12

The Impact of ICT on Productivity: The Moderating Role of Worker Quality and Quality Strategy

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1. Introduction

Technological innovation has generated considerable interest among academics and practitioners in recent years. In recent decades, Information and Communication Technologies (ICT) such as computer terminals, e-mail and the Internet and their applications have become the major drivers of innovation, growth and social change. Moreover, as the OECD points out (OECD, 2010), in times of crisis there must be a focus on the contribution of ICT to innovation and growth. However, although interest in this subject has grown substantially, research on the importance of the combination of organizational change together with technological innovation has been less common. Some studies suggest that technological innovation is not an isolated source of improvement, but part of a system or cluster of mutually-reinforcing organizational approaches.

Then, the simply availability of new ICT does not necessarily lead to success. On the contrary, it requires that firms accompany innovation with the development of best organizational practices (Brynjolfsson et al., 2002; Huerta et al., 2008), and it is therefore necessary to study the influence of this question in more detail, as we explore in this chapter. Our main goal is to examine whether technological innovation and organizational change are complementary, and whether they are associated with better performance.

In order to reach this objective, survey data from more than a thousand Spanish firms has been used. In particular, we analyze the impact of technological innovation and diverse complementary elements on organizational productivity. The main questions to answer are:

Is firm performance improved through ICT?

Are organizational characteristics complementary to ICT in improving firm performance?

These questions are especially important in today's highly competitive environment. Over the last decade, competition has intensified and companies have found the need to restructure and improve their business practices in order to find new and more efficient ways to obtain competitive advantage as a condition of survival.

We undertake diverse descriptive analyses, which allow us to observe the characteristics of more efficient firms. Following prior studies, we use a standard Cobb-Douglas production

function to model the production process, considering ICT as a factor of production (Brynjolfsson et al., 2011; Hitt and Brynjolfsson, 1996; Dewan and Min, 1997). With this analysis, we will asses the impact of these technologies on company efficiency and productivity.

To test organizational complementarities, we use a methodology that allows us to model the joint effects of ICT and organizational and human resources on performance. The results show the importance of organizational human capital in order to increase the benefits of the technological innovation.

Our results contribute to the international body of research and offer a new conceptualization and empirical evidence of the technology innovation performance.

We have structured the work into five parts, including this introduction. In the next section we review the main literature. We then discuss the theoretical relationship between ICT and competitive advantage, stating our hypothesis using the complementarities perspective as the main theoretical framework. Next, we present the research design, sample and definition of variables and we discuss the main results. In the final section, we present our conclusions, discuss certain limitations of our study, and propose several directions in which to continue our research.

2. Literature review

There have been many challenges and variations in the forces for globalization during the last decade. One that has garnered substantial attention over the past few years is concerned with the impact of information and communication technology on economic growth and on firm performance (OECD, 2004). The widespread diffusion of the Internet, the mobile phone and the broadband networks shows how pervasive these technologies have become.

According to much theoretical and empirical evidence, ICT offers benefits for a wide range of business processes and improves information and knowledge management within the firm, leading to better performance. Firms can manage their processes more efficiently and, as a consequence, they increase their operational efficiency. Moreover, ICT reduces the coordination costs of the firm because of lower procurement and inventory costs and closer coordination with suppliers (Tachiki et al., 2004; OECD, 2003, 2004). In addition, communication based on ICT and the Internet can also improve external communication, reducing the inefficiencies resulting from lack of co-ordination between firms, and increasing the speed and reliability of information processing and transfer. In general, ICT reduces transaction and coordination costs, maximizing the value of the transactions (OECD, 2004).

However, according to the literature review on the impact of ICT at the firm level, we can confirm the diversity of theoretical approaches and empirical evidence on the role of ICT in the improvement of the firm performance.

Much of the early literature on ICT, mainly in the 1980s and early 1990s, theoretically justified the advantages of information technologies, but they obtained contradictory empirical evidence, especially weak or with no link between ICT and firm performance (Brynjolfsson, 1993; Davenport, 1994; Kettinger et al., 1994; Loveman, 1994; Roach, 1987;

Strassmann, 1985, 1990; Weill, 1992; Wilson, 1993, 1995). This empirical evidence led to the so-called Productivity Paradox, well summarized by Nobel Prize Robert Solow (1987), who said, "You can see the computer age everywhere but in the productivity statistics."

According to Brynjolfsson (1993) and Brynjolfsson and Yang, (1996) the various explanations that have been proposed for this apparent lack of relationship can be grouped into four categories:

1. Mis-measurement of outputs and inputs
2. Lags due to learning and adjustment
3. Redistribution and dissipation of profits
4. Mismanagement of information and technology

However, moving beyond the productivity paradox, there is growing new evidence that ICT generates large positive returns that are even in excess of the returns from other types of investments (Dewan and Min, 1997). Authors such as Lichtenberg (1995) and Brynjolfsson and Hitt (1995, 1996) offer empirical evidence of the positive impact of ICT on a variety of measures of firm performance.

In any case, the notion that ICT per se does not generate sustainable competitive advantage has received important support in recent research (Kettinger et al., 1994; Powell and Dent-Micallef, 1997), giving rise to what has become known as the "strategic necessity hypothesis". According to the Resource Based View, also known as RBV (Rumelt, 1984; Wernerfelt, 1984; Peteraf, 1993; Barney, 1991) a resource must possess certain characteristics to be qualified as strategic. Specifically, in order to both generate and sustain competitive advantage over a period of time, a resource must be "valuable", "scarce", "unable to imitate" and "complementary with other elements or resources of the firm.

Today, ICT is so widely available that it can hardly be described as being scarce, or difficult to imitate, and thus it does not satisfy the necessary criteria to be considered critical. Conversely, critical value may reside in the complementary or synergic effects of ICT with internal resources and capabilities of the firm.

Recently, the empirical literature has begun to re-assess the association between ICT and a wide variety of complementary factors (Arvanitis and Loukis, 2009; Giuri et al., 2008; Aral and Weill 2007), with a consensus emerging that, in order for ICT to be properly utilised, it must be used in conjunction with complementary resources such as organisational structure, human resources or organisational resources (Walton, 1989; Bélanger and Collins, 1998; Bresnahan et al., 2002; Mata et al., 1995; Ramírez et al., 2001; Peppard and Ward ,2004; Aral et al., 2010).

Focusing on the retail industry in the US, Powell and Dent-Micallef (1997) find that ICT alone has not produced sustainable performance advantages, while some firms have gained competitive advantages by using these technologies with complementary human and organisational resources. Also for the US, Bresnahan et al. (2002) offer empirical evidence about the positive effects of combining ICT and organisational design on increasing firm productivity. The same results are offered by Black and Lynch (2001), who examine the impact of ICT, human resource practices, and firm reorganization on productivity.

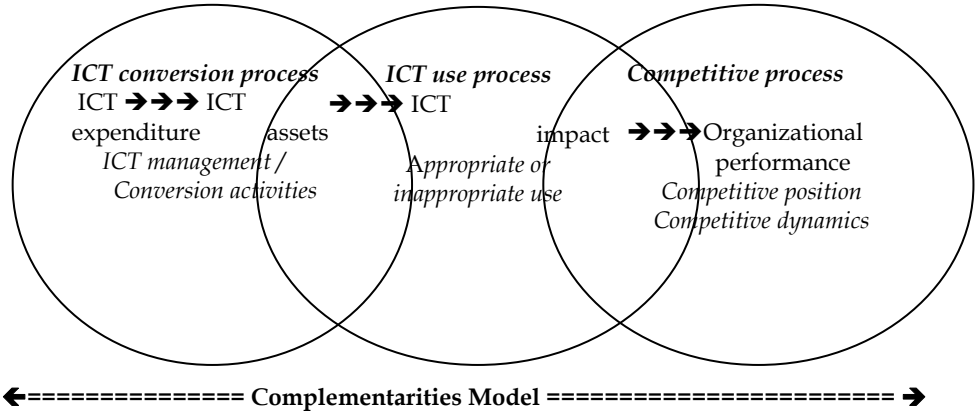
Crespi et al. (2007) examine the relationships between productivity growth, ICT investment and organisational change in UK firms, and their results support the idea that gains from IT need re-organisation to produce measured productivity growth.

Gretton et al. (2004) obtain empirical evidence of the positive impact of complementarities between the use of ICT and human resources, innovative business practices, and intensity of organizational change on the productivity growth of Australian companies.

In a comparative study, Arvanitis and Loukis (2009) offer empirical evidence of the positive impact of ICT capital, human capital and new organizational practices on labour productivity in Greece and Switzerland, while they observe that the Swiss firms are more mature and more efficient at combining these new production factors.

In general, all the studies analyzed contain the idea that, to achieve a more competitive position, the firm should complement ICT investments with an appropriate use of these technologies, for which, implicitly, complementary resources are required.

According to Soh and Markus (1995), we can establish three different processes that include, first, the conversion process in which ICT expenditures are converted to ICT assets; second, the ICT use process, where a higher or lower impact of ICT is obtained depending on the appropriate or inappropriate use of these technologies; and finally, the authors highlight the importance of the competitive process, in which any number of factors beyond the firm's control may result in failure to realize improved organizational performance. These three processes, and the integration of the complementarities model, are shown graphically in Figure 1:



Source: Adapted from Soh and Markus (1995).

Fig. 1. ICT management and competitive position process

In any case, it is generally accepted that ICT in itself is not a panacea and there is still a serious debate about how its adoption improves firm performance. In general, it is supposed that complementary investments in skills, organisational change, and innovation are the key to making these technologies work. In this study, we argue that the simultaneous presence of complementary resources increases the positive effect of ICT investment in performance.

3. Hypothesis development

As we have seen, although some research concludes that ICT has negative or irrelevant effects, since the last decade there has been a growing consensus that there is a strong positive link (Atzeni and Carboni, 2006). ICT can help improve productivity and the efficiency of all stages of the production process by reducing set-up time, run time and inspection time, which will help efficient firms to improve their market position. Accordingly, we propose our first hypothesis:

Hypothesis 1: "The impact of information and communication technologies on productivity will be positive"

However, within the theoretical framework of RBV and the complementarities discussed above, we can argue that the firm-level impacts of ICT may be higher in those companies that have been able to reorganise. In order to implement effectively and to reap benefits from ICT investments, complementary resources and capabilities will be needed.

Investment in human resources has been one of the factors most commonly explored, because of its possibilities for enhancing the effectiveness of organizational practice. Furthermore, human resources management is considered to be not only a determining factor of productivity, but also a complementary element of ICT (OECD, 2001a). According to 'skill-biased' technological change, we can argue that ICT is associated with a greater demand for highly educated workers (Acemoglu, 1998; Black and Lynch, 2001; Bresnahan et al., 2002; Caroli and Van Reenen, 2002). Skilled employees allow firms to integrate ICT more effectively in the planning process of the business (Bharadwaj, 2000). Available empirical evidence suggests that improvements in the composition of the labour factor have directly contributed to labour productivity growth in many countries (OECD, 2005). At the firm level, various authors have shown that ICT use can have positive effects on performance, but those positive effects may be smaller if the necessary complementary investments in skills have not occurred to a sufficient degree (Arvanitis, 2005; Powell and Dent-Micallef, 1997; Pinsonneault and Kraemer, 1997; Francalanci and Galal, 1998 and Bresnahan et al., 2002). As these authors show, ICT has substantial impacts on firm performance when it is combined with a higher level of better-qualified personnel. Therefore, we define the next hypothesis as follows:

Hypothesis 2: "The impact of ICT on results will be greater for organisations that combine ICT with a high level of worker qualification".

Research has also highlighted the importance of strategic alignment, defined in terms of ICT support for the business strategy (Tallon and Kraemer, 2008). Specifically, ICT adoption has been positively associated with those firms that attach greater importance to the quality of their products (Lal, 1999). ICT investments provide significant opportunities to decrease the costs of overseeing production and distribution. Insofar as quality systems are closely related to the availability of flows and information processing, ICT will offer new approaches to the implementation of quality assurance systems. In this context, implementation of ICT is most effective when introduced in conjunction with quality systems (Bruque and Moyano, 2007). Moreover, as Ramírez et al. (2001) stress, the impact of ICT on results is positively influenced by the adoption of TQM and re-engineering. Thus, we propose the following hypothesis:

Hypothesis 3: "The impact of ICT on results will be greater for organisations that combine ICT with an assurance and quality control strategy"

4. Research design and methodology

First, we are interested in estimating the effects of ICT, in conjunction with appropriate organizational and human resources. Following prior studies, the present paper deals with the productivity approach (Gurbaxani et al., 1998; Lichtenberg, 1995; Ramírez et al., 2001). In this sense, most econometric studies that attempt to assess the contribution of ICT to productivity rely on a standard Cobb-Douglas production function, created in 1927 by Paul Douglas and Charles Cobb, as the basic analytical framework (Loveman, 1994; Dewan and Min, 1997). It is the most commonly used form for the production function, and has the advantages of both simplicity and empirical robustness for the calculation of firm performance[1]. Recent studies, such as Badescu and Garcés-Ayerbe (2009) and Brynjolfsson et al. (2011) demonstrate the consistency of this methodology in formulating and estimating the impact of ICT capital on productivity.

In line with the majority of empirical studies, we assume that the production function for manufacturing firms can be described by an extended Cobb-Douglas function, in which we include ICT capital as a factor of production (Brynjolfsson and Hitt, 1996, 2003). In order to incorporate the interaction of ICT with the complementary resources, various dummies are added [$e^{\alpha_i \sum Di}$].

The coefficients of the multiplicative dummy variables show the direction of the joint effect of their components. A negative/positive estimated coefficient implies that the interaction of both variables will negatively/positively affect productivity.

In order to test previous hypotheses, the production function to be estimated is defined according to the following equation (Equation 1) :

$$Q = AK_{ICT}^{\beta_1} K_{NICT}^{\beta_2} e^{\alpha_i \sum DiICT_{01}} e^{\alpha_{leg} \sum D_{leg}} e^{\alpha_s \sum D_s} L^{\beta_3} e^{\mu} \quad (1)$$

Where β_i represents the output elasticity of ICT capital, non-ICT capital and labour, respectively, A is a parameter measuring the total productivity factor, a_{leg} and a_s are the coefficients of legal structure and industry dummy variables, and α_i refers to the multiplicative dummy variables.

The logarithmic transformation of equation (1) provides a log-linear form which is convenient and commonly used in econometric analyses using linear regression techniques. Performing the necessary transformations, we obtain the basic production model, including the effects of ICT and the importance of multiplicative variables (Equation 2).

$$Ln\ (Q/L) = \alpha + \beta_1 Ln\ (K_{ICT}/L) + \beta_2 Ln\ (K_{NICT}/L) + \beta_3 Ln\ L + \alpha_1 ICT_{QUALIF} + \alpha_2 ICT_{QUALIT} + \Sigma\alpha_{leg} D_{leg} + \Sigma\alpha_s D_S + \varepsilon \quad (2)$$

[1] See Brynjolfsson and Hitt (1996) for a discussion of this formulation.

4.1 Sample and definition of the variables

The empirical analysis is based on firm-level longitudinal data, from which we have information on the necessary variables. The sample comes from the Survey on Business Strategies (SBS)[2], carried out annually by the Spanish Ministry of Science and Technology [Ministerio de Ciencia y Tecnología], containing information on a wide range of firms Spanish manufacturing firms with 10 or more employees. The SBS has the advantage of a statistically representative sample of manufacturing firms in Spain (Fariñas and Jaumandreu, 1999). The sample covers those firms with 200 or more employees and firms with less than 200 employees are selected by a random sampling method.

The total number of manufacturing firms in the SBS for the year 2002 was 1,724. Excluding those observations for which the database does not provide information for all necessary variables, we are left with a final sample of 1,269 firms.

We have defined a performance measure that, in accordance with the specialised literature, could have a significant impact on the analysis of firm performance. Specifically, to test the validity of the propositions, the following variables have been defined:

Output Variable

Productivity is one of the performance measures most frequently used in the literature (Brynjolfsson and Hitt, 2003), as evidenced by its use in different samples, sectors and methodologies (Barua et al., 1995; Krueger, 1993; Mahmood and Mann, 2000). In line with previous research, in this study we define the output variable according to labour productivity, measured using the value added of the firm divided by the total number of employees *(Q/L)*.

Information and Communication Technologies Capital

We use the ICT capital intensity variable measured by ICT stock divided by number of employees of the firm (K_{ICT} / L). On the one hand, we define $\boldsymbol{K_{ICT}}$ as the amount of ICT capital per unit of labour input, where ICT capital is computed using the perpetual inventory method. This estimation allows for cumulative investments carried out over time in computer equipment and data processing equipment by the firm. The annual depreciation rate is assumed to be 0.20[3]. On the other hand, labour input is defined as the total number of workers at the firm at the end of the year.

Rest of Capital

We define the intensity of the rest of capital as the ratio between non-ICT capital and labour (K_{NICT}/L) that is non-ICT capital intensity. Non-ICT capital is measured by conventional

[2] Encuesta de Estrategias Empresariales (ESEE) in Spanish.

[3] Similar depreciation rates close to 20% have been used, for example by Kafouros (2006), who assumes a depreciation rate for intangible technological resources of 20%, and Shin (2000, 2006) who uses a depreciation rate of 22.4 % for ICT investments. In any case, although rates used in prior studies vary widely, Bloom et al. (2006) show that the significance and the magnitude of the coefficient obtained for ICT is not affected by the exact choice of the alternative depreciation rate.

capital, calculated as the difference between the total net fixed assets (obtained from the balance sheets) minus that part of net fixed assets corresponding to ICT. The use of accounting depreciation, rather than economic depreciation, and historic values, rather than replacement values, in the determination of conventional capital may reduce measurement accuracy (Lichtenberg, 1995). Nevertheless, this is not a problem, since both ratios, historic value and real value, and accounting depreciation and economic depreciation, remain constant for all the firms in the same sector; including a sectorial dummy variable, as we do, removes any bias. The labour factor is measured by the total number of employees of the firm.

Interaction variables

We include in our regression two multiplicative dummy variables that reflect the interaction effect of ICT and worker qualifications, and ICT and quality management strategy, respectively. They are constructed as follows:

- ICT and worker qualifications (ICT_{QUALIF}): this variable captures the interaction between the availability of ICT capital in the firm and the intensity of qualified workers, measured as the existence of a higher than sector-average number of qualified employees in the firm. According to the educational level completed by the workers (OECD, 2001b), we classify as qualified those employees who have completed a university degree, or trained as technicians and experts. The multiplicative variable takes a value of 1 when the firm has more highly qualified workers than the sector average, along with positive ICT stock, and 0 otherwise.
- ICT and Quality management (ICT_{QUALIT}): the quality management variable reflects activities related to quality carried out by managers. The multiplicative variable takes a value of 1 if the firm has made efforts in standardization and quality control and, at the same time, it has ICT capital, and 0 otherwise.

Control Variables

Following prior studies, the following variables have been considered as independent control variables to proxy for industry characteristics, legal structure of the firm, and organizational size:

- Sector of activity (D_S): This variable is defined by the first two digits according to the Spanish National Classification of Economic Activities (CNAE) Code.
- Legal structure of the firm (D_{LS}): We include a set of dummy variables in order to control for the effect of the diversity of corporate structure in our sample (limited liability company, public limited liability company, cooperative, Employee-owned).
- Size (L): Firm size variable is measured by the total number of employees of the firm at the end of the year.

Table 1 presents the main statistics (mean and standard deviation) of the variables for the total sample:

As we can see, intensity of ICT is lower than non-ICT capital intensity. However, the standard deviation value is higher for ICT intensity, reflecting the dispersion among firms and it shows that there exist significant differences in the level of effort that Spanish manufacturing firms are expending on ICT investments.

	Mean	Standard Deviation
ICT intensity	2.0870	7.99527
Rest of capital intensity	10.0388	1.67310
Size	4.2065	1.45488
ICTQUALIF	0.3436	0,47509
ICTQUALIT	0.3034	0.45990
Limited Company	0.3278	0.46960
Labour Anonymous	0.6225	0.48494
Productivity (VA / Nº workers)	0.0165	0.12762
Total number of firms	1,269	

Table 1. Main statistics of the sample

4.2 Main results and discussion

As noted previously, the dependent and independent variables are constructed and the empirical model estimated using the data set of 1,269 firms. First, we review the productivity differences between the group of firms that invest and the group that does not invest in ICT.

	$K_{ICT}=0$	$K_{ICT}>0$
Ln (*Q/L*)	10.2686***	10.6098***
N	531	738

*** Denote statistical significance at the 1% level (p<0,01)

Table 2. Productivity mean differences

As we can see in Table 2, firms with a positive value for the K_{ICT} variable achieve statistically higher values of productivity. Nevertheless, although it gives us a first idea about the positive relationship between ICT and performance, the empirical analysis offers a further understanding of the relationship. The most relevant results of the model of equation (2) are presented in Table 3.

We can see that the coefficient of the ICT intensity variable is positive and statistically significant. This allows us to accept Hypothesis 1, postulating a positive effect of ICT on the results. Moreover, the multiplicative variable representing ICT and qualifications interaction takes positive values and confirms the importance of qualifications. This allows us to corroborate Hypothesis 2. It is possible that the presence of more qualified workers can be related to the use of new workplace organisation such as team-work, decentralised decision-making, and flattering hierarchies, all practices that increase the possibilities of ICT. These results are in accordance with the studies that found that the use of equipment for data processing is mainly in the hands of workers with medium and high skills (Borghans and Ter Weel, 2007, 2011; Bresnahan et al., 2002).

	Original coefficients	Standardized coefficients
Constant	8.687***	---
Ln (K_{ICT}/L)	0.006***	0.068
Ln (K_{NICT}/L)	0.107***	0.267
Ln SIZE	0.058***	0.126
ICT_{QUALIF}	0.102**	0.073
ICT_{QUALIT}	0.075*	0.052
Limited Company	0.128	0.090
Anonymous Company	0.268***	0.194
Labour Anonymous Company	0.249*	0.047
D_S	Yes	Yes
R^2	35.6%	
Adjusted R^2	34.2%	
Total number of firms	1,269	

* Denotes statistical significance at the 10% level (p<0,10)
** Denotes statistical significance at the 5% level (p<0,05)
*** Denotes statistical significance at the 1% level (p<0,01)

Table 3. Results of the productivity regression analysis

As for the variable measuring ICT and quality strategy, a positive coefficient is obtained. Hence, we can conclude that Hypothesis 3 is accepted. These results are consistent with those obtained by Mata et al. (1995), who argue that ICT becomes really effective when it is handled proactively by management, and Bharadwaj (2000) who concludes that capacity for technical management allows firms to achieve better business results than their competitors.

The firm size variable presents a positive and statistically significant coefficient, consistent with those theories that establish a positive influence of firm size on performance, and with the presence of positive economies of scale. Regarding the legal structure of the firm, we can also highlight the positive and statistically significant effect of Anonymous Company and Labour Anonymous Company on firm productivity.

To sum up, the results obtained in the empirical work can be summarized according to the three hypotheses we have tested as follows:

Hypothesis	**Result**	**Implications**
Hypothesis 1	Accepted √	⇑ICT ⇒ ⇑ Productivity
Hypothesis 2	Accepted √	⇑ICT&Qualification ⇒ ⇑ Productivity
Hypothesis 3	Accepted √	⇑ICT&Quality⇒ ⇑ Productivity

The model achieves an acceptable explanatory power – with a correlation coefficient of around 34%– and it confirms the importance of ICT and the interaction between those technologies and organizational complementary resources in improving firm performance. Our results reinforce those obtained by Aral et al. (2010), who concluded that one reason for

the variations in the returns to ICT investments across firms may be differences in the adoption of complementary organizational practices.

5. Conclusion

The main goal of this chapter has been to gain a better comprehension of how information and communication technologies affect firm productivity, and of the importance of other complementary factors. Since there are few studies investigating the impact of ICT on firm productivity in Spain, the present study attempts to fill this gap. We have analyzed the role of the alignment of different elements in increasing the ICT impact, in a sample of Spanish manufacturing firms.

Our main contribution lies in the possibility of offering evidence supporting the existence of a statistically significant relationship, not only between ICT and productivity, but also between the multiplicative variables that represent ICT and other complementary factors.

The empirical evidence offered highlights the need to consider organizational aspects, such as human resources and strategic adjustment, in order to raise the potential benefits of ICT. According to this evidence, we conclude that investment in organisation and human resources skills is crucial in achieving higher levels of performance. Business management capabilities are growing in importance, rather than ICT alone. Thus, we can make certain practical recommendations that will be useful for all responsible agents in the management of ICT and other complementary factors.

Our findings suggest that differences in the use and impact of ICT across firms are probably due to the lack of complementary resources or the lack of fit between key organizational aspects. We can further postulate that the gap between Spanish and other European firms in realizing the potential of ICT may be due to the use of these technologies without adequate complementary resources at the firm level.

Factors related to the social, technological or legal environment may also play an important role in ensuring that the potential gains in productivity from the successful use of ICT are among the primary policy targets. For example, many governments provide ICT training or training support, some of them free of charge, or they offer financial support to cover part of training expenses.

Nonetheless, public policies need to be carefully designed to enhance their effectiveness and, in particular, it is necessary to take into account that without complementary firm investments and organisational change, the economic impact of ICT may be limited. Government programmes may sometimes fail because of a lack of organizational redesign at the firm level.

To conclude, it seems appropriate to indicate that this study has some limitations that point the way to further investigation. In future research, it would be interesting to include the time dimension to assess the impact of ICT investment on performance after a time lag, and compare this with earlier results. Another extension could be to distinguish among various types of information and communication technologies, testing possible differences on their impact. Unfortunately, the Survey on Business Strategies database does not offer this information, which prevents us from calculating separately the stock of different Information and Communication Technologies.

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It is widely accepted that technology is one of the forces driving economic growth. Although more and more new technologies have emerged, various evidence shows that their performances were not as high as expected. In both academia and practice, there are still many questions about what technologies to adopt and how to manage these technologies. The 15 articles in this book aim to look into these questions. There are quite many features in this book. Firstly, the articles are from both developed countries and developing countries in Asia, Africa and South and Middle America. Secondly, the articles cover a wide range of industries including telecommunication, sanitation, healthcare, entertainment, education, manufacturing, and financial. Thirdly, the analytical approaches are multi-disciplinary, ranging from mathematical, economic, analytical, empirical and strategic. Finally, the articles study both public and private organizations, including the service industry, manufacturing industry, and governmental organizations. Given its wide coverage and multi-disciplines, the book may be useful for both academic research and practical management.

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