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A FIRM-LEVEL ANALYSIS OF DIFFERENCES BETWEEN ADOPTERS AND NON-ADOPTERS OF ICT*

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Abstract

This paper analyses differences in the firm characteristics of adopters and non-adopters of ICT. Five factors are considered: environment, firm structural characteristics, human capital, competitive strategy and internal organization. We use the data collected in a survey of 337 Spanish firms of different sizes. Results highlight the importance of size, multinational ownership and high-skilled workforce in ICT adoption. Quality control systems and team-based organization of work also play a relevant role on the within-firm diffusion of certain elements of ICT.

Keywords

ICT adoption, human capital, size, multinational, ISO certification

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1. INTRODUCTION

The most recent empirical evidence confirms the positive effect of ICT on firm performance not only in terms of productivity, profitability, market value, and market share, but also in intermediate performance measures, such as process efficiency, service quality, cost savings, organizational and process flexibility, and customer satisfaction [8, 11, 23, 31].

ICT are enabling major changes to be made in all the firm's functional areas. ICT adoption has drastically modified communication, sales and information methods, thus enabling firms to achieve strong competitive advantage, in both production and other areas. ICT also helps companies to increase their potential for competitive advantage by enabling them to perform primary and support activities either at less cost or in a way that leads to differentiation and a premium price [37].

Nowadays, the debate is focused on variables relating to ICT usage and ways of increasing the positive impact of ICT on firm performance [9, 11]. Knowledge about the relationship between ICT and firm characteristics, firm strategies and the competitive environment can help firms to obtain greater benefits from ICT adoption. There is no doubt about the fact that, to obtain such benefits, it is absolutely essential to identify the variables that affect the decision of firms to adopt ICT. This concern has led in the last years to several studies analyzing the drivers of ICT adoption and usage [27, 45, 53].

In this context, this paper aims to analyze the role played in ICT adoption in a sample of Spanish firms by means of five variables: environment, firm structural characteristics, human capital, competitive strategies and internal organization.

The paper does not therefore consider the factors influencing the adoption of ICT by users, on which there is a large body of academic research that focuses on the traditional technology acceptance models (TAM, EDT, etc.). This study focuses its attention on the characteristics that identify firms as ICT adopters or non-adopters. Attention is paid to factors such as age of workers, competitive pressure, international markets, competitive strategies based on low cost or differentiation, and ISO certification.

In this way, new conclusions can be drawn regarding the introduction of the new technologies into the firm. By developing a better understanding of the factors affecting ICT usage, managers should be able to shape policies within their organizations to maximize the effectiveness of their efforts to stimulate ICT usage and, in the process, increase organizational performance and productivity.

Previous studies of the subject in this field have suffered from two important limitations, due to methodological issues and data collection problems.

Firstly, many studies have analyzed only one type of ICT; the traditional variable being computer use. In this paper, we consider other ICT usage indicators, such as the number of e-mail users or e-mail accounts per employee, and Internet infrastructure, such as intranet, extranet or website.

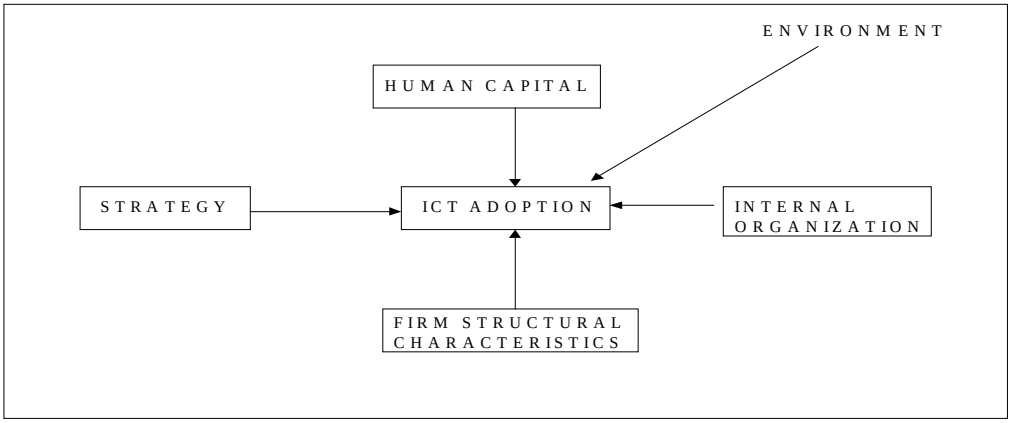
Secondly, previous studies have primarily analyzed industrial activities and large firms, thus neglecting service activities and SMEs. This analysis overcomes this limitation by including the industrial and service activities through a survey of 337 Spanish firms with 20 or more employees.

Following on from this introduction, the remainder of this paper is organized as follows. In the next section we introduce the theoretical hypotheses. These are followed in Section 3 by a description of the methodology adopted in this study, including both the model and the data sources employed in the estimations. Some descriptive statistics and the results of the model estimations are presented and interpreted in the penultimate section, and the paper concludes with some remarks on the findings and implications for ICT usage and adoption.

2. THEORETICAL BACKGROUND

As mentioned in the introduction, in the last few years, various studies have analyzed differences in firm characteristics between adopters and non-adopters of ICT. The chosen model, which is shown in Figure 1, is partially based on other existing models, such as that developed by Spanos et al. [44]. Our model defines five factors contributing to explain ICT adoption: environment, firm structural characteristics, human capital, competitive strategies and internal organization. These forces interplay and help to define the firm's approach to pursuing its objectives.

Figure 1. Theoretical model



2.1. Environment

The environment within which the firm performs its activities has a strong influence on the decision to adopt ICT [39, 49, 53]. We consider three variables with respect to firm environment: competitive pressure, activity sector and the geographical market in which the firm sells its goods and services.

a) Competitive pressure

Competitive pressure has long been recognized in the innovation literature [47] as a driver of ICT adoption. A firm in a competitive environment is more likely to invest in ICT, as a way of strengthening its performance and ensuring its survival, than a firm operating in a more sheltered environment [24]. When faced with stronger competition, firms are more eager to obtain immediate information to enhance their decisions [22]. Therefore, firms facing more intense competition in the market tend to attach more value to ICT innovations, which are seen nowadays as a requisite to compete in the marketplace [39]. Competitive pressure generates net effects or spillovers that soon promote the introduction of ICT into the firm [21].

Several authors have empirically considered competition as a core determinant of ICT adoption [4, 21, 40]. For example, competitive pressure has been shown to play an important role in the degree of computerization [10], in EDI adoption [39, 43], in e-commerce [14], and in website development [24]. Nevertheless, others papers find competitive pressure to be insignificant in ICT adoption [49, 50].

Generally speaking, ICT adoption should be positively influenced by competition. Thus the following hypothesis is proposed:

H1: Higher competitive pressure is positively associated with the ICT adoption.

b) Industry sector

The industry in which the firm operates may have an important influence on the ICT adoption process as long as differences in certain aspects are captured by it. Data processing requirements, for example, differ across sectors. Service industries, which are reliant on data processing, can be expected to depend more heavily on information systems [16]. In addition, firms in different industries have to deal with different types of business environment dynamics, which may affect ICT introduction [21]. The industry variable also reflects business environment factors such as heterogeneity and uncertainty, which are important in the adoption of new technologies.

The impact of this variable in ICT adoption has been empirically analyzed in several studies. In Love et al. [26] it is shown that organizations from different sectors differ

significantly in their level of IT investment. The above-average probability of adoption that clearly exists in some high-tech industries, both in the trading sector and in modern service industries, is a reflection of different technological opportunities [21]. In Singapore, however, there was no significant difference in terms of industry type between adopters and non-adopters of B2B electronic commerce [45].

Following the empirical evidence and the theory, we can therefore formulate the following hypothesis:

H2: ICT adoption is significantly associated with the firm's sector.

c) International market

A third environment variable that can affect firm behavior with respect to ICT adoption is whether or not the firm operates in international markets. This firm decision may be linked to its efforts to explore new markets and products. This induces the firm to search for new opportunities and to use new technologies. The empirical literature on technological innovation reveals a positive relationship between exports and innovation [25], due to the fact that internationalization implies growth in competitiveness and market size.

When we focus our attention on ICT, for example, website development may be aimed at raising the firm's visibility and attracting new customers. This is especially relevant when customers are far away, as is the case in firms exporting a high percentage of their sales [48]. New communication technologies reduce the impact of geographical locations and distances. Also, the propensity to export strongly stimulates early adoption of the Internet [21]. We can therefore establish the next hypothesis:

H3: Presence in international markets is positively associated with ICT adoption.

2.2.Firm structural characteristics

A firm's decisions are limited by its structural characteristics, which affect, among other things, its ability to adopt new innovations in accordance with the benefits and costs involved. The variables considered in this section are size of establishment, size of firm, and multinational ownership.

a) Business unit and firm size

Size is an explanatory variable that is used in most studies of firm behavior with respect to the adoption of new technologies in firms. There is a variety of coexisting views and arguments concerning the role played by firm size in the innovation implementation process, particularly when it comes to ICT adoption.

In support of the positive effect of size, it is claimed that larger firms are able to allocate more resources and capital to face the expenses involved in the adoption, which is a key point,

particularly in the initial stages. Also, their greater access to financial resources makes them better able to absorb the risks associated with the possible outcomes of ICT implementation [40].

It is also hypothesized that larger establishments generate more complex coordination problems and a greater need for information movement, which makes them more likely to use ICT-related tools [10]. This also applies to the size and number of establishments that make up the firm. When it has a number of units located in different places, the need for inter-unit coordination increases the likelihood of ICT adoption [15].

As an argument to support the negative effect of size, it is suggested that some Internet-based ICT applications may be viewed as tools to enable small firms to compete with larger ones. This relationship can be explained by the fact that SMEs are more flexible and can adapt to a changing environment more quickly than larger companies are able to [16].

Overall, the empirical evidence shows that the adoption of ICT increases with the size of firms and plants [4, 12, 46, 49]. Nevertheless, it is also possible to find empirical evidence against this positive relationship [26, 47]. In other studies, the relationship, though positive, is non-lineal [21].

Taking correlation by ICT type, computer use seems to be positively related to firm size [12, 19, 33, 35], website development is positively related to firm size in Kowtha and Choon [24], while e-commerce adoption and use is negatively related in Teo and Ranganathan [45].

Despite the fact that the theoretical and empirical literature has not reached full consensus about the relationship between size and ICT adoption in the firm, there is stronger evidence for a positive than for a negative relationship, suggesting the following hypothesis:

H4: Establishment and firm size are positively related to ICT adoption.

b) Multinational ownership

Although the effect of corporate status is likely to be ambiguous and independent institutions may be better positioned to undertake implementation, once the decision to adopt has been taken, the majority of reasons cited in the literature support a positive relationship between multinational ownership and ICT adoption.

Among the arguments, it is pointed out that firms forming part of a group are better informed and able to reduce the risk involved in adopting new technologies [17]. The existence of a network external to the organization plays a substantial role in the adoption process, since networking heightens awareness of innovation and increases the likelihood of its adoption [1]. Multinational ownership also increases the probability of integration in a broader internal network, increasing the need for ICT adoption [15]. Globalization challenges

multinational firms to coordinate their activities at international level, a task in which ICT can be very useful.

The literature has found unequivocal empirical evidence to support this positive relationship [15, 40]. Baldwin et al. [4] also found that foreign-owned plants were more likely to adopt advanced technologies than domestic plants. Nevertheless, in some studies there is no difference in this respect between adopters and non-adopters of business-to-business electronic commerce [73].

Let us, then, assume the following hypothesis:

H5: Multinational ownership is positively associated with ICT adoption.

2.3.Human capital

Numerous studies have verified that individual characteristics play a crucial role in the implementation of new technologies by influencing the user's views on adoption [29, 52].

a) Education

One of the main workforce variables taken into account is educational level. In the ICT adoption literature, it is often posited that qualified workers increase organizational readiness for innovation, because a higher educational level in potential adopters makes them more innovative. Plants using more advanced technologies require high-skilled workers [13]. On the one hand, the benefits of ICT can be increased by training in problem-solving, statistical process controls and computer skills; on the other, highly computerized systems produce such a vast data output that workers need to be sufficiently skilled to use it adequately [3].

High-skilled workers can make ICT investment and adoption easier [3, 7, 27, 38] because their higher educational level enhances ICT usage and impacts. There are no more than a few studies in which only a weak relationship [30], or not at all [41], is found between educational level and ICT adoption.

Computer use is the main variable related to the educational level, strong evidence of correlation between computerization and the educational composition of the firm having been found in many countries [13, 14].

The following hypothesis can therefore be established:

H6: A high-skilled workforce is positively related to ICT adoption.

b) Workforce age

One of the problems in the adoption of any innovation, including ICT, is the lack of full support from the workforce for the modifications that it requires in work practices. The introduction of innovations can be intimidating for employees, particularly if it requires them

to change their current practices or acquire new skills [5]. As a consequence, many employees see ICT adoption as a complication of their jobs, and this might deter their introduction.

One of the most significant socio-demographic characteristics to explain worker disagreement over the introduction of new work practices is age. In organizations with a younger workforce, managers seem more enthusiastic towards ICT adoption. The opposite occurs in firms with older, more experienced workers, who are likely to be more reluctant to accept innovation because they are assumed to have more firmly established work practices.

These arguments lead us to the next hypothesis:

H7: The younger the workforce the greater the likelihood of ICT adoption.

2.4. Competitive strategy

Firm strategy reflects the objectives and actions selected by the firm in its attempt to adapt to the environment and gain a specific competitive advantage. According to Porter [36], there are two different types of competitive strategies: differentiation strategy and low-cost strategy.

Some authors indicate that ICT adoption can contribute to either a quality strategy or a low-cost strategy [44, 48]. On the one hand, ICT may allow firms to achieve a differentiation advantage by securing relationships with customers through better quality and greater ability to respond rapidly to market changes. On the other hand, a low cost strategy can be implemented at different points in the value chain, by using formal and analytical managerial practices that can be supported by MDS (Management Decision Support) systems, which allow them to display and predict cost indicators.

In relation to differentiation through innovation, the same authors claim that there is an international tendency towards the use of information access and analysis instruments that increase the firm's innovative capability. ICT usage can provide the means to increase product quality. Computer applications such as DAA (Data Access and Analysis), ERP (Enterprise Resource Planning) and PSI (Process Support and Improvement), can dramatically improve a firm's capacity to sustain continuous high quality.

Alegre-Vidal et al. [2] point out that firms who prioritize quality are more innovative than those applying low-cost strategy. In some studies on strategies and ICT adoption, however, the results are not clear [44]. Craighead and Laforge [9] find no relationship between ICT adoption at different stages of the supply chain and the competitive priorities of plants.

Following the literature on the relationship between ICT adoption and strategies based on differentiation or low cost, the following hypothesis can be tested:

H8: Competitive strategy is significantly associated with ICT adoption.

2.5. Internal organization

Firms have different ways of organizing their activities and resources, and their decisions with respect to ICT adoption vary accordingly. In fact, organizational factors influence not only the firm's innovative capability but also in the ICT contribution to the organizational principles followed by the firm.

a) Quality assurance system

A quality system generates, of itself, new needs that may induce a firm to invest in ICT. Thus, ICT can be a complementary and positive factor in the adoption of JIT systems, in increasing customer proximity and in developing ways to integrate suppliers in product and process design [15].

Often, in order to monitor and analyze production processes, Quality Management Systems require ICT usage. These managerial systems are known as CAQ - Computer Aided Quality Management. In spite of the fact that these instruments are in their early stages, and still limited to statistical process controls (such as Quality Function Deployment and Modal Failure and Effects Analysis), inclusion of ICT in quality control systems is increasing their efficiency [42].

The implementation of ISO 9000 leads to further changes in the firm's internal organization, which may require further ICT adoption. For example, knowledge codification and the formalization of practices required by the ISO 9000 may increase the firm's propensity to use internal and external computer networks as a means of communication and coordination among different departments [15]. The empirical evidence supports a positive association between ISO certification and ICT adoption [15, 20].

Therefore, the hypothesis to be tested is the following:

H9: The implementation of quality control systems is positively related to ICT adoption.

b) Decentralization

The relationship between centralization and innovation adoption might be positive, because it favors management-promoted innovation, despite the resistance of lower level managers. However, this situation can lead to a negative correlation with the adoption of innovations that are more compatible with the interests of lower-level employees [32].

It is generally accepted that ICT helps firms to decentralize and break down hierarchies since it permits top management to communicate with bottom-tier workers without the need for mediation by middle managers. Wherever there is decentralization, and employees are empowered to make their own decisions, there may be important synergies with ICT. People

empowerment may benefit ICT implantation by allowing the delegation of responsibility for systems development to the lowest organizational levels.

This leads to the following hypothesis:

H10: Decentralization is positively related to ICT adoption.

3. METHODOLOGY

3.1. Data

The data used in this paper come from the first (2002) wave of the Information Society Survey of business establishments conducted by the Statistical Institute of Navarre (Spain). The population scope of the survey is the total number of business units employing twenty or more workers and includes all sectors of the region's economic activity. The sample was stratified by size and sector. The data were collected in the months of April and May 2002 by means of a survey that was distributed by post and answered by telephone, fax or e-mail. Since it was conducted by the regional government, it obtained a very high response rate of 97.12 per cent. The final sample is made up of 337 establishments.

The survey questionnaire, which comprises mainly questions referring to ICT, is based on the OECD questionnaire to measure the business use of ICT [34]. It also provides information about the main firm profile and firm environment characteristics. It also includes questions on issues relating to human capital, human resource management, the organization of work and firm strategy.

3.2. Definition of the variables

3.2.1. Dependent variables

Given the amount and variety of the technologies comprised in ICT, and in order to improve the validity and scope of our results, we found it convenient to analyze the determinants of a number of the most representative technologies, instead of restricting the analysis to just one of them. We believe that this adds to the value of our paper in that it enables us to determine whether the various types of ICT exhibit different adoption patterns, as several articles have shown [27, 40]. Next, we define the dependent variables, which capture aspects relating to ICT infrastructure and the usage of some of them.

- *PCs per employee.* This quantitative variable is defined as the number of computers divided by the number of employees. It has been used, among others, by Hollenstein [21].
- *Computer users.* This indicates the percentage of the workforce that use computers in their daily work. It is a very common variable in the literature on ICT adoption, since it is a particularly good measure of computer usage in the workplace [12, 19, 30, 35].

- *Videoconference.* This binary variable equals one if the firm has videoconferencing equipment. It has been used as a dependent variable in several papers on ICT [53].
- *Intranet and extranet.* These binary variables take a value of one when there is an intranet/extranet at the workplace and zero when there is not. Both these variables have been used to evaluate ICT infrastructure at the firm level in several studies [3, 15, 21, 44, 46, 53].
- *Website*. The questionnaire includes two questions about the presence of this ICT tool in the workplace. The first inquired whether the establishment had its own web page. The second asked whether, if the establishment was part of a group of firms, there was a web page at the corporation level. In the estimations, we use a new qualitative variable that takes a value of one if the answer is yes in either case, and zero when it is negative in both cases. This variable has been tested in several articles [5, 46, 47].
- *E-mail users* indicates the percentage of employees that have been assigned an e-mail account and use it. This variable has been frequently employed in the ICT adoption literature [21, 46, 53].
- *Internet access points per employee*. This variable is defined as the number of Internet access points divided by the number of employees.
- *E-mail accounts per employee* is defined by the number of email accounts divided by the number of employees.

Although, as far as we know, these last two variables have not until now been used in the literature, we believe they might come in useful if we want to analyze the availability of Internet and e-mail infrastructure.

Table 1 reports the descriptive statistics of these variables, as well as the correlation matrix. From the data, we can infer that there are huge differences in the adoption rates of the different ICT applications considered. It is found, for example, that, while 61.7 per cent of the establishments have *Intranet* and 57.1 per cent have a *web page*, only 11.2 per cent of the sample have *videoconferencing equipment* and 17.8 per cent *extranet*.

Table 1. Descriptive statistics and correlation matrix of TIC variables

	Mean	St.dev.	1	2	3	4	5	6	7	8
1. PCs per employee	0.365	0.558								
2. Computer users	44.521	34.828	0.463***							
3. Videoconference	0.112	0.315	0.077	0.164***						
4. Intranet	0.617	0.486	0.182***	0.216***	0.204***					
5. Extranet	0.178	0.383	0.124**	0.254***	0.192***	0.335***				
6. Website	0.571	0.495	0.210***	0.271***	0.160***	0.276***	0.236***			
7. Internet access points per employee	0.224	0.496	0.925***	0.332***	0.020	0.148***	0.073	0.171***		
8. E-mail accounts per employee	0.186	0.279	0.637***	0.458***	0.185***	0.231***	0.196***	0.293***	0.550***	
9. E-mail users	29.137	31.650	0.357***	0.675***	0.174***	0.155***	0.218***	0.272***	0.311***	0.506***

***p<0.01, **p<0.05, *p<0.10

Differences in the provision of ICT infrastructure are not as great. The number of *computers per employee* is 0.36, the number of *Internet access points per employee* is 0.22 and the number of *e-mail accounts per employee* is 0.19. As far as the percentage of users is concerned, an average of 44.52 per cent of the workforce handles a computer, whereas 29.14 per cent use e-mail.

If we take a look at the correlation matrix, we can see that the correlations between the different ICT tools are quite high. The highest correlations are found among the variables that capture ICT infrastructure (e.g., correlation between *PCs per employee* and *internet access points per employee* is 0.92), among the different ICT user variables (e.g., correlation between *computer users* and *email users* is 0.67), and between a given infrastructure and the percentage of employees that use it (e.g., correlation between *email accounts per employee* and *email users* is 0.50)

3.2.2. Independent variables

Competition in the market where the unit sells its goods and services is frequently captured by the number of competitors. Following the article by Baldwin et al. [4] for Canadian companies, we use a binary variable that takes a value of one when the number of competitors in the market is greater than five and zero otherwise.

To measure the importance of industry in ICT adoption, we use three binary variables to show whether the establishment belongs to the agricultural industry, the building industry or the services industry. The reference sector omitted in the subsequent estimations, therefore, is the manufacturing industry.

A binary variable that differentiates between the international and regional or domestic market is used to capture the geographical scope of the market where the establishment operates.

Establishment size is measured according to the number of workers employed. It is considered small if there are fewer than 50, and large if there are more than 250. The category omitted in the estimations is medium-sized establishments, that is, those with between 50 and 250 employees. The number of employees was selected as being representative of business size because of its generalized use in the literature [21, 53].

Company size is measured by the logarithm of the number of establishments in which the firm carries out some part of its activity. Log transformations are usually taken in order to reduce data variance [27, 49, 53].

A binary variable is employed to take into account membership of a higher-level organization with multinational ownership. It equals one if the firm belongs to a business group of this kind and zero otherwise [27].

As far as human capital is concerned, the youth of the workforce is represented by the percentage of employees below the age of thirty, while the qualification level is measured by the fraction of employees with a university degree. This variable has been used in several studies [3, 27].

To examine the role played by strategy, the interviewees were requested to assess, on a scale of 0 to 10, the importance of cost and quality when defining the establishment's competitive strategy. In our analyses we use a variable that takes a value of one when the respondent indicated quality to be more important than cost. As a consequence, the category that is omitted in the empirical estimations corresponds to establishments that assigned at least as many points to cost as to quality for its role in strategic market competition.

In order to capture the implementation of a quality management system in the plant, it was asked whether or not the establishment was certified according to any of the ISO 9000 standards.

Finally, decentralization is measured by a dichotomous variable that indicates whether or not project development teams are used in the workplace. The use of such teams is usually associated with greater worker autonomy and, therefore, with more decentralized decision-making. This variable has been used in other research [3, 21].

Table 2 shows the mean, standard deviation and correlation matrix for these explanatory variables. As for relationships among the independent variables, it can be observed that there is no severe multicollinearity.

Two thirds of the establishments in the sample reported having more than five competitors in their market, whereas 41.4 per cent of them sell their goods or services in international markets. As far as sectoral distribution is concerned, the bulk of the sample is concentrated in the services industry (35%), and the manufacturing industry (40.1%). From Table 2 can also be seen that 43.6 per cent of the whole sample employ fewer than fifty people and 6.8 per cent more than 250. Moreover, 17.2 per cent of the establishments belong to a multinational group. The average proportion of employees below the age of 30 is 28.8 per cent and the average proportion with a university degree is 17 per cent. Only 39.7 per cent of the establishments claimed that they compete mainly on quality. Slightly more than half are certified according to the ISO 9000 standard (51.8 percent) and use project development teams (50.4 per cent).

Table 2. Descriptive statistics and correlation matrix of the dependent variables

	Mean	St.dev.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Competition	0.666	0.472													
2. International	0.414	0.493	0.086												
3. Agriculture	0.129	0.336	0.018	0.076											
4. Building	0.120	0.326	0.168***	-0.254***	-0.153***										
5. Services	0.350	0.477	-0.081	-0.269***	-0.283***	-0.272***									
6. Small	0.436	0.496	0.008	-0.251***	-0.167***	0.207***	0.154***								
7. Large	0.068	0.253	0	0.117***	-0.003	-0.101*	-0.034	-0.240***							
8.No.estab.	0.529	1.197	0.053	0.070	-0.047	-0.034	0.237***	-0.022	0.098*						
9. Multinational	0.172	0.378	-0.031	0.437***	-0.040	-0.146***	-0.192***	-0.279***	0.296***	0.158***					
10. Youth	28.776	21.334	-0.040	-0.028	-0.119**	-0.073	0.210***	0.068	-0.008	0.041	-0.004				
11. Qualification	17.002	20.582	-0.030	-0.117**	-0.070	-0.082	0.266***	0.053	-0.048	0.151***	-0.037	0.088*			
12. Quality	0.397	0.490	-0.001	0.036	0.063	-0.117**	0.080	-0.071	-0.052	0.066	-0.087	0.021	0.085		
13. ISO	0.518	0.500	-0.041	0.299***	0.063	-0.014	-0.312***	-0.236***	0.172***	0.033	0.303***	-0.009	-0.081	0.019	
14. Teams	0.504	0.500	0.056	0.287***	0.049	-0.085	-0.187***	-0.187	0.079	0.023	0.191***	0.073	0.101*	0.089	0.222***

***p<0.01, **p<0.05, *p<0.10

3.2.3. Estimation method

The choice of method to test the hypotheses formulated in the theoretical section of the article depends on the type of dependent variable analyzed [8].

Ordinary least squares (OLS) regression is the standard statistical procedure for explaining the variance in continuous dependent variables. In the case of censored variables, where values below or above a certain threshold - typically zero - are not observed, OLS regression results in inconsistent estimators and predictive values that may fall below the threshold [18].

Then, as the dependent variables are in some cases non-negative variables, left-censored at zero, we have estimated a series of Tobit regression models. The Tobit model [51] is a censored regression model for left-censored data, assuming a normally distributed error term.

Defining Y_i as the i^{th} observation on the dependent variable and Y^*_i as its corresponding latent value, the Tobit model can be represented by the following censoring rule:

$$\text{if } Y^*_i \bullet 0 \text{ , then } Y_i = 0 \ ; \qquad \text{if } Y^*_i > 0 \text{ , then } Y_i = Y^*_i \tag{1}$$

where the latent dependent variable Y^*_i is described by the regression equation

$$Y^*_i = x'_i \text{ß} + \mu_i \qquad \text{with } \mu_i \sim N(0, \ ^2) \tag{2}$$

The same caveats for OLS regression apply, when the dependent variable is binary and can therefore take only one of two values. In these cases we have estimated probit models. In these models:

$$\text{if } Y^*_i \bullet 0 \text{ , then } Y_i = 0 \ ; \qquad \text{if } Y^*_i > 0 \text{ , then } Y_i = 1 \tag{3}$$

where the latent dependent variable Y^*_i is described by the regression equation

$$Y^*_i = x'_i \text{ß} + \mu_i \qquad \text{with } \mu_i \sim N(0, \ ^2) \tag{4}$$

All our models are estimated with Limdep, version 8 [18].

4. RESULTS

Table 3 presents the estimates of the tobit models for *PCs per employee*, *Computer users*, *Internet access points per employee*, *E-mail accounts per employee* and *E-mail users*. The five models are statistically significant at the one per cent level and all include a large number of variables with coefficients that are statistically significant different from zero.

The number of *PCs per employee* is positively influenced by the size of the establishment, as shown by the coefficients of large and small, which are significantly different from zero. From the positive sign of the coefficient of the first variable and the negative sign of the second, we can deduce that size has a negative effect on the value of this variable. The percentage of employees with a university degree is also observed to have a positive effect on the presence of this infrastructure. As far as industrial sector is concerned,

only building industry units behave differently from those in other sectors. Firm ownership characteristics, such as multinational ownership and total number of business units, also encourage computer adoption. Finally, ISO 9000 certification and the pursuit of a quality strategy boost the number of *PCs per employee.*

Coefficient estimates for *computer users* are fairly similar to those found for *PCs per employee*. Thus, employee qualification, multinational group membership, and total number of establishment show a strongly positive effect. Fewer ICT users are found in the building and agricultural industries. Establishment size also has a negative, though considerably weaker, effect. On the organizational side, the use of project teams has a positive impact on the level of *computer use*.

The coefficients on the number of *Internet access points per employee* are essentially expressions of the negative effect of size, together with the positive influence of employee qualification and presence in international markets. At the same time, firm strategy and ISO 900 certification have considerable relevance. Finally, we should stress that correlation with the dependent variable is not as strong in agricultural business units.

The variable *email accounts per employee* follows in this same direction in its correlation with employee qualification and international market presence. In this case, moreover, membership of a multinational group is seen to have a beneficial effect, while that of plant size is negative.

The percentage of *e-mail users* is lower in agricultural establishments. Meanwhile, as in other dependent variables, a quality-based competitive strategy and a university-educated workforce lead to higher percentages of *e-mail users*. With respect to the size variable, business unit size shows a slightly negative effect, while the effect of firm size is positive.

Table 4 displays the estimated probit coefficients for the variables that measure adoption of *videoconference, intranet, extranet* and a *webpage*. As in the previous table, all the probit models are globally significant at the one percent level.

Videoconference is more likely in non-agricultural units and in those with fewer than five competitors in the main product. The effect of the multinational variable, meanwhile, is positive, as is the impact of project development teams and ISO certification.

Table 3. Tobit estimations for *Pcs per employee, Computer users, Internet access points per employee, E-mail accounts per employee* and *E-mail users*

	Pcs per employee		*Computer users*		*Internet access points per employee*		*Email accounts per employee*		*Email users*	
	Coef.	t-ratio	Coef.	t-ratio	Coef.	t-ratio	Coef.	t-ratio	Coef.	t-ratio
Constant	0.0635	1.436	19.140***	2.712	0.0120	0.329	0.0123	0.609	21.5681***	3.667
Competition	0.0061	0.222	-0.7301	-0.166	-0.0300	-1.299	0.0146	0.610	-3.9071	-1.052
International	0.0275	0.870	0.1466	0.029	0.0461*	1.752	0.0632**	2.315	0.3473	0.083
Agriculture	-0.0638	-1.560	-11.3304*	-1.774	-0.0686**	-2.009	-0.0229	-0.651	-13.6004**	-2.517
Building	-0.1020**	-2.206	-14.2543**	-1.974	-0.0191	-0.499	-0.0475	-1.184	-9.692	-1.562
Services	0.0451	1.276	5.9529	1.069	0.0386	1.313	0.0489	1.602	1.1508	0.244
Small	0.0824***	2.908	5.908	1.312	0.0668***	2.925	0.0191	0.780	-3.0542	-0.805
Large	-0.1655***	-3.100	-15.558*	-1.867	-0.0705	-1.591	-0.0858*	-1.866	-12.5564*	-1.718
No.estab.	0.0299**	2.539	3.6054*	1.839	0.0072	0.745	0.0123	1.220	2.9764*	1.778
Multinational	0.1012**	2.497	13.5962**	2.092	-0.0030	-0.090	0.0736**	2.105	6.2454	1.149
Youth	-0.0004	-0.616	0.0363	0.371	-0.38e-4	-0.076	-0.0005	-1.113	-0.0798	-0.979
Qualification	0.0084***	12.443	0.8837***	7.736	0.0053***	9.694	0.0030***	5.219	0.7212***	7.745
Quality	0.0509*	1.926	5.1097	1.223	0.0512**	2.333	0.0284	1.248	6.1473*	1.741
ISO	0.0689**	2.414	4.9487	1.101	0.0605**	2.552	0.0330	1.341	-4.9660	-1.312
Teams	0.0321	1.167	10.2229**	2.361	0.0270	1.183	0.0356	1.501	6.8599*	1.860
Sigma	0.2301***	25.884	35.5324***	21.984	0.1911***	25.884	0.1980***	25.275	30.1979***	22.946
Chi-2	196.998***		213.938***		132.710***		72.336***		103.560***	
N	335		337		335		334		332	

***p<0.01, **p<0.05, *p<0.10

The *Intranet* adoption results indicate a similarly positive effect for competition, multinational ownership and ISO certification. They also show that the size of the business unit exerts a positive impact, as do the number of establishments in the firm and the pursuit of a quality-based competitive strategy.

Table 4. Probit estimations for *Videoconference, Intranet, Extranet* and *Website*

	Videoconference		*Intranet*		*Extranet*		*Webpage*	
	Coef.	t-ratio	*Coef.*	t-ratio	*Coef.*	t-ratio	*Coef.*	t-ratio
Constant	-3.777***	-4.949	-0.1327	-0.505	-1.4536***	-4.507	-0.3642	-1.328
Competition	-0.8330***	-2.785	-0.4040**	-2.345	-0.1537	-0.798	-0.3127*	-1.771
International	0.0564	0.157	0.1701	0.907	0.2326	1.016	0.8243***	4.183
Agriculture	0.7732**	2.039	0.1306	0.534	0.1044	0.362	-0.3864	-1.552
Building	-7.5812	0	0.1170	0.439	-7.0814	0	-2.0015***	-3.978
Services	-0.0360	-0.082	0.2847	1.340	0.5814**	2.232	0.0405	0.189
Small	0.3051	0.863	-0.2371	-1.434	-0.3118	-1.449	0.0965	0.543
Large	-0.1362	-0.332	1.0756*	1.848	0.3506	1.125	0.0292	0.078
No.estab.	0.0101	0.082	0.3398***	2.842	0.1209	1.639	0.3692***	2.887
Multinational	1.5563***	4.495	0.4740*	1.664	0.4549*	1.818	0.5134*	1.674
Youth	-0.0106	-1.512	-0.0018	-0.513	-0.0077*	-1.657	-0.0034	-0.901
Qualification	0.0034	0.474	0.0010	0.260	0.0074*	1.742	0.0024	0.592
Quality	0.4375	1.527	0.4290***	2.667	-0.0717	-0.376	0.2448	1.436
ISO	1.2589***	2.654	0.3719**	2.192	0.3335	1.527	0.3573*	1.959
Teams	1.6097***	3.745	0.2412	1.457	0.1614	0.790	0.3914**	2.221
Chi-2	95.475***		69.853***		52.534***		140.848***	
Pseudo-R2	45.349		15.887		17.602		31.076	
N	332		333		333		332	

***p<0.01, **p<0.05, *p<0.10

The *extranet* results reveal this technology to be more widely used in the services industry and in multinational firms. It is also necessary to stress the role played by workforce composition. The more university graduates and employees aged over thirty there are in the workforce, the more likely firms are to adopt Extranet.

Finally, the presence of a firm *web page* is more widespread in firms competing in an international market and facing less competition, while they are less common in the building industry. Membership of a multinational company and the number of business units again

have a positive effect. Lastly, the presence of a *website* is positively associated with ISO 900 certification and with the use of project development teams.

5. DISCUSSION AND CONCLUSIONS

In this paper we have analyzed the role that is played in the adoption and usage of different ICT tools by five factors: environment, structural firm characteristics, human capital, competitive strategy and organizational structure. To fulfil the goal of the article we have employed data from a sample of 337 workplaces from different sectors of economic activity.

Except in a few specific cases, the hypotheses on the influence of firm environment have not been confirmed. In general, neither competition nor presence in international markets is significantly associated with the ICT adoption. Nor do we appreciate any differences between the two most representative sectors of economic activity, namely, manufacturing and services. This suggests that ICT incidence should be analyzed at a lower level, such as the firm or establishment.

There is a contrast between the results for the two hypotheses on human capital. Our results highlight, in particular, the complementarities between the general level of employee qualification and their use of ICT. However, the workforce age profile lacks any relevance to the diffusion of ICT. This proves that, even in an environment such as Spain, where the introduction of these technologies is quite recent, age is not proving to be an obstacle to their diffusion within firms.

The results show a clear influence of firm structural characteristics on the different types of ICT analyzed. Of all the explanatory variables included in the article, membership of a multinational group is undoubtedly the most powerful to characterize organizations that have adopted ICT. As happens in areas outside technology management, foreign investment appears to be a strong driver of ICT adoption. It is therefore worth underlining its contribution as a generator of productive improvements in business management in a given geographical region.

The hypothesis advanced in support of a positive relationship between size and ICT incidence is only partially confirmed. Whereas for firm size in terms of the number of establishments, the proposed effect is seen to be present, the relationship with the number of employees turns out to be negative. This has important implications for public policies in support of ICT adoption. Traditionally, government policies have focused support for ICT implementation on small size establishments. The results obtained in this paper recommend a review of this policy, however, since small workplaces do not currently appear to be at a disadvantage; in fact the opposite is found to be true.

The observed association between strategy and ICT in this paper is not unambiguously clear. Nonetheless, a weak link between ICT adoption and the search for competitive advantage through quality seems to have been detected. In our view, this result should be interpreted as a consequence of weak incorporation of strategy in decision-making across the different departments of the firm.

Regarding ties with organizational structure, we should underline the following findings. On one hand, the use of project development teams is closely linked to the two variables that measure the percentage of users (computer and email users). This seems fairly logical, since these variables are directly linked to workers' daily job reality. As in the case of ICT users, employees are the main elements around which organizational structures, such as project development teams, revolve. On the other hand, the certification of a quality assurance system is linked to the presence of several types of ICT infrastructure. Thus, the relationship that emerges is different from the one found with project teams. This is because the ISO system is aimed at formalizing work processes. The impulse for its implementation usually comes from the top of the hierarchy, and does not necessarily take into account the views of employees. In consequence, although firms have understood the importance of ICT infrastructure for ISO 9000 certification, they still have some distance to cover in terms of its application in the daily routine of their employees.

The main limitations of the study lie in the nature of the information used. Firstly, they are data for a single region, which may limit the potential generalization of the results. Different levels of ICT diffusion may be linked to differences in the factors of incidence. The second limitation has to do with the cross-sectional nature of the data. The use of this kind of data hinders the unambiguous detection of causality relationships. As a result, the findings are confined to the confirmation or otherwise of associations between ICT adoption and other firm related variables.

Future research should be aimed at conducting a dynamic analysis of the subject, incorporating longitudinal information that could lead to a more accurate assessment of the nature of the relationship between ICT and other firm management variables. In this way, it would be possible not only to determine the impact that different variables exert on ICT adoption, but also to analyze the influence of ICT as a driver of change in other areas of management.

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