show that the quadratic influence that was predicted is still present in the reduced sample. Finally, the impact of the control variables does not show any qualitatively important variation, confirming the stability of our results.

The second analysis that we develop was intended to show that research that considers the link between firm boundaries and investment in information technologies has to take into account the nature of the technology analysed. Therefore, we focused on beyond firm technologies, which are supposed to be related to the vertical limits of the organization, but that have no evident link with diversification decisions. Table 4 shows the results of estimating a multivariate probit model and serves to test Hypothesis 2.⁴ Therefore, it attempts to confirm that firms with a higher externalization of production are more likely to use certain information technologies. In particular, those that are used for interorganizational communication. The first four columns of Table 4 only use the control variables, whereas the four last columns introduce the variable of interest, which measures the percentage of products and components that are produced by a third party. The Wald test shows that the full model is globally significant. The results obtained confirm that the externalization of production is positively related to the adoption of three out of the four technologies analysed, namely, supplier to business, business to business and CAD. It is important to highlight that the coefficient corresponding to business to consumer is not significant, reducing the concerns that product externalization is either related to every technology or to ebusiness technologies. Similarly, it is important to take into account that this result is robust to a control for diversification. The variables measuring both the degree and the type of diversification are generally non-significant, although non-diversified firms have a lower likelihood of having adopted S2B.

Regarding the effect of the other control variables and focusing on the full models, we can observe that they do have an important role in explaining the decision to

⁴ Tables 1 and 2 offer some descriptive statistics and correlations on the variables of interest.

adopt interorganizational communication technologies. Market and product stability have a very significant and negative effect on the adoption of interorganizational technologies, as in the first analysis. In other words, as suggested by the model, an environment with lower uncertainty and a product with less changes reduces the incentives of firms to invest in beyond-firm information technologies. Apart from CAD, the diffusion process of all the three ebusiness technologies still seems to be underway, given the significance of the dummy variable that picks the epidemic effect up. The four technologies are generally responsive to the other variables that are frequently used to explain diffusion. Supplier to business is positively affected by the integration of the firm in a business group, by a higher export propensity and by investments in R&D. Business to business is positively affected by all the control variables, except for market concentration, whose coefficient is negative, and R&D intensity, which is non-significant. Business to consumer is positively affected by firm size and R&D intensity and negatively by market concentration, finding no significant impact for the rest of the variables. Finally, the adoption of CAD is explained by the integration in a business group, export propensity, firm size and R&D intensity, given that all the coefficients corresponding to these variables present a positive and significant impact.

Finally, the bottom of the Table presents the coefficients that show whether the adoption of the four technologies is related. A positive sign means either that the technologies are related or that they are explained by common factors omitted by our estimations. All the 6 coefficients are positive and very significant confirming that the adoption of one of the technologies creates an incentive to adopt the other three. The highest relationship is observed between B2B and B2C, whereas the lowest is the one that relates B2C and CAD. It is important to note that all the ebusiness technologies present higher values for the rho coefficients when the comparison is performed with another ebusiness technology, suggesting that their adoption is frequently simultaneous. In other words, the lowest coefficient is found when CAD is compared with the other three technologies.

Table 4. Multivariate probit estimates of the decision to adopt interorganizational technologies (years 2002 and 2006)

Dependent variable	S2B	B2B	B2C	CAD	S2B	B2B	B2C	CAD
Production externalization					0.003** (2.49)	0.005*** (2.92)	0.002 (1.10)	0.004*** (3.09)
No Diversification	-0.282*** (-2.67)	-0.013 (-0.09)	-0.150 (-1.01)	0.079 (0.72)	-0.285*** (-2.70)	-0.020 (-0.14)	-0.151 (-1.02)	0.079 (0.72)
Unrelated Diversification	-0.189 (-1.38)	0.064 (0.35)	-0.052 (-0.26)	0.336** (2.45)	-0.193 (-1.41)	0.060 (0.33)	-0.052 (-0.27)	0.336** (2.45)
Market Stability	-0.190*** (-3.86)	-0.142** (-2.24)	-0.154*** (-2.21)	-0.145*** (-3.14)	-0.185*** (-3.76)	-0.135** (-2.13)	-0.150*** (-2.15)	-0.140*** (-3.03)
Product Stability	-0.219*** (-3.74)	-0.160** (-2.13)	-0.089 (-1.06)	-0.386*** (-6.82)	-0.212*** (-3.61)	-0.147* (-1.96)	-0.084 (-1.01)	-0.379*** (-6.67)
Year 2002	-0.442*** (-8.49)	-0.278*** (-4.04)	-0.184*** (-2.43)	-0.044 (-0.91)	-0.441*** (-8.47)	-0.276*** (-4.00)	-0.184*** (-2.43)	-0.042 (-0.88)
Integrated in a business group	0.172*** (2.86)	0.216*** (2.81)	0.012 (0.14)	0.238*** (4.05)	0.171*** (2.83)	0.214*** (2.78)	0.011 (0.12)	0.234*** (3.97)
Foreign capital	-0.030 (-0.41)	0.225** (2.60)	0.131 (1.29)	-0.069 (-0.96)	-0.029 (-0.40)	0.228** (2.64)	0.132 (1.30)	-0.065 (-0.91)
Export propensity	0.451*** (4.52)	0.298*** (2.35)	0.087 (0.59)	0.430*** (4.39)	0.442*** (4.42)	0.291*** (2.29)	0.081 (0.55)	0.417*** (4.25)
Firm size	0.059 (1.52)	0.158*** (3.92)	0.124*** (2.62)	0.124*** (2.73)	0.061 (1.58)	0.161*** (3.98)	0.126*** (2.66)	0.128*** (2.81)
Market concentration	-0.002 (-0.47)	-0.013*** (-2.59)	-0.016*** (-2.66)	0.001 (0.24)	-0.001 (-0.39)	-0.012*** (-2.42)	-0.016*** (-2.62)	0.001 (0.35)
R&D intensity	4.646*** (3.93)	1.600 (1.09)	3.485* (2.37)	7.456*** (5.26)	4.374*** (3.69)	1.144 (0.77)	3.298** (2.23)	7.101*** (5.03)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.483* (-1.81)	-1.054*** (-2.82)	-1.083** (-2.48)	-1.450*** (-4.94)	-0.504* (-1.89)	-1.104*** (-2.96)	-1.094*** (-2.50)	-1.480*** (-5.04)
	rho21	0.418***	rho32	0.784***	rho21	0.418***	rho32	0.784***
	rho31	0.395***	rho42	0.130***	rho31	0.392***	rho42	0.125***
	rho41	0.129***	rho43	0.111***	rho41	0.126***	rho43	0.110***
No. Observations		3624				3624		
Wald Test		1063.65				1082.13		
LR test $\rho_{ij}=0 \forall i \neq j$		590.37***				588.38***		
Test comparison (model 2 vs. 1)		---				20.34***		

***, **, *: Variable statistically significant at the 1%, 5% or 10%, respectively. T-ratios in parentheses

5.- Conclusions

This paper studies the relationship between the vertical and horizontal scope of the firm and investments in information technologies using a sample of Spanish manufacturing firms. As expected, the pattern of these investments is different depending on the information processing capabilities of firms and on their information processing needs. In other words, investments in information technologies varies depending on the choice of the firm's vertical and horizontal boundaries.

Regarding the investments in in-firm information technologies our results show that they are related to both the horizontal and the vertical boundaries of the organization. First, we have found a that concurrent sourcing has the highest influence on information processing needs and, therefore, demands the highest degree of investment. As predicted, there is a quadratic influence of production externalization on investments in in-firm information technologies, with both the use of the hierarchy and the market at the two extremes, for which the need of increasing the information processing capabilities through the technology is lower. Second, our results confirm that the internal coordination costs that diversification originates increase the information processing needs and create incentives to invest in in-firm information technology. That is, they show that diversified firms make higher investments in information technologies to manage the coordination costs stemming from the use of more complex structures. However, we have not found differences in the investments of information technologies depending on the type of diversification.

Regarding the investments in beyond-firm technologies, our estimations point out that those firms which outsource production are more likely to use them. In this sense, and in order to compensate for the unbalance created between information needs and capabilities, firms invest in technologies that elude or decrease the costs stemming from the transactions with the suppliers of the outsourced production. Specifically, we find that higher levels of production externalization are positively related to the use of supplier to business, business to business and CAD. With the exception of supplier to business, we do not find that the horizontal dimension of the firm is related to these technologies.

These results have clear implications for the study of firm boundaries and for the adoption of information technologies. First, the finding that those firms with medium levels of production externalization present higher levels in the stock of in-firm

information technologies is interesting in terms of the study of the different forms through which firms may organize their transactions. This result suggests that the firms that use concurrent sourcing have the highest coordination needs due to the interdependences that arise between the in-house and the outsourced production. Parmigiani (2007) and Puranam et al. (forthcoming) highlight the advantages of using concurrent sourcing, arguing that it allows the firm to simultaneously monitor suppliers, produce efficiently and improve processes, among others. Prior works support the use of both sources simultaneously, using arguments based on uncertainty and synergies (Harrigan, 1986), control and innovation processes (Bradach, 1987), or firm and supplier expertise and technological uncertainty (Heide and John, 1988). However, the benefit from these advantages come at the expense of managing a complex process that combines the the market and the hierarchy (Parmigiani, 2007). As a result, firms have to invest in in-firm information technologies that allow the external and internal information to be fused.

Second, given the necessary fit between the information processing needs and capabilities implied by the model and its expected relation to the performance of the firm our results suggest that any change in both vertical and horizontal limits should be accompanied by a change in the levels of investments in technology. Accepting the implications on performance, our results not only suggest the situations in which managers should invest more in information technologies, but also the type of technology that should be selected. Variations in the horizontal limits modify internal coordination costs and create incentives to invest in in-firm technologies. Regarding beyond-firm technologies and although we accept that the absence of evidence cannot be used as an evidence of absence, our results suggest that their adoption is not affected by modifications in the horizontal boundaries of the firm. Similarly, regarding vertical integration, the decision to use concurrent sourcing creates the need of increasing the information processing capabilities of the firm through in-firm investments in IT. In this case, the extent to which firms outsource production also affect the need to adopt technologies that are used for connecting the stages of the production process that take place inside the firm and those that are developed in the market.

On a more general basis, the results are generally consistent with the information processing needs-capabilities model and they also show a promising way for integrating the literatures on information systems and on technology diffusion. On the one hand, they offer support to the arguments developed in Galbraith (1974) and subsequent papers (see,

for example, Tushman and Nadler, 1978). For example, they support the idea that those activities that need to be tightly coordinated generate higher information processing needs and higher incentives to invest in information technologies, as it happens in the case of concurrent sourcing. Similarly, firms that diversify are likely to develop a more varied number of tasks than non-diversified firms, increasing coordination costs. However, the results also support the idea that routine tasks that are developed in more predictable environments generate less information processing needs. This is shown by the fact that both product and market stability are negatively related to investments in information technologies, irrespective of the type of technology considered. On the other hand, the success in integrating the analysis of the boundaries of the firm suggested by the information processing needs-capabilities model and the variables from the technology diffusion literature recommends a more frequent combination of both literatures. Although, as shown by this paper, they look complementary in depicting the types of factors that can explain technology adoption, the impression is that they have evolved separately, which impedes offering a complete picture of the factors conditioning technology diffusion.

Our study is subject to some limitations. First, the measure of diversification only indicates whether the firm is diversified or not but does not indicate its extent, or the relative importance of using each type of diversification (related or unrelated). Second, the study only analyses the increase in information processing capabilities derived from technology investments, and do not consider other interorganizational mechanisms that may help the firm to increase information capabilities. Along with information technology mechanisms, Bensaou and Venkatraman (1995) propose two additional interorganizational mechanisms. On the one hand, firms could increase their information processing capabilities through the use of interorganizational structural mechanisms (number of information channels, frequency and extend to which the information exchange between firms is for coordination vs. control purposes). On the other hand, process mechanisms (the use of a cooperative vs collaborative approach for solving disputes, the utilization of commitment and joint effort between firms, ...) could also affect the information flow within structural mechanisms and, therefore, a firm's information processing capabilities. This latter limitation opens the opportunity to future empirical research that jointly analyze several mechanisms affecting information processing capabilities.

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685/2012

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