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INFORMATION TECHNOLOGIES AND FINANCIAL PERFORMANCE: THE EFFECT OF TECHNOLOGY DIFFUSION AMONG COMPETITORS♦

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Abstract:

This research analyzes the implications that uneven diffusion of IT among firms populating an industry has on profitability. With this aim we move away from the dominant RBV approaches and focus on the competitive dimension of the technology. We argue that the IT imitation process is much more complex and heterogeneous than implicitly assumed on current research. Indeed, in our framework it is this heterogeneity what allows for the existence of IT-based competitive advantages. We investigate how the adoption patterns of competitors influences firm profitability through its *relative position* in terms of IT implementation. We test our propositions through the analysis of ATM diffusion in the Spanish Savings Banks between 1986 and 2004. We find that it is not the absolute but the relative level of implementation what drives the profitability impact of IT. In addition, we find that over time, as a "technological race" takes place, any potential benefit obtained with IT adoption is dissipated, resulting on an aggregated negative impact on profitability.

Key words: IT, Technological Diffusion, Relative Position, ATM, Savings Banks,

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1. INTRODUCTION

The introduction of new technologies, their shortening lifecycle and their fast rate of diffusion have redefined the characteristics and boundaries of many industries, posing complex challenges to the strategic management field (Bettis and Hitt, 1995). Specifically, the wide diffusion of new technologies is placing competitive pressure on firms, making the choice of appropriate strategic responses necessary. Firms are forced to react to the adoption of new technologies by competitors under the threat of competitive disadvantage (Abrahamson and Rosenkopf, 1993).This phenomenon has been especially relevant in the case of Information technologies (IT), the type of technology on which we will focus. As a consequence, their adequate management has become a prime concern for strategic management.

The evidence that competitors quickly react to the introduction of new technologies by rivals makes value appropriation a main concern for technology management (Teece, 1986). When a firm introduces a new technology, appropriation can be achieved through the use of certain mechanisms such as patents, secrecy, lead time or pre-emption in complementary assets (Teece, 1986; Levin et al, 1987). Nevertheless, some of these mechanisms have been shown to be relatively ineffective in the past. For example, patents tend to provide weak protection, as reverse engineering, information disclosed in the patenting process or "inventing around" allow competitors to imitate the technology (Mansfield et al, 1985; Levin et al., 1987; Lieberman and Montgomery, 1988; Harabi, 1995). Keeping secrecy around new technologies is also a difficult task, since a number of mechanisms such as worker mobility or formal and informal communication networks diffuse information and makes copy possible within relatively short periods of time (Mansfield, 1981; Lieberman and Montgomery, 1988; Mata et al, 1995).

Value appropriation becomes even more difficult when the technology is widely available within the industry. This is an extreme case in which neither patents nor secrecy can be used as protection mechanisms. In this context, the mechanisms that explain value appropriation are related to the nature of the technology, the development of complementary assets and the strategic actions taken by firms (Teece, 1986; Levin et al, 1987; Harabi, 1995). Even if they do not prevent from full imitation, they could delay the process or at least prevent imitators from being as efficient as the innovator (or first adopter) at exploiting the technology. In such a setting, the wide diffusion of successful technologies and competitor imitation will be the norm rather than the exception. Therefore, understanding the process of imitation and the competitive dynamics that it triggers becomes a critical task for firm managers.

Our main objective in this paper is to shed light on the consequences of competitive imitation on firm profitability. More precisely, pioneer firms adopt new technologies in the expectancy of achieving competitive advantage, but competitive advantage is eroded as followers also introduce the technology. Imitation is possible thanks to the wide availability of the technology and the relative ineffectiveness of protection mechanisms. Therefore, we are in a position close to the one described by Clemmons and Kimbrough (1986) or Clemmons and Row (1991), in the sense that the decision to adopt the new technology is seen as a *strategic necessity* for the firm: its critical impact on performance makes adoption necessary for any firm to obtain normal profits, but its wide availability makes competitive parity the only result that a firm can expect from adoption.

Taking these ideas as a departure point, our main contribution is to assess the role of technology diffusion at explaining the differences in profitability attributable to the adoption of a new technology. We focus on the evolution of these differences over time. More precisely, our framework attributes a limited importance to the *level* of adoption of the technology and changes its focus towards the *relative position* of the firm regarding the exploitation of the technology at explaining firm profitability. The reasons to focus on IT are varied. First, it is important to note that IT are paradigmatic in the study of strategic necessities. Since almost every activity of the firm generates information, these technologies are ubiquitous and can be applied to a wide array of activities (Parsons, 1983; Porter 1985; Porter and Millar, 1985). In other words, IT have a critical impact over activity performance (Rai et al, 1997). Second, information technologies are frequently acquired externally, are available to any competitor and are extremely difficult to keep proprietary (Mata et al, 1995; Carr, 2003), thus allowing for wide imitation. Thirdly, the literature that focuses on their impact over performance is more developed than in the case of any other technology, providing us with more consistent theoretical developments from which to build our proposal.

The rest of the paper is structured as follows. In the Second Section we present an overview of the literature that analyzes the impact of IT on firm performance. We outline the main research streams that explain the relationship between IT and performance and emphasize the points which, in our opinion, need further development. Section Three presents our hypotheses, which focus on the consequences of the competitive process on profitability. Section Four describes our sample and estimation methods and Section Five analyzes the results. We conclude the paper by discussing the main implications of our research and the main recommendations that can be drawn for the management of IT.

2. LITERATURE REVIEW

2.1. IT and the strategic necessity hypothesis

During their early development, IT raised high expectations about their potential to generate increases in business performance. In the 80's, case studies characterized IT as a groundbreaking technology which would redefine the basis of modern competition (Parsons, 1983; McFarlan, 1984; Porter and Millar, 1985). The expected competitive advantages derived from IT would stem from different sources, depending on their use and characteristics. In the case of internally focused innovations, the improvements in information availability and coordination would lead to efficiency increases (Porter and Millar, 1985). For externally oriented IT, reduced transaction costs, increased value and the creation of consumer switching costs (Clemons, 1986) would increase the performance of those firms that adopted them faster, giving way to the so-called *create-capture-keep* paradigm (Clemons and Kimbrough, 1986).

However, a decade later, the picture seemed to be rather different. The *create-capture-keep* paradigm had been rejected as a source of competitive advantage and superior performance (Mata et al., 1995). IT were increasingly understood as a commodity and their potential for achieving competitive advantage vanished. Some authors went even further and argued that the extensive use of IT placed their adopters in a situation of competitive disadvantage, given the high investments needed (Kemerer and Sosa, 1991), the unpredictable impacts on industry structure (Vitale, 1986) or the existence of cheaper and more efficient solutions to the same problems (Warner, 1987). This change in the way of thinking about the value of IT went hand in hand with the difficulties that existed to find any benefits attributable to them when using rigorous econometric methods instead of case studies. Thus, some authors began to talk about a *productivity paradox* (Solow, 1987; Brynjolfsson and Hitt, 1996).

At the firm level, some authors attempted to solve this apparent contradiction between case studies and quantitative analyses by means of the ideas of the resource-based view and formulated the *strategic necessity hypothesis* (Clemmons and Kimbrough, 1986; Clemmons and Row, 1991). According to them, the lack of support of a positive relationship between technology adoption and competitive advantage is a consequence of the commodity character of IT. Since any firm interested in IT can acquire and put them into use, any potential benefit stemming from the new technology will be lost through competition and the consequence of the investment will be competitive parity (Barney, 1991). Thus, the adoption of the new technology becomes *a necessity* and firms that delay it experience competitive disadvantages that result in performance and market share penalization. The implications of the strategic necessity hypothesis could be synthesized in two points: i) those firms failing at adopting the technology will likely experience a sharp reduction on their competitiveness, ii) the only reward that adopters can expect is competitive parity.

The strategic necessity hypothesis does not reject the idea that IT are valuable, but points out that competition will dissipate any competitive advantages stemming from them. Actually, empirical research has demonstrated that IT do provide adopters with benefits in the form of increased labor and administrative productivity or cost efficiency (Hitt and Brynjolfsson, 1996; Rai et al, 1997). However, these improvements do not directly translate into higher levels of profitability, which may suggest that global performance depends on additional factors that have yet to be identified. To the extent that current research on that stream does not provides us with consistent results, it is not possible to offer firm's managers adequate guidelines to deal with IT.

2.2. Theoretical approaches to the effect of IT on business performance

Recent *theoretical research* provides evidence which is useful to assess the value of IT and their appropriate management. This literature centers on determining the conditions in which IT can be a source of competitive advantage. From a theoretical point of view, it is possible to distinguish two relevant research streams. The first one is grounded on *contingency theory* (Schoonhoven, 1981; Tosi and Slocum, 1984; Drazin and Van de Ven, 1985; Ginsberg and Venkatraman, 1985). Contingency theory posits that there is no a *best practice* valid in any situation; instead, the optimal behavior varies from firm to firm. Strategy will be specific to the contingent factors the firm faces and the final outcome is determined by the fit between these factors and the strategy followed by the firm (Schoonhoven, 1981; Tosi and Slocum, 1984; Drazin and Van de Ven, 1985).

When contingency theory is analyzed within the context of IT, the key concept is the one of strategic alignment between IT and the strategy of the firm (Weill and Olson, 1989; Henderson and Venkatraman, 1993; Chan and Reich, 2007; Oh and Pinsonneault, 2007). This literature considers that the technology does not generate value *per se*. It is the alignment between IT and firm strategy which leads to higher levels of performance (Henderson and Venkatraman, 1993; Zahra and Covin, 1993; Chan and Reich, 2007). However, the empirical results are still inconclusive and further work in this field is necessary (Oh and Pinsonneault, 2007).

The second theoretical approach usually employed to asses the contribution of IT to firm performance is based on the resource-based view (RBV) of the firm (Wernerfelt, 1984; Barney, 1991; Peteraf, 1993; Amit and Schoemaker, 1993). A narrow interpretation of this approach -considering IT just as a type of resource- leads us back to the arguments provided under the strategic necessity hypothesis previously examined. Therefore, a first approximation of the RBV to the evaluation of the impact of IT would lead us to conclude that they could not generate competitive advantage because of its non-proprietary character and its wide availability. Nevertheless, the RVB has also recognized that firm resources do not provide their services in isolation, but with the collaboration of other resources that together form capabilities and are more difficult to imitate. For example, in the context of the appropriability of the value created by innovations, Teece (1986) highlights the importance of complementary resources at the time of securing a greater share of the value provided. This line of research shows that complementarities in certain resources and capabilities, such as production and services, are one of the most important isolating mechanisms preventing efficient imitation from competitors (Cohen, Nelson and Walsh, 2000). Similarly, research on the diffusion of new technologies recognizes not only that new technologies could be complementary (Stoneman and Kwon, 1994), but also that these complementarities could be extended to work practices (Colombo and Mosconi, 1995).

In the case of the capability of IT to generate competitive advantage, it has been found that these complementary critical resources exist in forms as diverse as IT management skills (Mata et al, 1995), human and business resources (Powell and Dent-Micallef, 1997) or IT enabled intangibles (Bharadwaj, 2000). It is only the rational use of IT to leverage these types of resources what grants the firm competitive advantages and abnormal rents.

The RBV seems to have been the preferred framework to explain the relationship between IT and firm performance (Melville et al, 2004; Ravichandran and Lertwongsatien, 2005). Nevertheless, it is important to note that, while both theoretical approaches are presented here as alternative (Oh and Pinsonneault, 2007), researchers on the RBV have frequently considered that the alignment between organization, technology and strategy can be seen as a kind of resource: the strategy integration capability (Powell, 1992; Powell and Dent-Micallef, 1997; Ravichandran and Lertwongsatien, 2005). Therefore, in a sense, the RBV could be seen as (at least partially) capturing the contents of contingency theory.

2.3. IT diffusion among competitors and competitive advantage

A shared point between the strategic necessity hypothesis, the RBV and the contingency approaches is that IT do not generate competitive advantages by themselves. Instead, these advantages arise when IT are used to leverage scarce and difficult to imitate resources belonging to the firm or when IT are correctly aligned with firm strategy (Mata et al, 1995; Powell and Dent-Micallef, 1997). Accordingly, the elements that are important for achieving competitive advantage are located within the boundaries of the firm, in its resource endowment. This reasoning has been criticized because it does not sufficiently reflect the role played by the competitive environment in which the firm operates (Porter, 1991; Spanos and Lioukas, 2001).

The streams of research reviewed in the previous subsections treat the competitive environment in a simple and passive way. The influence of competitors' actions on the profitability of the focal firm is restricted to their ability to match the resources owned by the firm, which, in turn, depends on their scarcity, imitability and mobility (Barney, 1991). Importantly, those approaches do concentrate in the commodity character of IT, paying limited attention to their diffusion process. The unstated premise is that the diffusion of the technology among rivals is virtually instantaneous, rendering the imitation process of no interest. In contrast, the research on technology diffusion has shown that, even when a technology is readily available, its diffusion takes long time to be completed, both among different firms (Griliches, 1957; Mansfield, 1961) and within the organization (Battisti and Stoneman, 2005; Fuentelsaz, Gómez and Polo, 2003). In addition, different factors such as the lack of complementary resources or incompatibility with the current strategy can prevent some firms from exploiting technology as successfully as others, creating persistent differences in their level of implementation (Battisti and Stoneman, 2003; 2005). As a consequence, our research focuses on the implications that uneven diffusion of the technology among competitors has on profitability (instead of looking at the integration of the technology within firm's resource endowment -RBV perspective- or within firm strategy -contingency theory perspective).

Firm success depends on the *attractiveness of the industry* in which it operates and on its *relative position* (Porter, 1980; 1991). The former depends on the concurrence of five competitive forces which influence average profitability: bargaining power of suppliers, bargaining power of customers, rivalry within the industry, threat of substitute products and entry threat by new competitors Porter, 1980). *Relative position* refers to the position of the firm within the industry in comparison with the position held by its competitors. It depends on the configuration of activities that every firm chooses to implement (Porter, 1991, 1996). As a consequence, an organization may show a highly efficient configuration of activities but, when its direct competitors are equally efficient, the focal firm's relative position will not be strong and so neither its profitability. Conversely, a firm with a relatively inefficient configuration of activities may obtain profitable relative positions in industries where competitors are unable to optimally configure their value chain. In other words, the competitive position of a firm should be assessed not in absolute terms but in comparison with its direct competitors.

In the extent that industry attractiveness includes factors that affect similarly to all the firms that compete in the industry, it can not explain intraindustry performance differences. As a consequence, to analyze how IT influence firm profitability we will focus on the concept of *relative position*. In the following section, we develop some theoretical arguments that explain how firm implementation of specific IT applications and its diffusion among its direct competitors influences firm's results depending on their relative position in the market[1].

3. HYPOTHESES

With the aim of framing our argumentation, it is important to set bounds to IT decisions that will be considered in this research. We will use the term technology strategy to make reference to the firm's approach to the development and use of technology (Porter, 1985). Accordingly, the term includes decisions regarding the technologies the firm is going to develop, the choice of an adequate approach to exploit them and decisions about a licensing strategy.

In the case of IT, firms have limited possibilities to decide about these dimensions. Firstly, given that the development of IT usually takes place outside the company, firms do not have to decide about which technology to develop. Their only decision is whether to adopt the technology which is diffusing in the industry. Secondly, the wide availability of IT renders them difficult or impossible to keep proprietary (Mata et al, 1995; Carr, 2003). Thus, decisions regarding technology licensing are also out of the control of the adopting firm. The only technology strategy dimension under the control of the firm is the choice of an appropriate implementation to exploit it. Specifically, our analysis focuses on the automation dimension of firm activities that result from the adoption of additional units of the technology (Zahra and Covin, 1993). In this context, we study the competitive implications of the decision to adopt the technology, as well as the intensity of adoption.

[1] The diffusion of a new technology among the firms populating the industry also influences its attractiveness (Porter, 1985). Schroeder (1990), for instance, describes how the diffusion of a new process technology (Flaskless Matchplate Molding) altered the bargaining power of different agents and dramatically increased the rivalry by generating overcapacity in the founding industry. As a result, the average profitability decreased.

3.1. IT implementation and competitive advantage

Under this setting, it is clear that the implementation of a technological strategy implies the acquisition and deployment of technological assets along the firm. To the extent that these assets are generally non-proprietary (Mata et al, 1995) and that they are widely available through the industry as commodities (Carr, 2003), the sheer acquisition and deployment of IT can not generate competitive advantages. As mentioned above, Clemmons and Row (1991) coined the term strategic necessity to make reference to both, the imitability of technological assets and the need to adopt them in order to achieve competitive parity. In other words, under their view, IT are unable to place the adopting firm in a favorable competitive position, but failing to adopt them would provide the firm with *under normal* profits.

Moreover, the assimilation of new technologies can be a difficult task. The strategy of a firm is the result of balancing the different activities that the firm performs in order to define its position in the market. This is a complex process that requires taking care of the potential trade-offs between these activities and optimizing their fit (Porter, 1996). New technologies can disrupt the configuration of activities inside the firm (Lengnick-hall, 1992) and their adoption will make necessary to reach a new balance with the aim of establishing an adequate business strategy (Porter, 1996). This adaptation may be costly, because the new technology may disrupt the firm investment plan, internal political dynamics and the established culture (Hannan and Freeman, 1984). Thus, the adoption and exploitation of IT cannot be done without significant efforts and adjustments in the firm, being the disruption larger the more intense the implementation of the IT.

> ***Hypothesis 1****: the extent of implementation of IT will have a negative effect on firm profitability*

The firm can be seen as a collection of interrelated activities that define the competitive position that it holds in the marketplace (Porter, 1991). Designing the strategy consists in defining an appropriate configuration for these activities, optimizing their fit, complementarities and trade-offs (Porter, 1996). From this conceptualization, the basic unit of analysis at studying competitive advantage is the activity, and the impact of IT adoption on firm competitive position depends on the impact of IT on the different activities that the organization performs: a firm will improve its position in the market as long as the new technology improves the efficiency of a set of activities that defines its value chain.

Previous research has confirmed that the performance of the activities carried out by the firm improves after the adoption of IT (Hitt and Brynjolsson, 1996; Rai et al, 1997). Every activity in the value chain generates and uses information in some form, with varying degrees of intensity (Porter and Millar, 1985). Therefore, IT can contribute to the performance of activities anywhere in the firm, enhancing the competitive position of every adopter. Nevertheless, IT are readily available in the market, so any rival can also adopt it resulting on the dissipation of relative advantages obtained with the IT application and stability of their *relative positions*.

Competitive advantage and superior profitability accrue to firms that perform their activities at a collectively lower cost than rivals or perform some activities in unique ways that create buyer value and allow the firm to command a higher price (Porter, 1991). Therefore, the existence of competitive advantages should be examined within the competitive scope of the firm. Only firms being able to implement the IT more intensively than its direct competitors will obtain higher efficiency improvements of their value activities, enjoy a better relative position and, as a consequence, obtain superior profitability. As a consequence of the different strategies followed by competitors in the market, sustained by different configurations of activities (Porter, 1996), there will be persistent differences in the level of technology implementation and, in turn, on profitability impact of IT. Indeed, it is this heterogeneity in the deployment of IT what allows for the existence of competitive advantages based on IT adoption.

> ***Hypothesis 2****: Higher relative technology implementation positively influences firm profitability*

3.2. IT impact on profitability over time

The analysis of the internal development of technologies has been subject of study for decades (Mansfield, 1963; Astebro, 1995; Cool, Dierickx and Szulanski, 1997; Fuentelsaz, Gomez and Polo, 2003; Battisti and Stoneman, 2005). One of the key findings in this research is that the intensity and speed of deployment of the technology within the firm (*intrafirm diffusion*) is explained by the so-called decision theoretic diffusion models (Battisti and Stoneman, 2005). These models suggest that managers decide about the appropriate implementation of a new technology with the aim of maximizing its impact on profitability. Profitability is conditioned by factors such as the order of adoption -*order effects*-, the number of firms using the technology -*stock effects*- or firm, technology and environment characteristics -*rank effects*- (Karshenas and Stoneman, 1993; Battisti and Stoneman, 2005). According to decision theoretic models, differences in the timing and intensity of adoption among firms are the result of differences in the above mentioned factors.

The previous subsection indicated that the relative level of implementation of direct rivals influences the benefit a firm is able to obtain from IT. Therefore the level of technology deployment of the firm rivals will place competitive pressure on the firm, which will try to leapfrog them to obtain competitive advantage and profitability. Similarly, once the firm reacts to rivals' IT deployment, they will counter attack, increasing competitive pressure leading to an increase in the deployment of the technology. These dynamics imply that firms will engage on a "*technological race*" consisting on a process of continuous increases in technological implementation.

If the efforts needed for increased level of implementation had no negative impact on firm performance we would observe a cycle of mutually reinforcing technological competition, leading to an industry populated by more efficient and productive firms, in a similar way to the learning process that Barnett and Hansen (1996) call "Red Queen Competition". However, as we pointed above, the deployment of new technologies requires efforts and adaptation by the adopting firm, which eventually can harm its performance. Thus, while the relative implementation of the different firms may be stable through time, the level of technological efforts needed to hold their relative positions will not. Consequently, the "technological race" generated in the process will lead to a progressive reduction of the benefits obtained with the technology as a consequence of the increased effort to "stay in the race".

Hypothesis 3a: *the profitability impact of IT is higher in the first stages of diffusion of the technology.*

However, it is not easy to sustain this process. As the technological race advances, the level of technology implementation required to maintain the relative position will also increase, reducing the profitability of staying in the race, so the incentive of every firm to continue with the intrafirm diffusion process will also decrease. Overtime the negative effect of time on profitability will be lower as a consequence of the decreasing rate at which firms will try to increase their level of technology deployment. Eventually, further increases on relative adoption will be offset by the costs of implementation required, slowing the process and, as a consequence, the negative effect of time on profitability.

> ***Hypothesis 3b:*** *the negative effect of time on the profitability obtained with the technology will be decreasing in magnitude over time*

4. DATA AND METHODS

4.1. The adoption of ATM by Spanish Savings Banks

Our theoretical model will be tested in the context of the diffusion of Automated Teller Machines (ATM) in the Spanish savings banks market between 1986 and 2004. This industry is especially suitable for our analysis because it is possible to accurately identify the markets in which every firm operates. Retail banking activities have a clear local character (Kwast et al., 1997; Simons and Stavins, 1998). The basic tactical unit in the savings banks strategy is the branch (Fuentelsaz and Gómez, 2006). Through their branches, savings banks obtain their basic input (money in the form of deposits that is converted into credits) and provide their services. By observing the location of the branches, we can determine the market served by every firm and identify its closest competitors (Chen, 1996). This identification is crucial in our model, since we stress the importance of comparing the actions of the firm with the ones of its direct rivals (and discarding the actions adopted by firms with no market overlap, Chen, 1996).

We consider that ATM are an appropriate technology for our purpose because of three main reasons. Firstly, this technology has been identified as a strategic necessity in the financial sector (Banker and Kauffman, 1988; Clemmons and Knez, 1988; Clemmons and Row, 1991). In a different setting, it has been proved that lagged adoption of ATM leads to a decrease in both business performance and market share (Banker and Kauffman, 1988; Hannan and McDowell, 1990; Dos Santos and Peffers, 1995). Secondly, a particularity of the Spanish banking sector is that, given the capillarity of the network (Spain presents the highest number of branches per population in Europe, European Central Bank, 2007), ATM tend to be located within branches. Thus, we can obtain a rather simple and appropriate measure of technology implementation: the number of ATM per branch. Thirdly, the process of diffusion of ATM has been very intensive between 1986 and 2004, the period in which our analysis is focused. Their availability increased from 3,058 to 30,349 units in only 18 years and we can observe the effects of the diffusion process of the technology among competitors almost from its beginning.

The data were collected from the Spanish Confederation of Savings Banks (CECA) and the National Institute of Statistics (INE). From INE, we gather information about the evolution of the population in the 52 provincial markets that constitute the country and the inflation rate. CECA publishes every year the balance sheets and financial statements of every firm, as well as the distribution of their branches among the 52 provinces.

4.2. Variables

Dependent variables

Our dependent variable is firm profitability. We approach it through two financial measures: Return on Assets (*ROA*) and the ratio of operating profits to total assets (*Margin*).

Independent variables

The two key variables in this research are those related to the adoption of the technology: the extent of implementation and the relative adoption by the firm. The former *(implementation)* is measured by means of the ratio number of ATM divided by the number of branches. In our opinion, this measure is appropriate both as a measure of intensity of adoption (branches approximate the size of the firm) and from a strategic perspective (branches articulate the strategy).

$$Implementation_{it} = \frac{ATM_{it}}{Branches_{it}}$$

where “i” stands for the firm and “t” for time.

The firm's *relative adoption* is measured as the extent of implementation of the focal firm compared with the reference level. We express it as a ratio because we consider that the relative position should be normalized by the level of implementation of the technology by competitors.

To define this measure, we follow a three step procedure. First, we estimate a market level of implementation in each of the 52 provinces that form the country. To do so (and given that we only have information about the total number of branches and ATM of every firm, but not their provincial distribution), we calculated a weighted average *(market implementation)* that takes into account the number of branches of each firm in every market *k*:

$$Market\ Implementation_{kt} = \sum_i Implementation_{it} \times \frac{Branches_{ikt}}{\sum_i Branches_{ikt}}$$

Second, we calculate an *implementation reference* for every firm that is defined as the weighted (by its market share) average of the market implementation in all the provinces in which the firm operates.

$$Implementation\ Reference_{it} = \sum_k Market\ Implementation_{kt} \times \frac{Branches_{ikt}}{\sum_k Branches_{ikt}}$$

Finally, the relative adoption is calculated as the quotient between market implementation and implementation reference:

$$Relative\ Adoption_{it} = \frac{Implementation_{it}}{Implementation\ Reference_{it}}$$

Control variables

A number of control variables are included in the analysis. First, following conventional structure-performance foundations we include controls for market ***concentration*** and market ***share***. Firms operating in more concentrated markets are expected to obtain higher profitability as a consequence of the potential reduction in competition. Similarly, the efficiency hypothesis usually tested in the literature suggests that market share is usually correlated with firm profitability. To operationalize these variables, concentration is measured through the weighted Herfindahl Index in the market (again, branches are used as weight). Market share of a firm in a given market is also calculated in terms of the number of branches. We also control for firm ***size*** (logarithm of total assets) and firm ***risk*** (total loans to total assets).

Given the potential impact that the diffusion of the technology has on industry attractiveness we also include a control for the density of ATM in every market. Its effect it is not clear. On the one hand, its diffusion among rivals and legitimation in the sector can increase the investment necessary to compete in the market, heightening entry barriers and increasing average profitability. On the other hand, the diffusion of the technology may generate excess capacity, leading to an increase in rivalry. ***ATM densitiy*** in a market (number of ATM per inhabitant) is calculated multiplying market implementation by the number of branches and dividing it by total population. For firms operating in several markets, this variable is weighted by the importance of the market for the firm.

Finally, we allow for firm and year fixed effects to control for the economic cycle and firm-specific unobserved heterogeneity. It is also important to note here that during our observation window there was a number of M&A between savings banks. In order to recognize the potential restructuring influence of these corporate operations, a new fixed effect is considered every time that a merger takes place. Descriptive statistics on all the variables are provided on table 1.

4.3. Estimation Strategy

Following our discussion in the previous section, the basic structure of the model can be expressed as follows:

$$Y_{it} = \alpha_i + \alpha_t + \beta_1 Concentration_{it} + \beta_2 Share_{it} + \beta_3 Size_{it} + \beta_4 Risk_{it} + \beta_5 ATM\ Density_{it} \\ + \beta_6 Implementation_{it} + \beta_7 Relative\ Adoption_{it} + u_{it}$$

Where Y_{it} is the dependent variable (either margin or ROA) of firm "i" in year "t", "α_i" and "α_t" stand for firm and year fixed effects, "u_{it}" is the error term and the other variables have been previously been defined. To estimate the model, we run a two-way fixed effects OLS. Standard errors are corrected for heteroskedasticity and serial correlation. According to decision theoretic diffusion models, both the level of technology implementation and relative implementation are decisions under the control of the firm. Thus, it is necessary to control for unobserved heterogeneity and a potential simultaneity (Hamilton and Nickerson, 2003). The inclusion of fixed effects is a valid control for time invariant omitted variables (Greene, 2003). However, the long observation window we use in this research (19 years) casts some doubts on the stability of omitted variables. To avoid this problem, we complement the empirical analysis with a two-stage least squares instrumental variables estimations (2SLS-IV) corrected with GMM, treating implementation and relative adoption as endogenous. Standard errors are robust to heteroskedasticity and serial correlation. Following usual methodologies, we use lags of the potential endogenous variables as instruments (See, for instance, Geroski, Machin and Van Reenen, 1993).

5. ANALYSIS OF RESULTS

Table 2 shows the results of the estimation of our model over the 1056 observations available. The first two columns show OLS estimations including just the control variables of the model for both ROA and Margin. The next two columns (3 and 4) show the results of the OLS estimation including the main variables of interest (implementation and relative implementation). The last two columns (5 and 6) show the 2SLS-IV estimations in which we correct for the endogeneity of the decisions regarding technology strategy[2].

The choice of fixed effects is justified on theoretical grounds, since we can track the evolution of every firm over time. Additionally, the use of fixed effects models instead of pooled estimations is supported by the significance of the fixed effects parameters in estimations of the basic model (not shown here). Both, random and fixed effects, control for time invariant unobserved heterogeneity (Greene, 2003). However, Hausman tests shown in the bottom of table 2 confirms the adequacy of fixed effects against random effects models.

[2] Note that using lags of the dependent variable as instruments leads as to lose a number of observations (three periods for every firm). Additionally, those firms for which after dropping three observations just remains one observation are excluded as a consequence of the singleton variables problem that appears when using fixed effects. The appropriate number of lags used as instrument is chosen taking into account underidentification tests and J-statistic (shown on the bottom of table 2).

Table 1: Descriptive Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Minimum	-0,0232	-0,0034	0,0153	0,0158	0,1717	10,0057	0,0000	0,0000	-1,0000
Mean	0,0113	0,0167	0,1511	0,4000	0,5340	14,0374	0,0004	0,8111	-0,5960
Maximum	0,0435	0,0364	0,5322	0,9924	0,8898	17,9301	0,0011	3,2890	11,8508
S.D.	0,0054	0,0056	0,0800	0,2441	0,1307	1,3138	0,0002	0,4917	0,5499
1. ROA	1,0000								
2. Margin	0,5843	1,0000							
3. Concentration	0,0134	-0,0370	1,0000						
4. Share	0,1292	0,2545	0,2927	1,0000					
5. Risk	-0,1317	-0,2657	-0,0624	-0,2839	1,0000				
6. Size	-0,1357	-0,1955	0,4140	0,2499	0,1545	1,0000			
7. ATM Density	-0,1638	-0,4919	-0,0026	-0,3948	0,5528	0,3333	1,0000		
8. Implementation	-0,0931	-0,3438	-0,0152	-0,0860	0,5188	0,4904	0,6461	1,0000	
9. Relative Adoption	0,0446	0,0257	-0,0637	-0,0450	-0,0360	-0,0142	-0,0911	0,2238	1,0000

Table 2: Estimation results

	OLS (1) ROA	OLS (2) Margin	OLS (3) ROA	OLS (4) Margin	2SLS (5) ROA	2SLS (6) Margin
Concentration	0.031 (0.52)	0.0043 (0.67)	0,0013 (0,22)	0,0047 (0,69)	0,0085 (1,55)	0,0079 (1,22)
Share	**-0.0072***** **(-2.64)**	0.0004 (0.13)	**-0,0061**** **(-2,17)**	-0,0019 (-0,64)	-0,0025 (-0,77)	0,0007 (0,20)
Risk	-0.0043 (-1.29)	**0.0068**** **(2.17)**	-0,0038 (-1,15)	**0,0077***** **(2,51)**	-0,0027 (-0,74)	**0,0097***** **(2,86)**
Size	**-0.0055***** **(-3.41)**	**-0.064***** **(-3.72)**	**-0,0048***** **(-3,08)**	**-0,0060***** **(-3,62)**	**-0,0046***** **(-2,63)**	**-0,0039**** **(-2,31)**
ATM density	**-9.8742***** **(-2.81)**	**-7.1379***** **(-2.44)**	**-11,0843***** **(-2,93)**	**-5,7111*** **(-1,83)**	**-13,4437***** **(-3,22)**	**-8,4202**** **(-2,26)**
Implementation	-	-	-0,0003 (-0,25)	**-0,0030***** **(-3,01)**	-0,0014 (-0,84)	**-0,0035***** **(-3,25)**
Relative Adoption	-	-	**0,0016***** **(4.50)**	**0,0014***** **(5,80)**	**0,0044*** **(1,94)**	**0,0049***** **(2,85)**
Year FE	Significant***	Significant***	Significant***	Significant***	Significant***	Significant***
Adjusted R^2	0.241	0.410	0,261	0,433	0,191	0,425
F	10.35***	20.82***	10,74***	22,32***	6,69***	16,72***
Hausman Test	20,48***	47,05***	27,16***	33,77***	16,36*	25,14***
Underidentification	-	-	-	-	66,603***	62,561***
J-Statistic	-	-	-	-	5,762	5,158
Number of Obs.	1056	1056	1056	1056	748	748

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

Columns 1 and 2 show our baseline model. We obtain an R-squared of 0.241 for ROA and of 0.410 for Margin. These values are common when global performance measures are taken as dependent variable (see, for instance, Powell, 1992; Hitt and Brynjolfsson, 1996 or Powell and Dent-Micallef, 1997). Year and firm fixed effects are significant in all the estimations. The model has overall explanatory power at p-value < 0.01

Models 3 to 6 include the variables that test our hypotheses 1 and 2. We find that the degree of implementation of the technology presents a negative coefficient in all the estimations, being significant in two of them. Thus, hypothesis 1 is partially supported. This result confirms that the investment on IT does not generate competitive advantages by itself and it is consistent with the usual findings of the literature on the relationship between IT and profitability. Moreover two out of our four estimations (the ones that include Margin as the dependent variable) show that a higher commitment with IT reduces profitability, which seems to confirm that, while IT are not directly linked to increases on profitability, their link with costs seems clearer.

Consistently with our model, relative adoption positively influences the profitability of the firm (hypothesis 2 supported). As predicted by our model, it is not the level of implementation of the technology, but a firm's relative position what explains the profitability of the technology. This finding confirms the mediating role of the competitive environment.

There are no significant differences between the OLS and 2SLS/IV estimations, with the exception of the relative adoption parameter, that appears to present an even stronger effect in the latter. As a consequence it seems to be that neglecting the effect of endogeneity introduces a downward bias in the estimation of the benefits that a firm obtains by implementing the technology more intensively than its direct competitors. This may be understood as weak evidence that firms being outperformed by its rivals invest heavily in IT as an attempt to improve its competitive position and catch on their rivals.

Regarding our control variables, we may observe that the concentration index presents the expected positive coefficient, but it is not significant. Market share is only significant in models 1 and 3, showing a negative effect. In addition, in the other estimations its sign varies, showing no clear effect on profitability. Savings banks incurring in higher levels of risk tend to obtain superior results. Firm size shows consistently negative effects over performance, suggesting the non-existence of scale based competitive advantages. Therefore, smaller firms are more profitable than larger firms.

It is interesting to analyze the consistently negative impact of ATM density over firm performance. The capability of new technologies to influence average profitability of a sector by altering structural characteristics of the competitive forces is widely acknowledged (Porter, 1983). Our estimations find that the more intensively the new technology spreads in the market, the lower is the profitability of the firms operating on it. This result suggests that, in addition to the interplay between implementation and relative implementation, an unforeseen effect exists. The posited technological race could be altering the attractiveness of the industry by, for instance, generating excess capacity and, in turn, increasing rivalry. Therefore, we introduce this third variable in our analysis of the temporal evolution of the results every firm obtains from the new technology.

To test hypotheses 3a and 3b we take the parameters of the 2SLS-IV estimations and obtain the impact of the technology on profitability. We focus on Margin because the explanatory power of the model is greater (0.425 versus 0.191). The impact of every firm's technology strategy is calculated by adding the effect of its level of implementation and its relative adoption:

$$Strategy\ Effect_{it} = \beta_6 Implementation_{it} + \beta_7 Relative\ Adoption_{it}$$

Additionally, the net effect of the technology over firm profitability is also calculated, including both the impact of the technology strategy and the effect of ATM density:

$$Global\ Effect_{it} = \beta_5 ATM\ Density_{it} + \beta_6 Implementation_{it} + \beta_7 Relative\ Adoption_{it}$$

Figures 1a and 1b show the evolution of these values over time. Two outlayers in the first years are excluded from this analysis to keep the figures nicely scaled. Their exclusion does not alter the estimations neither the conclusions.

Figure 1a. Effect of technology strategy over time (dependent variable is Margin)

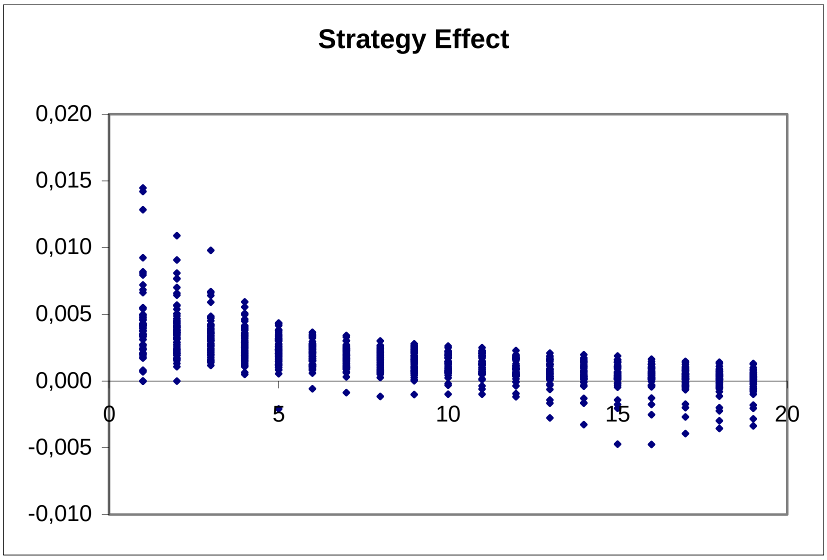
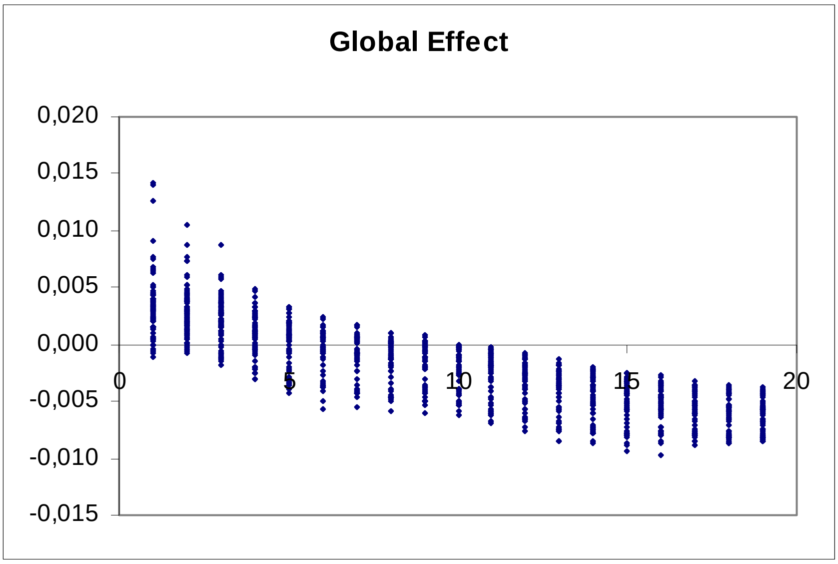


Figure 1b. Global Effect of the technology over time (dependent variable is Margin)



The figures present the patterns predicted in our hypotheses. Figure 1a shows what we have called "strategy effect", that is, the effect attributable to variables partially or totally under the control of the firm: its level of implementation and its relative adoption. Three patterns of the data deserve attention. First, the effect of technology on firm profitability decreases over time, as predicted in hypothesis 3a. Second, this decrease is faster in the earlier periods, while in the later the impact of IT on profitability seems to stabilize, consistently with hypothesis 3b. Third, while in the first periods every firm seems to benefit from the adoption of the technology, as time advances some firms begin to experience negative returns, presumably as a consequence of unattractive relative adoptions that harmed their competitive position.

Figure 1b shows the “global effect”, it is, the aggregation of the effect of the three variables related with technological diffusion within firms and industry. Again, patterns consistent with hypotheses 3a and 3b appear. Additionally, we observe how every firm seems to obtain negative returns from the IT diffusion through time, as a consequence of the strong negative effect of ATM density.

In order to confirm the negative evolution of the impact of IT on business profitability we regress the estimated values of strategy and global effect on time. We consider three specifications of the relationship: linear, quadratic and logarithmic. Results are shown in Table 3. Standard errors are corrected for heteroskedasticity and autocorrelation. Dependent variable is multiplied by 100 to appear expressed as profitability percent points.

Table 3: Impact of IT on performance over time

	Strategy Effect			Global Effect		
Intercept	0,3790*** (29,52)	0,4486*** (19,73)	0,4693*** (23,77)	0,3354*** (19,83)	0,4305*** (15,77)	0,5266*** (20,86)
Time	-0,0232*** (-21,50)	-0,0450*** (-9,63)	-	-0,0562*** (-37,69)	-0,0860*** (-13,41)	-
Time Squared	-	0,0011*** (5,41)	-	-	0,0015*** (5,07)	-
Ln(Time)	-	-	-0,1558*** (-18,01)	-	-	-0,3634*** (-31,37)
Adjusted R^2	0,49	0,52	0,51	0,70	0,71	0,67
F	461,18***	272,29***	323,88***	1417,59***	772,16***	982,27***
Number of Obs.	1056	1056	1056	1056	1056	1056

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

The first three columns show the regressions for strategy effect and the last three for global effect. Columns 1 and 4 present the linear model, 2 and 5 quadratic models and 3 and 6 logarithmic models. The six models are significant. All the estimations suggest reductions on the profitability of the technology through time. Note here that for the quadratic models the minimums are reached out of our range of 19 periods (periods 21 and 29 respectively for strategy effect and global effect), so in this specification the effect of time on profitability is also negative during the observation window[3]. Thus, hypothesis 3a is supported.

The logarithmic and quadratic specifications would suggest a pattern consistent with hypothesis 3b, that the negative effect of time on profitability decreases in magnitude over time. In contrast, a linear specification would reject that hypothesis. In the case of strategy effect both the logarithmic and quadratic specifications seem to fit the data better than the linear specification. In the case of the global effect just, the quadratic specification fits the data better than the linear one. Additionally, Wald tests indicate that the quadratic specification is superior to the linear one ($\chi^2 = 29.27$ for strategy effect and $\chi^2 = 25.66$ for global effect. In both cases p-value < 0.001). Therefore, hypothesis 3b is supported.

6. CONCLUSION AND DISCUSSION

The ways by which IT can improve the profitability of firms have attracted a large deal of attention in the last three decades. Currently, this literature seems to be dominated by two different theories; RBV and Contingency Theory (Oh and Pinsonneault, 2007). These theories consider that the impact of IT on profitability is contingent on the alignment between the technology and the strategy followed by the firm, or the control over complementary, valuable, scarce and difficult to imitate resources.

This research offers a different approach. We argue that the implicit assumption that, because of its imitability, IT will be adopted and identically deployed by all the firms operating in the sector can be misleading. Following technological diffusion literature, the level of internal deployment of technology differs among firms operating in the same industry (Battisti and Stoneman, 2003). These differences in implementation allow some firms to improve their competitive position in relation to their rivals. Specifically, we find that the absolute level of IT deployment does not generate profitability gains in and by itself. What determines the profitability of IT adoption is the relative level of implementation a firm holds compared with its direct rivals. This means that in markets populated by technology laggards, low levels of deployment will grant high returns. In contrast, in markets

[3] The correlation between "Time" and "Time Squared" is very high ($r = 0.97$, $p < 0.001$), which may provoke multicollinearity. However, the implication of multicollinearity is inflated standard errors, causing a bias towards the non-rejection of the null hypothesis (O'Brien, 2007). Since parameters are found significant in Table 3, multicollinearity does not bias our conclusions.

where operating firms are intensive IT adopters, high levels of technology deployment will not provide the firm with any competitive advantage. Thus, the assessment of the profitability impact of IT should not be done without paying explicit attention to the rivals a firm meets in the market.

Another interesting finding in this research is that as the density of ATM per inhabitant grows the profitability of the firms operating in the market decreases. This effect has been previously considered in technological diffusion literature under the signature of “stock effect”, signaling that the diffusion of the technology in the market has a negative effect on firm profitability (Stoneman and Kwon, 1996). We do not deepen on the mechanisms explaining this negative effect, but its importance may render it worth of further inquiry. For instance, Porter (1985) argued that the diffusion of a new technology in the market may alter the industry attractiveness. In our case, factors such as excess capacity, variations on relative bargaining powers of stakeholders or convergence on competition base may be behind this effect.

We also explore the evolution of the profitability gains from IT. We find that the gains from IT adoption reduce over time at a decreasing rate, showing a fast reduction on profitability impact in the first periods and less important in the last years of our observation window. It is interesting to stress the main difference between the effect we obtain for the variables under the control of the firm and the effect when we also account for the variations on ATM density. When considering those variables representing firm technology strategy we find that most of the observations show positive returns from IT deployment. This means that, on average, firms do not increase implementation levels when the associated costs offset potential benefits. However, when we also take into account the effect of ATM density, all the firms obtain negative outcomes. Thus, our conclusion on this regard is that over time the technological imitation leads not only to the dissipation of any rent generated by IT, as RBV suggests, but also to aggregated deterioration of financial performance for every firm.

Our results can be conciliated with the dominant RBV. In technology diffusion literature differences on intrafirm diffusion between firms operating in the same market are a result of differences on different firm-level characteristics. From RBV these differences may respond to the kind of complementary assets owned by the firm. Firms with superior IT-related resource endowments may be able to exploit the new technology with more intensity than their direct competitors, obtaining competitive advantages. Thus, previous research on the RBV stream in which resource base was compared to competitors may be capturing also this relative adoption effect.

Our findings are specially suited for the case of IT because of its wide availability off the shelf and its strategic necessity character (Carr, 2003). However, similar patterns may arise in other technologies which meet these criteria. Indeed, Schroeder (1990)'s case study of the diffusion of Automatic Flaskless Matchplate Molding in the founding industry showed a similar pattern. Every firm had to adopt the technology to stay in the market, but its wide diffusion generated excess capacity in the market, leading to increased rivalry and decreasing returns.

For practitioners, our findings offer two interesting insights. Firstly, the effect of IT on performance is depends on the level of adoption of competitors. In order for a firm to obtain competitive advantages from the adoption of a new technology it is necessary to be able to adopt IT more intensively than its competitors. Therefore, analyzing the process that leads to higher levels of technology implementation can result valuable by helping the firm at strengthening its relative adoption. Second, the net effect of these new technologies on performance can be negative as more and more competitors adopt them and a new pattern of competition emerges. This pattern seems to be characterized by increased investment on the technology and constant attempts to leapfrog rivals, leading to a costly technological race. Thus, when a firm gets involved in such a technological race, managers must be aware of the potential loss that may eventually derive from this decision

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