Paper to be presented at the DRUID 2012

on

June 19 to June 21

at

CBS, Copenhagen, Denmark,

FIRM BOUNDARIES AND INVESTMENTS IN INFORMATION TECHNOLOGIES

Idana Salazar
La Rioja
Economia y Empresa
idana.salazar@unirioja.es

Jaime Gómez
La Rioja
Economía y Empresa
jaime.gomez@unirioja.es

Pilar Vargas
La Rioja
Economía y Empresa
pilar.vargas@unirioja.es

Abstract

The objective of this paper is to analyse the relationship between information processing needs and capabilities. Both outsourcing and diversification influence the amount and the type of investments that firms perform in information technologies. In particular, we expect more vertically desintegrated firms to be more likely to use those technologies that facilitate interorganizational communication, such as e-business. Similarly, the coordination costs generated by diversification will create the need to invest in information technologies, specially in the case of related diversification. Our hypotheses are tested on a panel of Spanish manufacturing firms. Our findings are consistent with the hypotheses

developed.

Jelcodes:O33,-

FIRM BOUNDARIES AND INVESTMENTS IN INFORMATION TECHNOLOGIES

Abstract. The objective of this paper is to analyse the relationship between information processing needs and capabilities. Both outsourcing and diversification influence the amount and the type of investments that firms perform in information technologies. In particular, we expect more vertically desintegrated firms to be more likely to use those technologies that facilitate interorganizational communication, such as e-business. Similarly, the coordination costs generated by diversification will create the need to invest in information technologies, specially in the case of related diversification. Our hypotheses are tested on a panel of Spanish manufacturing firms. Our findings are consistent with the hypotheses developed.

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

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 and an organization needs to develop. Therefore, the optimal design for organizations is based on the concept of fit.

The aplication of the information processing needs-capabilities framework is far from being limited to the understanding of firm structure. The many dimensions determining both the needs and capabilities of firms for processing information open the opportunity for new aplications. In particular, given that the information processing capabilities of firms are partially dependent on the investments that firms perform in information technologies, it seems natural to use the framework in order to study these investments.

The objective of this paper is to test whether those firms with higher processing needs or those with lower processing capabilities are also more likely to use certain types of technologies. 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 the firm. We argue that those firms that outsource a larger proportion of their production are more likely to invest in those technologies that allow a formalization of interorganizational communication, such as e-business technologies. The reason is that not using the hierarchy for organizing the transactions lowers the information capability of firms and it has to be compensated by the use of information technologies. Similarly, more diversified firms have to invest more in information technologies in order to manage the different activities in which they participate, given the higher variety of tasks that the firm is involved in and, therefore, the higher information processing needs. Information processing needs are, in turn, specially important for firms that present higher degrees of related diversification, given that the main benefits of this strategy stem from the tight coordination of close activities that generate sinergies. 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 invest more in information technologies.

To test our hypotheses we have chosen a sample of manufacturing firms operating in Spain. The data collected provides us with information on the horizontal and vertical boundaries of around 2000 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 and on the adoption of certain types of technologies that are mainly used for interorganizational communication. This 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 for the horizontal and vertical boundaries. First, we test the relationship between the extent of outsourcing and the use of technologies that are used for market governed transactions. 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. The use of a multivariate probit helps to analyse the information available on several technologies in an integrated way. Second, we estimate the total investment that firms incurr in information processing equipment. In this case, our expectancy is that those organizations with a higher degree of (related) diversification (i.e, they have higher information processing needs) are more likely to invest in information systems equipment. The censured nature of the dependent variable makes the use of a Tobit model necessary in this case.

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. Furthermore, we control for the fact that other factors, such as the stability of the market or the modifications of the products that the firm sells, may have an impact 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 is lower for non-vertically integrated firms (see, for example, Forman and Gron, 2011, and Gertner and Stillman, 2001). These findings are at odds with the postulates of the framework used here and also with the prevailing view that developments in information technologies have allowed firms to reduce their limits (Forman and Goldfarb, 2006). One reason to explain these results is that they focus on single industries (Formand 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. An alternative reason, explored in this paper, is that this relationship may be dependent on the types of technologies analysed.

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 three 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 then to the existing empirical evidence. The final section concludes and discusses the major implications of this paper.

2.- A framework for understanding information processsing 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 challengues associated to the activities that it has to perform. As Tushman and Nadler (1997), 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 processsing 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 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.

2.1. Outsourcing, information processing needs and investments in technology

Our first focus of attention is 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, 1987). 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, 1987). 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 all the production process of a given product internally or it can outsource a given proportion of it. If all the 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 infraestructure 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 the mechanisms just described in order to manage a given transaction. In this situation, a feasible way to improve information processing capabilities is to invest in information technologies that facilitate the management of the interorganizational transaction. These investments 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 et al., 1987; Clemons et al., 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 establisment 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 thecnologies 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 et al., 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).

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

Hypothesis 1. *Firms that outsource production are more likely to invest in information technologies that facilitate interorganizational communication*

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 steaming 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 IT investments as a way to increase their information processing capabilities and reducing internal coordination costs (Hitt 1999; Dewan et al., 1998; Gurbaxani and Whang 1991). Contrarily to the first hypothesis, in this case we focus on information technology investments that are used inside the firm, given that they are more likely to be necessary to coordinate the different activities that it performs. Therefore, our second hypothesis can be written as follows:

Hypothesis 2. *More diversified firms are more likely to invest in information tecnologies 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 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 information technologies to coordinate different lines of business, obtaining economies of scope as the coordination and control required when the firm shares 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 IT investments and the greater need to reduce the costs of interdependences in related diversification firms, the demand for IT investments should be greater in those firms with a relatedly diversified strategy (Hitt, 1999; Dewan et al. 1998).

Hypothesis 3. *Those firms with related diversification are more likely to invest in information technologies that facilitate intrafirm coordination than the ones with related diversification*

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 and the (2) investments that the firm perform in information processing technologies.

In order to test our hypothesis we have performed two analysis. The first one helps us testing Hypothesis 1. This hypothesis maintains that outsourcing reduces the use of the hierarchy, reducing the information processing capabilities of firms and increasing the need to use those technologies that facilitate interorganizational communication. The data collected offers information on the use of several information technologies every four years (1994, 1998, 2002 and 2006) and refers to the use of production technologies. The data also offers information on the use of ebusiness from 2000. 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 technologies we choose those that facilitate interorganizational communication, namely, S2B, B2B and CAD. 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 1, we cannot not 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 this 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.

The second analysis allows us to test the two remaining hypotheses (Hypotheses 2 and 3). Given that these hypotheses are based on internal coordination costs we have calculated an indicator that picks up the investments in technologies that reduce 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 tree year capitalized valued for the training expenses. In order to homogenise the time reference we have calculated this variables 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 lower than the first one mainly due to the increasing need for available data that the calculation of the perpetual inventory method requires.

3.2 Variable description and Measurements.

Dependent variables

Information technologies. As explained above, for testing Hypothesis 1 we have considered four technologies. Two of them are technologies which 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. 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.

Information Technology Stock. The measure of IT stock combines investments in information processing equipment with a capitalized value of IT expenses and is used to test Hypotheses 2 and 3. 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 equipment of processing information (EPIt) 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 IT 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 IT training, is obtained through the following specification of IT 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.

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

Market stability. As comented, predictability of the environment is one factor to take into account when the information processing needs is being analyzed. Those activities developed in inestable markets generate higher information processing needs 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.

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 IT mainly to find information about the latest market trends and for the co-ordination of activities with foreign partners (Lal, 2002; 1999). 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 a firm's export orientation and IT adoption. Export intensity is measured by the ratio of total exports to sales.

Firm size. Previous studies that analyse 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 IT adoption, Battisti, Canepa and Stoneman (2009) argue that this variable could pick up several firm characteristics that justify the positive relationship between size and IT 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.

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 constract a concentration ratio (CR_4).

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 technologies.

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, what 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).

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). That is, the firm could outsource activities of the firm in order to free up coordination capacity to carry out other activities such as diversification.

3.3. Methodology.

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

First analysis: vertical boundaries and the adoption of interorganization technologies

The first 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).

Second analysis: diversification and investments in information technologies

Regarding the second 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):

$$y_i^* = x_i\beta_i + \varepsilon_i$$
$$y_i = 0 \ \text{ if } \ y_i^* \leq 0$$
$$y_i = y_i^* \ \text{ if } \ y^* > 0$$

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 is censored at 0 otherwise.

4.- Results.

Table 3 shows the results of estimating a multivariate probit model and serves to test Hypothesis 1.[1] 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 interorgnizational communication. The first four columns of Table 3 only use the control variables, whereas the four last columns introduce the variable of interest, which measures the percentaje 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

---

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

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.

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 adopt interorganizational communication technologies. Market and product stability have a very significant and negative effect on the adoption of interorganizational technologies. 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 information technologies. Apart from CAD, the diffusion process 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 and 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.

Insert table 3 about here

Table 4 shows the results of the estimation of a tobit model on the 3,576 observations available.[2] It is used to test for Hypotheses 2 and 3. 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 2 (column 2) and Hypothesis 3 (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.

---

[2] Furthermore, the analysis of the comparison of the models reveals that model 2 is preferred to models 1 and 3.

Hypothesis 2 argued that firms with higher degrees of diversification have higher information processing needs and will invest more in information technologies. Column 2 adds one additional variable, whether the firm is diversified or not, that allows us to test it. 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 information technologies.

Hypothesis 3 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.

The results of the preferred model provide us with important information about the effect of the control variables on the stock of 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 and showed by the results on the adoption of interorganizational technologies. They also show that those firms that have higher levels of production externalization and 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 diversification and investments in technology is that the latter could include the adoption of technolgies that are used for interoganizational communication. These technologies should play a minor role in the case of managing a diversified corporation and the aggregate measure of the stock of information technologies that we use could include them. 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 any of the dimensions (vertical or horizontal) and due to the high number of firms using it.

Columns 4 to 6 present the estimations over the restricted sample. The estimates show very similar results both for the variables of interest and for the control variables. Diversified firms invest more in 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 are positive and significant is all the cases. Finally, the impact of the control variables does not show any qualitatively important variation, confirming the stability of our results.

Insert table 4 about here

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.

On the one hand, the externalization of production reduces the information processing capabilities, especially those that have to do with managing external coordination costs. In order to compensate this unbalance firms increase information processing capabilities through the use of 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 business to business, we do not find that the horizontal dimension of the firm is related to these technologies.

On the other hand, regarding the horizontal scope, our results confirm that the internal coordination costs due to diversification increase information processing needs and create incentives to invest in technology. That is, our results confirm that diversified firms make higher investments in IT to manage the coordination costs stemming from the use of more complex structures. However, we have not found differences in the investments of IT depending on the type of diversification.

Interestingly, we find that those firms with higher levels of production externalization present higher levels in the stock of information technologies. These results seem to be robust to the specification of the model and to the elimination of the firms using interorganizational technologies. Given that our measure of vertical integration captures the breadth dimension of the production stage this result seems to indicate that these firms have higher coordination needs due to the interdependences may arise between the in-house and the outsourced production. Parmigiani (2007) highlights the advantages of using concurrent sourcing, arguing that it allows the firm to simultaneously monitor suppliers, produce efficiently and improve processes. 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). Despite these advantages, when firms use a concurrent sourcing, a complex management process emerges because the market and the hierarchy must be managed simultaneously (Parmigiani, 2007).

References

References

Argyres, N., 1999: The impact of information technology on coordination: evidence form B-2 “Stealth” bomber, Organization Science, 10(2): 162-180.

Astebro, T., 2002: Noncapital investment costs and the adoption of CAD and CNC in US metalworking industries. Rand Journal of Economics, 33(4): 672-688.

Atallah, G., 2002: Production technology, information technology and vertical integration under asymmetric information, CIRANO Working Papers 2002-32.

Baptista, R. 2000: Do innovations diffuse faster within geographical clusters?. International Journal of Industrial Organisation, 18: 515-535.

Bardhan, I.,Whitaker, J., Mithas, S., 2006: Information technology, production process outsourcing, and manufacturing plant performance. Journal of Management Information Systems, 23(2): 13-40

Battisti, G., Canepa, A., Stoneman, P., 2009: E-Business usage across and within firms in the UK: profitability, externalities and policy, Research Policy, 38: 133-143.

Bensaou, M., Venkatraman, M., 1995: Configurations of interorganizational relationships: a comparison between U.S. and Japanese automakers. Management Science, 41(9): 1471-1492.

Blois, K. J., 1986: The electronic Re-organisation of industry: Implications for sub-contractors. European Journal of Marketing, 20(8):41-48.

Bradach, J., 1987: Using the plural form in the management of restaurant chains. Administrative Science Quarterly, 42: 276-303.

Bertschek, I., H. Fryges, 2002: The Adoption of Business-to-Business E- ommerce: Empirical Evidence for German Companies, Discussion Paper No. 02-05, Centre for European Economic Research.

Cappellari, L., Jenkins, S.P. 2003: Multivariate probit regression using simulated maximum likelihood. The Stata Journal, 3(3), 278-294.

Clemons E.K., Row M.C., 1991: Sustaining IT advantage: the role of structural differences. MIS Quarterly, 15(3): 275-292.

Clemons E.K., Reddi, S.P., Row, M.C., 1993: The impact of Information Technology on the organization of economic activity: the “move to the middle” hypothesis. Journal of Management Information System, 10(2): 9-35.

Cohen, W.M., Levinthal, D.A., 1990: Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly, 35: 128–152.

Dewan, S., Min, C-K., 1997: The substitution of Information technology for other factors of production: a firm level analysis. Management Science, 43 (12): 1660-1675.

Dewan, S., Michael S.C., Min, CH-K., 1998: Firm characteristics and investments in information technology: scale and scope effects. Information Systems Research, 9(3): 219-232.

Dewan, S., Kraemer, K., 2000: Information technology and productivity: evidence from country-level data. Management Science, 46 (4): 548-562.

Forman, C., Goldfarb, A. 2006: Diffusion of information and comunication technologies to business, in Terrence Hendershott (ed): Economics and Information System: 1-43.

Forman, C., Gron, A. 2011: Vertical integration and information technology investment in the insurance industry. Journal of Law, Economics & Organization, 27(1): 180-218.

Galbraith, J.R., 1974: Organization design: An information processing view. Interfaces, 43): 28-36.

Gertner, R, Stillman, R., 2001: Vertical integration and Internet strategies in the apparel industry. The Journal of Industrial Economics, 49: 417-440.

Greene, W.H. 2008. *Econometric analysis*. 6th ed. Upper Saddle River, NJ: Prentice-Hall.

Gurbaxani V., Wang S., 1991: The impact of information systems on organizations and markets. Communications of the ACM, 34(1): 59– 73.

Harrigan, K. R. 1986: Matching vertical integration strategies to competitive conditions. Strategic Management Journal, 7(6): 535–555.

Heide J.B., John G. 1988: The role of dependence balancing in safeguarding transacion-specific assets in conventional channel, Journal of Marketing, 58: 20-35.

Hill C.W.L., 1988: Internal capital market controls and financial performance in multidivisional firms. The Journal of Industrial Economics 37(1): 67-83.

Hill C.W.L., Hoskisson R.E., 1987: Strategy and structure in the multiproduct firm. Academic Management Review 12 (2): 331-341.

Hitt L., 1999: Information technology and firm boundaries: evidence from panel data. Information Systems Research, 10(2): 134-149.

Hollestein, H., 2004: Determinants of the adoption of Information Comunication Technologies (ICT). An empirical analysis based on firm-level data for Swiss business sector. Structural Change and Economics Dynamics, 15:315-342.

Hollestein, H., Woerter, M. 2008: Inter and intra-firm diffusion of technology: The example of the e-comerce. An analysis based on Swiss firm-level data. Research Policy, 37: 545-564.

Karshenas, M., Stoneman, P., 1993: Rank, stock, order, and epidemic effects in the diffusion of new process technologies: an empirical model. Rand Journal of Economics, 24 (4): 503–528.

Lal, K., 1999: Determinants of the adoption of information technology: a case study of electrical and electronic goods manufacturing firms in India. Research Policy, 28: 667-680.

Lal, K., 2002: E-business and manufacturing sector: a study of small and medium-sized enterprises in India. Research Policy, 31: 1199-1211.

Linchtenber, F. (1995): The output contributions of computer equipment and personnel: a firm-level analysis. Journal of Economics of Innovation and New Technology, 3: 201-217.

Lucking-Reiley, D., Spulber, D., 2001: Business-to-business electronic commerce. Journal of Economic Perspectives, 15 (1): 55-68.

Malone T.W., Yates J., Benjamin, R.I., 1987: Electronic markets and electronic hierarchies. Communications of the ACM, 30(6): 484–497.

Merino, F., Salas, V. 1995: Empresa extranjera y manufactura española: efectos directos e indirectos. Revista de Economía Aplicada, 9: 105-131.

Merino, F., Salas, V. 1996: Diferencias de eficiencia entre empresas nacionales y extranjeras en el sector manufacturero. Papeles de Economía Española, 66:191-207.

Parmigiani, A., 2007: Why do firms both make and buy? An investigation of concurrent sourcing, Strategic Management Journal, 28: 285-311.

Reinganum, J.F., 1981: Market structure and the diffusion of new technology", The Bell Journal of Economics, 12 (2): 618-624.

Romeo, A.A., 1975: Interindustry and interfirm differences in the rate of diffusion of an innovation. Review of Economics and Statistics, 5(3): 311-319.

Shin N., 2006: The impact of information technology on the financial performance of diversified firms. Decision Support Systems, 41: 698-707.

Tanriverdi, H., 2006: Performance effects of information technology synergies in multibusiness firms. Mis Quarterly, 30(1): 57-77.

Teece, D.J., 1982: Towards an economic theory of the multiproduct firm. Journal Economic Behavior and Organization, 3(1): 39-63.

Thusman, M., Nadler, D., 1978: Information processing as an integrating conceptin organizational design. Academy of Management Review, 3: 613-624.

Wang, C., Benaroch, M., 2004: Supply cahin coordination in buyer centric B2B electronic markets. International Journal of Production Economics, 92: 113-124.

Zhou, Y., 2011: Sinergy, coordination costs, and diversification choices. Strategic Management Journal, 32: 624-639.

Table 1.- Mean differences depending on whether the firm has adopted the technology or not (years 2002 and 2006)

	S2B			B2B			B2C			CAD		
	Mean		z	Mean		z	Mean		z	Mean		z
	Yes 760	No 2864		Yes 285	No 3339		Yes 190	No 3434		Yes 1388	No 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

Table 3. 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**	0.005***	0.002	0.004***
					(2.49)	(2.92)	(1.10)	(3.09)
No Diversification	-0.282***	-0.013	-0.150	0.079	-0.285***	-0.020	-0.151	0.079
	(-2.67)	(-0.09)	(-1.01)	(0.72)	(-2.70)	(-0.14)	(-1.02)	(0.72)
Unrelated Diversification	-0.189	0.064	-0.052	0.336**	-0.193	0.060	-0.052	0.336**
	(-1.38)	(0.35)	(-0.26)	(2.45)	(-1.41)	(0.33)	(-0.27)	(2.45)
Market Stability	-0.190***	-0.142**	-0.154***	-0.145***	-0.185***	-0.135**	-0.150***	-0.140***
	(-3.86)	(-2.24)	(-2.21)	(-3.14)	(-3.76)	(-2.13)	(-2.15)	(-3.03)
Product Stability	-0.219***	-0.160**	-0.089	-0.386***	-0.212***	-0.147*	-0.084	-0.379***
	(-3.74)	(-2.13)	(-1.06)	(-6.82)	(-3.61)	(-1.96)	(-1.01)	(-6.67)
Year 2002	-0.442***	-0.278***	-0.184***	-0.044	-0.441***	-0.276***	-0.184***	-0.042
	(-8.49)	(-4.04)	(-2.43)	(-0.91)	(-8.47)	(-4.00)	(-2.43)	(-0.88)
Integrated in a business group	0.172***	0.216***	0.012	0.238***	0.171***	0.214***	0.011	0.234***
	(2.86)	(2.81)	(0.14)	(4.05)	(2.83)	(2.78)	(0.12)	(3.97)
Foreign capital	-0.030	0.225**	0.131	-0.069	-0.029	0.228**	0.132	-0.065
	(-0.41)	(2.60)	(1.29)	(-0.96)	(-0.40)	(2.64)	(1.30)	(-0.91)
Export propensity	0.451***	0.298***	0.087	0.430***	0.442***	0.291***	0.081	0.417***
	(4.52)	(2.35)	(0.59)	(4.39)	(4.42)	(2.29)	(0.55)	(4.25)
Firm size	0.059	0.158***	0.124***	0.124***	0.061	0.161***	0.126***	0.128***
	(1.52)	(3.92)	(2.62)	(2.73)	(1.58)	(3.98)	(2.66)	(2.81)
Market concentration	-0.002	-0.013***	-0.016***	0.001	-0.001	-0.012***	-0.016***	0.001
	(-0.47)	(-2.59)	(-2.66)	(0.24)	(-0.39)	(-2.42)	(-2.62)	(0.35)
R&D intensity	4.646***	1.600	3.485*	7.456***	4.374***	1.144	3.298**	7.101***
	(3.93)	(1.09)	(2.37)	(5.26)	(3.69)	(0.77)	(2.23)	(5.03)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.483*	-1.054***	-1.083**	-1.450***	-0.504*	-1.104***	-1.094***	-1.480***
	(-1.81)	(-2.82)	(-2.48)	(-4.94)	(-1.89)	(-2.96)	(-2.50)	(-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

Table 4. 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		-0.827*** (-3.65)	-0.981*** (-2.92)		-0.815*** (-2.90)	-1.046** (-2.43)
Unrelated Diversification			-0.266 (-0.62)			-0.384 (-0.71)
Production externalization	0.015*** (3.35)	0.015*** (3.35)	0.015*** (3.35)	0.013** (2.37)	0.013** (2.33)	0.013** (2.32)
Market Stability	-0.545*** (-3.71)	-0.540*** (-3.68)	-0.543*** (-3.70)	-0.509** (-2.20)	-0.517** (-2.24)	-0.521** (-2.26)
Product Stability	-0.523*** (-2.84)	-0.531*** (-2.89)	-0.531*** (-2.88)	-0.494*** (-2.78)	-0.490*** (-2.76)	-0.493*** (-2.78)
Year 2002	1.306*** (8.65)	1.319*** (8.75)	1.319*** (8.76)	1.460*** (8.08)	1.469*** (8.15)	1.469*** (8.14)
Integrated in a business group	2.016*** (10.75)	2.031*** (10.85)	2.034*** (10.87)	2.158*** (9.20)	2.174*** (9.28)	2.182*** (9.31)
Foreign capital	0.979*** (4.26)	1.009*** (4.40)	1.004*** (4.37)	0.916*** (3.08)	0.943*** (3.18)	0.937*** (3.16)
Export propensity	2.868*** (9.12)	2.876*** (9.16)	2.872*** (9.15)	2.918*** (7.40)	2.936*** (7.46)	2.932*** (7.45)
Firm size	1.439*** (10.08)	1.398*** (9.78)	1.393*** (9.73)	1.325*** (7.27)	1.279*** (7.01)	1.269*** (6.93)
Market concentration	0.007 (0.64)	0.008 (0.73)	0.008 (0.73)	0.005 (0.41)	0.007 (0.51)	0.007 (0.51)
R&D intensity	18.584*** (4.67)	18.766*** (4.72)	18.799*** (4.73)	25.048*** (4.45)	25.295*** (4.50)	25.321*** (4.51)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	7.321*** (10.13)	8.086*** (10.77)	8.239*** (10.43)	6.953*** (8.04)	7.697*** (8.54)	7.935*** (8.26)
No. Observations	3576	3576	3576	2683	2683	2683
Test comparison (models 2, 3 vs. 1)	---	13.35***	6.87***	---	8.39***	4.45**
Test comparison (models 3 vs. 2)	---	---	0.39	---	---	0.50
VIF (max/mean)	6.76/2.50	6.78/2.46	6.78/2.49	6.37/2.37	6.38/2.33	6.38/2.38
LR χ^2	1033.60***	1046.93***	1047.31***	749.65***	758.03***	758.53***

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