IT INVESTMENT IN SMALL AND MEDIUM ENTERPRISES: PARADOXICALLY PRODUCTIVE?

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ABSTRACT:

Recent research has demonstrated the existence of a positive relationship between IT investment and productivity in the context of large firms. However, the validity of such relationship for small and medium enterprises (SMEs) has not yet been established. The issue is of critical importance for SMEs, which suffer a constant struggle for survival due to the absence of slack resources and high competitive pressures. The present study analyzes a sample of 1,700 SMEs from Spain using a sample selection model, and examines several indicators of IT investment and their impact on productivity. The results confirm for SMEs the positive relationship between IT investment and productivity previously found in large firms: the so-called "productivity paradox" does not hold true for SMEs either.

KEYWORDS: Small and medium enterprises, SME, Information technology investment, Productivity Paradox, Production function.

ISRL Categories: DA0201, EI0205, EF04, EL03, EF07

Are computers helping small and medium enterprises (SMEs) to be more productive? Do SMEs with a higher degree of IT investment compete better than their low-IT counterparts? The answer to these questions interests not only researchers, but also practitioners, stakeholders and policy makers. SMEs constitute a highly dynamic and important sector of the economic activity in most developed economies: a survey covering the U.S., Japan and Western Europe (IDC, 1995) revealed that SMEs constitute nearly an 86% of all business establishments. In Spain they represent more than 99.9% of all businesses registered, generate about 70% of the employment and contribute to 65% of the gross domestic product (Faces, 1999). As a group, SMEs constitute a very interesting and dynamic sector. On one hand, they have to struggle with high competitive pressure, and they need to be very careful in their decisions, since slack resources are often scarce or nil. On the other hand, they are usually much more informal and unstructured in their management style, definition of strategy or decision-making processes. This allows them to compete in flexibility and responsiveness, being close to their markets and customers. Regarding IT investment, we see many differences between large and small firms. SMEs seldom have an explicit IT plan or strategy, or even a defined IT budget. Decisions to adopt a particular technology are in many cases driven by personal attitudes or perceptions of the firm's owner, rather than by any formal cost-benefit or strategic analysis.

The question of whether IT investment contributes to productivity is an old one. The so-called "productivity paradox" has attracted the attention of researchers and practitioners in the last few years. We have moved from "we see computers everywhere except in the productivity statistics" (Solow, 1987), to "shortfall of evidence is not necessarily evidence of a shortfall" (Brynjolfsson, 1993), and, only recently, to precise -and positive- estimates of the marginal product of each dollar spent in IT (Brynjolfsson and Hitt, 1996). All evidence regarding this positive payoff has been gathered in the context of large firms, usually Fortune 500 companies, which were extremely worried about the possibility of having invested millions of dollars and remodeled their structures for something that was being proved to be unproductive. However, no research has been done, to the author's knowledge, on whether this productivity paradox or an equivalent phenomenon exists for SMEs. We know that SMEs are actively investing in IT, but we still don't have any empirical evidence of a positive payoff in productivity terms. Furthermore, the latest findings on the issue (Brynjolfsson and Hitt, 1998) point to a relationship between IT investment and company redesign as a key to get the desired objectives. According to the authors, firms could actually be worse off if they just invest in IT without adapting their organizational structures to make better use of it, by flattening their structures, empowering their workers and other related measures. This fact raises some doubts about the applicability of the conclusions to SMEs: are they using their superior flexibility to adapt their organizations, thus enabling the expected IT-driven productivity increase? Or are they lagging behind in this aspect due to their traditional lack of attention to activities such as organizational design or training? Are the theoretical frameworks and empirical relationships discovered in large firms applicable to SMEs, or are we talking about completely different worlds with completely different rules?

The present study addresses these issues by examining a large sample of SMEs from Spain and exploring whether or not their investments in IT are contributing to make them more productive. The remainder of the paper is organized as follows: the next section reviews the relevant literature and introduces the research design. Section 3 briefly discusses the data and methodology employed in the analysis. Section 4 presents the results obtained, which are then discussed in Section 5. Section 6 concludes the article and highlights implications for researchers, practitioners and policy makers.

1. Literature review

Productivity is, apparently, a very simple concept, yet paramount in the management and economics literature. The concept was formalized and instrumented, among others, by prominent economists such as Solow (1957), and it represents a measure of the efficiency with which physical inputs are converted into physical outputs. Productivity defines, in the long term, the success or failure of firms, and influences global aspects of our life such as the wealth of nations. The economics literature includes numerous studies on productivity at the industry level, either country-specific or for country comparison. At the firm level, however, studies become so intensive that they depend strongly on the availability of data, which usually come from public and private databases and census. These databases provide data about firm's inputs and outputs, and therefore allow for a comparison of which firms are being more effective in transforming these inputs into outputs. This comparison needs to take into account factors such as the economic sector in which firms develop their activities, the different types of inputs and how each one of them contributes to the final revenue. Typically, the basic inputs considered are capital and labor, which are finally converted in a more or less effective way into revenues.

The relationship between IS and productivity has been widely studied in the context of large corporations (see Brynjolfsson, 1993 for a review). The pattern of the analysis, following the previous paragraph, consists in subdividing the basic inputs, capital and labor, into IS and non-IS, and check whether the IS part makes a significant difference in the amount of revenue generated. In most of the cases, the approach is longitudinal, trying to ascertain whether the IT investment made at a particular time is fruitful later on. This type of analysis gave birth to the so-called “productivity paradox”: there was little or no apparent evidence that investment in IT was in fact contributing to any concrete gain in revenues. These analyses caused alarm within the business community, particularly among large firms, which were at that particular time investing heavily in technology. The sole idea that all that money could be worthless was a source of major nightmares for managers in these companies, particularly in the IS departments, who were suddenly being questioned and considered almost as "deadweight".

There is now general agreement about the existence of a positive relationship between IT investment and productivity. It has been proved that large firms get a positive payoff out of their IT investments, both for computer capital and for IS labor expenses (Lichtenberg, 1995; Brynjolfsson and Hitt, 1996; Dewan and Kraemer, 1998; Lohr, 1999). However, this positive payoff appears to be contingent on organizational changes such as flatter, decentralized, less hierarchical structures with empowered workers (Brynjolfsson and Hitt, 1998), a process described by Drucker (1988) as "the coming of the new organization". Brynjolfsson and Hitt (1998) conclude that firms that invest in IT but retain the old structures could even be worse off, getting a negative marginal product out of their IT investment. The bottom line is that the lion's share of the cost associated with IT investment does not consist in the actual purchase of hardware and software, but in the costs involved in changing and adapting the organization to make an effective use of this new equipment. Undoubtedly, the high degree of inertia exhibited by large corporations makes these organizational changes costly, time consuming and risky.

The story changes when we bring SMEs into the reasoning. According to Lefebvre and Lefebvre (1992), SMEs are less bounded by bureaucracy and cumbersome organizational systems, a fact that makes SMEs more flexible and able to respond to customer needs. However, the literature does not come to a clear agreement regarding the issue of flexibility. Other authors consider SMEs to be less flexible due to their lack of resources, which forces them to invest incrementally, generating a number of incompatible systems that are difficult to network (Hasmi and Cuddy, 1990). This lack of resources may force SMEs to consider their investments in IT as something that should last for a long time, thus contributing to the preponderance of older, isolated systems. Other authors point out the link between flexibility and characteristics of the CEO (Blili and Raymond, 1993): visionary, IT knowledgeable CEOs could be capable of building a flexible environment, although this is not necessarily the most common scenario. In a very interesting viewpoint, Levy and Powell (1998) consider that survival is, instead of flexibility, the most salient characteristic of SMEs. Flexibility is more a characteristic of SMEs as a sector, achieved through organizational birth and death. Some empirical data appear to support such claim: about 11% of SMEs fail to survive in any given year, and, in a period of five years, about 80% of all new firms close their activities permanently (Storey and Cressy, 1995). On the other hand, these facts bring additional difficulties to the task of measuring productivity in SMEs adopting a longitudinal perspective, as it has been traditionally made in large corporations.

Additionally, SMEs tend to have very little power to influence the market or the price of the product. They generally have small market shares, and they are unable to erect solid barriers of entry to deter competitors. They usually depend on a small number of customers to whom they sell a limited number of products. Regarding technology, SMEs typically exhibit a complete lack of a defined business or IT strategy, limited access to capital resources, an emphasis on automating, and limited information skills (Ballantine et al., 1998).

The classic innovation literature draws a positive relationship between innovation and firm size (see Damanpour, 1992 for a meta-analysis and review). Considering IT as an innovation, we know that IT investment in SMEs is a relatively recent phenomenon, linked to the availability of low priced technology. To that extent, we can consider that SMEs have been traditionally slower than their larger counterparts in devoting resources to IT. But are these resources contributing to an effective gain in productivity? Two scenarios are intuitively possible: the first one depicts SMEs as erratic investors. They do not develop anything that resembles a strategic plan for IT or even for the whole business. Instead, they just bring in technology and try to use it without any kind of additional investment, organizational changes or training. Furthermore, the lack of financial resources conditions their possibilities of investing in top technology and keeping it up to date, so they maintain a position of technological laggards. In this scenario, the likelihood of getting a consistently higher productivity due to such investments appears dubious. A second scenario portrays SMEs as savvy investors, capable of overcoming capital and technical limitations and of making wise acquisition decisions based on the knowledge of the CEO and other experts in the firm. Additionally, SMEs would also be able to naturally change their flexible and unstructured organizations to take advantage of the newly introduced technology, therefore capitalizing on its gains.

Accordingly, the main hypotheses of this study are formulated as follows:

Hypothesis 1: The output contribution of SMEs' IT investment is positive.

Hypothesis 2: The output contribution of SMEs' IT investment is greater than its cost.

These hypotheses are parallel to the ones set by Brynjolfsson and Hitt (1996) to test this relationship on large firms. It attempts to test whether IT investment contributes to a significantly higher output, once the effects of capital, direct labor and economic industry have been controlled for. If true, firms with a higher IT base should, other things being equal, outperform their low-IT counterparts consistently across all industries.

2. Data and methodology

2. 1. Data Collection

Data for this study belong to an extensive survey conducted by the Consortium for Technological Development of SMEs[1], in whose design the author participated. The survey was administered in March 1999 by Sigma Dos, one of the leading firms in survey research in Spain, via telephone interview with the owner or general manager of the company. The sample covered a total of 1,700 SMEs selected from CAMERDATA, a business directory. Once the sample was completed, a database from INFORMA, S.A. was used to add data about total capital and revenues of the firms.

We define an SME using the definition of the U.S. National Institute of Standards, namely, less than 200 employees and $50 million in revenue. The data gathered included general information such as total capital, revenues, number of employees and industry; as well as specific data about the use of IT and several indicators of IT-related decision processes.

The process of collecting data in SMEs is difficult and risky. This sector of the economy, although very important in both number of firms and volume of revenues, constitutes a highly unstructured environment. Firms are sometimes involved in informal economic activities, do not declare all of their revenues or transfer funds in not completely regular ways between firm and owner. As a consequence, it is a sector in which certain data, such as capital or revenues, are considered “sensitive”, and many firms are reluctant to report them even when confidentiality is ensured. In some cases, particularly in smaller firms, the lack of adequate accounting techniques causes that the respondent is simply not able to report some of the data. The common recommendation is to ask participants to position their firms within a range, but this would add a high degree of imprecision to a study like this. Therefore, we decided to use a secondary source to complement our database. This procedure, however, caused a large incidence of missing values, so the final complete sample is comprised of 441 firms. A battery of t-tests was performed in order to test the existence of significant differences between respondents and non-respondents, indicating that non-respondents were, in general, smaller firms. This constitutes a predictable trend, since the smaller the firm, the easier it is to withhold information and behave in irregular ways. Although there is no apparent reason to consider that firms with a lack of transparency could be related to any high or low IT investment behavior, it constitutes a clear sample bias, a fact that was addressed by employing a sample selection technique for the estimation.

The instrumentation and metrics of the variables are the following (see Table 1 for a summary of descriptive statistics):

Revenues (*Rev*): Total annual revenues of the firm, in thousands of US dollars. It is used as a measure of output, as the dependent variable in our instrumentation.

Capital (*Cap*): Total capital of the firm in thousands of US dollars as reported in the official balance sheet.

Employees (*Emp*): Total number of employees in the firm. It represents labor, one of the classical inputs in the production function.

Industry (*SS*): Approximately equal to an SIC code, designates the industry in which the firm develops its activity. Classified from 1 to 21.

[1] The Consortium for the Technological Development of SMEs is a not-for-profit initiative of the Instituto de Empresa, Hewlett-Packard, Microsoft, Telefónica and Telefónica Móviles.

PCs (*PC*): Number of personal computers in the firm. It represents our measure of IT investment. Since some 12% of the firms did not have any PCs at all, the measure had to be adjusted by adding one to the number of PCs in order to be able to use the proposed functional form for the estimation.

Table 1: Descriptive statistics

Variable	n	Minimum	Maximum	Average	Std. Dev.	Skewness	Kurtosis
Rev	1,027	6.25	50,000	7,321.9	20,909.4	15.04	317.8
Cap	459	0.2	11,851.9	1,611.7	6,058.6	16.0	303.5
Emp	1,672	1	195	33.3	41.5	1.7	5.1
PC	1,639	0	300	8.7	17.7	6.7	75.3
Valid n (Listwise)	441						

2.2. Data Analysis

In order to test our hypothesis, we define a production function F. The SME_i in our sample, classified into *j* industries, produce an output Q or revenues, by means of a number of inputs, such as capital (*K*), labor (*L*) and *IT*. Therefore, our production function is represented as

$$Q = F(K, L, IT; j) \tag{1}$$

This approach is defined by Lieberman, Lau and Williams (1990) as a total factor or multi-factor productivity ratio, computed by dividing output by a weighted sum of several input types, and is widely regarded as the most appropriate measure for productivity.

In order to estimate our function, we use the *de facto* standard Cobb-Douglas specification, a classic, widely used and convenient way to estimate production functions. As noted by Griliches (1979), the choice of functional form is not critical in the estimation of output elasticities.

Accordingly, the function can be written as

$$\mathrm{Re}\,v_i = Cap_i^{b_1} Emp_i^{b_2} PC_i^{b_3} \prod_{j=1}^{21} e^{d_j SS_{ij}} \tag{2}$$

By taking logs and adding an error term, we get

$$Log\ (Rev_i) = b_1 Log\ (Cap_i) + b_2 Log\ (Emp_i) + b_3 Log\ (PC_i) + \sum_{j=1}^{22} d_j SS_{ij} + e_i \qquad (3)$$

This equation can be conveniently estimated through linear regression.

3. Results

The correlation matrix is reported in Table 2. Some concerns with potential multi-collinearity were raised by the correlation of the size of the firm (expressed in number of employees, revenues or capital) with the variable reflecting IT investment (number of PCs). As mentioned earlier, this positive relationship between size and IT investment can be explained by previous theoretical studies in innovation theory, which state that larger firms tend to be more proactive in IT investment and innovation due to their greater need for coordination and the availability of slack resources. Notwithstanding this circumstance, appropriate multi-collinearity tests were conducted and their outcome was regarded as satisfactory.[2]

Table 2: Correlation Matrix

	Rev	**Cap**	**Emp**	**PC**
Rev	-			
Cap	.38	-		
Emp	.43	.28	-	
PC	.52	.34	.51	-

The regression equation (3) was estimated through ordinary least squares (OLS) using a sample selection model, following the Heckman (1979) approach. First, the selection process was modeled by using a probit regression. This probit estimation provided a clear glimpse of how the selection process was working: smaller firms, with few employees and few PCs, were significantly associated with a high incidence of missing data. These results were consistent across all industries. Then, the estimates obtained for this regression were introduced as an additional variable (l) in the final regression. This additional variable was

[2] An analysis of the eigenvalues of the correlation matrix yielded condition indices (the square root of the largest eigenvalue to each successive eigenvalue) always below 15 (see Chaterjee and Price, 1977).

significant and with a negative coefficient (-.38). The correlation of disturbance in regression and selection criterion (*Rho*) displayed a value of -.48, clearly indicating the selection process underlying our sampling procedure.

The main regression displayed an R^2 of .59 (adjusted R^2 of .57), enough to ensure an adequate explanatory power. The coefficients for labor (.25), capital (.24) and number of PCs (.34) were all significant at .01 level. Among the different industries, 15 out of the 21 displayed significant coefficients at the .1 level. Banking/Financial (1.83) and Real State (1.53) showed the highest coefficients, while Textiles (.81) and Heavy Industry (.86) displayed the lowest ones.

4. Discussion

The results lend support to our hypotheses. The output contribution of IT investment is significant and positive. Our continuous IT variable, number of PCs, displayed a positive elasticity of .34, higher than the obtained for number of employees (.25) and capital (.24). Following our functional form, the marginal product would then be defined by

$$MP_{PC} = \frac{\Delta \operatorname{Re} v}{\Delta PC} = b_3 \frac{\operatorname{Re} v}{PC} \tag{4}$$

The average output of the firms in our sample is about 7.3 millions of dollars, and assuming that the average price of a personal computer during the 1996-1998 period is $2,650 [3], the gross marginal output contribution (increase in dollar output per dollar invested in computers) or ROI (return on investment) for computers would then be 93.9% per year: one dollar invested in computers would generate an approximate increase in output of 94 cents. This figure is slightly higher than the results reported by Brynjolfsson and Hitt (1996) for large firms, 81%[4]. As a cautionary measure, a sensitivity analysis was performed considering average prices for computers between $2,000 and $3,000. The values obtained for the gross marginal contribution under such circumstances oscillated between 124% and 83%. When we

[3] Author's estimation, by averaging data for that period published in the Spanish edition of PC-World.
[4] The average price for computers considered by these authors was much higher, due to the coexistence of both personal computers and mainframes. The introduction of an additional question in our instrument allowed us to practically discard the existence of mainframes in our sample, as it was initially suspected due to the different time frame of the analysis and the nature of the firms studied.

deviate from the average firm, the evolution of the marginal product follows the typical evolution derived from the adopted functional form (see Figure 1): the highest marginal products would then be in the unlikely case of large firms with very few computers. Under such circumstances, the addition of one computer would have a substantial effect on productivity. In any case, the effect of adding one computer is obviously higher when this computer is the first one or among the first ones in the firm, and, in contrary, the effect becomes marginal when the computer is the last one being added in a firm that already had a lot of them. Also, and given the expression of the marginal product, increments are always more noticeable in large firms than in their smaller counterparts (see Figure 2).

To assess Hypothesis 2, we must take into account how much of this computer capital is amortized every year. According to US tax regulations, category 14: "Office, Computing and Accounting Machinery (OCAM)" have an average service lifespan of seven years. Although the fast pace of technological advances might have reduced this lapse form a practical perspective, we also know from previous research that SMEs are likely to extend the lifespan of their computers to a maximum due to the scarcity of slack resources. If the seven years amortization period were accepted as valid, this would imply subtracting 14.29% per year, so as the stock will be completely depreciated after seven years. Following this criterion, the net ROI estimate will be 79.6%. Shorter amortization periods, such as five or even three years, would lead to 73.9% and 60.6% respectively. In either case, Hypothesis 2 can be considered reasonably validated for the general case.

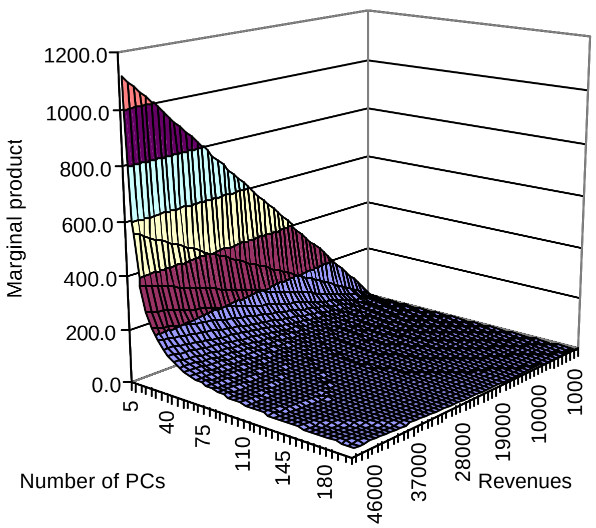

Figure 1: Behavior of the marginal product function

By fixing the level of revenues we can obtain the relationship of marginal product and PCs, which would correspond to the traditional marginal product function. Three particular cases (small, medium-small and medium-large firms) are represented in Figure 2.

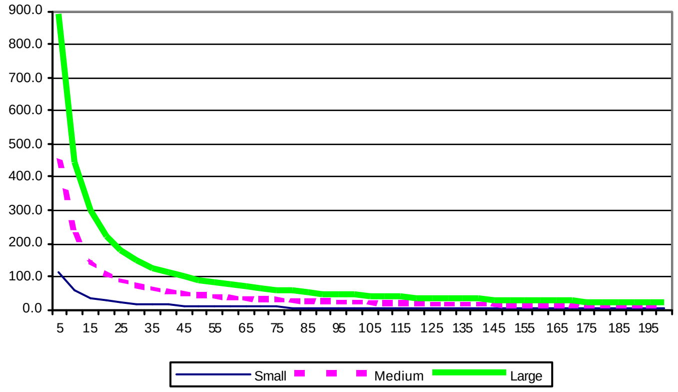

Figure 2: Three particular cases of the marginal product function

As observed in Figure 2, the difference between the three lines appears abnormally high, a fact that, together with a cautious observation of the series, led us to consider the possibility of different elasticities according to the size of the firm. The sample was classified into small (1 to 5 employees), medium-small (6 to 20) and medium-large (21 to 199) and the elasticities re-estimated. Obviously this leads to a much higher standard error, even when we reduce the number of parameters by removing the dummies that control for industry. In the smaller segment (only 41 firms due to the aforementioned selection bias), the coefficient for the number of PCs reaches a value of .99, while being .42 in the medium-small segment (145 firms) and .26 in the medium-large sub-sample (255 firms). The results of the three particular cases aforementioned when taking into account the specific elasticities (see Figure 3) show that the differences between them are greatly reduced.

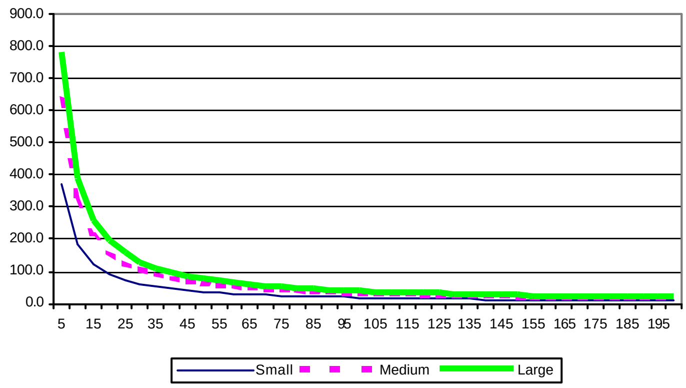

Figure 3: Marginal product functions for the average firm in each segment

Although we should caution about the interpretation of these results, such an unusually high elasticity for the smaller firms is however consistent with the conclusions of Brynjolfsson, Malone, Gurbaxani and Kambil (1994), who found evidence that under some circumstances, smaller firms may benefit disproportionately from investment in information technology. This results would also confirm Brynjolfsson and Hitt (1998): the higher flexibility exhibited by the smaller firms would enable them to face the organizational changes required to benefit from the IT investment in a more advantageous way. However, even though the elasticity is higher for smaller firms, the fact that the marginal product is directly dependent on the amount of revenues causes the final payoff in absolute terms to be much lower: the relative investment required to buy a PC, while being relatively affordable for large firms, represents a problem for their smaller counterparts, as Hasmi and Cuddy (1990) previously pointed out. This fact could act as a disincentive for IT investment in the case of small firms.

Our study should be interpreted as exploratory. Our measures for IT investment represent an attempt to measure a highly complex concept in an uncertain scenario. Although the PCs are probably an important part of the total IT capital in many firms, other chapters might have their importance too. For instance, investment in networking technologies, software or training, much more difficult to quantify on an aggregate basis, could also impact our conclusions.

Our proposed model explains 59% of the variance in our data, in comparison to the 98% explained by Brynjolfsson and Hitt (1996). We must take into account that the previous study used a pool of equations with data from five years, while this study uses data from just one year due to the difficulties in collecting redundant data in a sector with such a high mortality rate. The SMEs universe, as we mentioned earlier, appears much more unpredictable and heterogeneous than the Fortune 500 world. The introduction of additional variables that increase the percentage of variance explained by the model could be a successful avenue for future research.

5. Conclusion

The main findings of this study show a positive correlation between IT investment and productivity. According to our results, firms that invest more in IT consistently tend to have higher revenues than their low-IT counterparts, across practically all industries.

Our findings confirm the previous literature in two ways: they are consistent with the findings of other scholars in relation to the productivity paradox, and also with the SMEs literature, that depict these firms as privileged actors in their relationship with technology due to its superior flexibility. The bottom line is that computers practically always help to improve productivity, although in the smaller firms such productivity gains might be hard to materialize. These findings can be of interest for researchers, since they represent a generalization of an already known relationship, but in a different and elusive context such as SMEs. It can also serve as a warning of the difficulties that arise when sensitive information is requested from SMEs. Finally, practitioners and policy makers might be interested in the effect of technology in productivity improvement, and also in how public policies must be designed and implemented to ensure the access to technology for SMEs in order to materialize these productivity improvements.

A future research agenda should include improved measures, taking into account SMEs' special characteristics. A potentially interesting or promising avenue could be to study the effect of particular technologies: why are firms motivated to invest in certain technologies, or what are the drivers for this adoption. The understanding of these phenomena could help to understand the interesting relationship between SMEs and technology that this study has began to uncover.

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