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Information and Communication Technologies: Their Use and Short and Long Run Effects

Adel Ben Youssef
University of Nice Sophia-Antipolis (GREDEG-CNRS)

Leila Peltier- Ben Aoun
STATEC Luxembourg

Abstract

This paper examines the links between the use of Information and Communication Technologies (ICT) and the firm's performance using a sample of Luxembourgian manufacturing and services firms (2 183 firms). The data used is the 2008 Survey on ICT Usage and e-Commerce in Enterprises in the case of Luxembourg (STATEC, 2006, 2007). We found four original results. First, the use of the latest generation of ICT increases firms' revenues (short term returns) if the ICT use serves to customize their products. Second, the use of the latest generation of ICT enables long run returns if they are used for several purposes such as setting a catalogue online, developing e-commerce solutions and customizing the website. Third, while ICT seems to need dedicated human capital and technological absorptive capacity for increasing revenue, this is not valid for reaching new customers. Finally, we found also that "belonging to a group" has no impact on increasing the revenue of the firm when it uses ICT, while it has a negative effect on capturing new customers.

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Contact: Adel Ben Youssef - adel.ben-youssef@unice.fr, Leila Peltier- Ben Aoun - leila.ben-aoun@statec.etat.lu.

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Long and short run performances of Innovative Uses of Information and Communication Technologies: Evidence from Luxembourg

Ben youssef Adel
University of Nice Sophia-Antipolis (GREDEG-CNRS)

Abstract

This paper contributes to the literature by investigating the causal links between adoption of new generation of Information and Communication Technologies (ICT) and firm's performance using a sample of Luxembourgian manufacturing and services firms (2183 firms). The data used is the 2008 Survey on ICT Usage and e-Commerce in Enterprises in the case of Luxembourg . We found two original results. First, the use of the last generation of ICT increases firm's revenues (short term returns) especially when ICT are used to customize the services and products and as long as firms have the dedicated IT staff. Second, using the last generation of ICT permits long run returns to the extent that these technologies are used intensively for several purposes (setting a catalogue online, setting e-commerce solutions and customizing the website).

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1. Introduction

An emerging strand of the literature suggests that the newest generation of Information and Communication Technologies (ICT) has better output elasticity (Cardona et al. 2013), more impact on firm productivity (Engelstätter and Sirbu, 2013, Colombo et al. 2013), lesser need of investment in complementary assets (Ben Youssef et al. 2015) and better impact on the firms' innovation capacity (Bertscheck et al. 2013). Cloud computing is a perfect illustration of this radical change in the scope and the purpose of the newest generation of ICT with powerful impact on productivity and innovation (Sultan, 2013).

Previous literature has considered revenue generation and productivity as the main indicators of firms' performance associated with ICT use (Bresnahan et al. 2003; Basant et al. 2006; Draca et al. 2007; Biagi 2013). These indicators reflect, among others, short-term impacts of ICT use. However, other facets including more long-term oriented measures like enhancing firm reputation through better visibility or enlarging its market share by acquiring more clients and customers are less used.

In fact, firms aiming to acquire new customers or enhance their reputation need to make costly specific investments that may lower their short run profit and revenue. However, these investments are expected to generate more revenues in the long-term since they allow enlarging the demand. For example, capturing new customers in several sectors like banking or telecommunications sectors push the firms to make new commercial offers especially for the new customers. They may charge no fees for a given period of time or propose exclusive temporary prices below the marginal cost for new customers. While the impact on revenue can be negative in the short-term, it is expected to become positive in the long-term[1]. For this reason, reaching new customers is rather associated with long-term performance of the firm.

While most of the economic literature has focused on immediate revenues generation linked to ICT use, few papers have challenged the question of how information technologies impact on long-term performances (Hall et al. 2012; Bertscheck et al. 2013; Crespi et al. 2014). More importantly, few papers have tried to observe how the usages are more linked to reach several objectives.

To improve our understanding of the economic impacts of ICT usage by firms, we propose in this paper to focus on how the use of innovative ICT is related to immediate performance of the firm such as revenue rising, and to long-term performance such as acquiring new customers. Methodologically, we make use of a bivariate Probit model testing with sample selection estimated by maximum likelihood applied to a sample of Luxembourgian firms in order to examine the long-term or short-term performances of new ICT. The performances are observed (or not) only for the firms that have introduced new ICT innovations, this methodology in two steps allow us to test whether those firms are similar or not to those that did not (sample selection).

Luxembourg is a small country with a competitive economy, particularly keen to adopt the latest generations of ICT; nevertheless there are discrepancies among sectors and size of the firm. It is one of the few countries that have developed database with detailed

[1] Acquiring new customers is not obvious in competitive markets. Firms need to invest in advertising campaigns and to make special offers for the new clients. The main argument is the fact that for consumers switching from a firm to another are confronted to « switching costs ». In order to convince new customers, firms can subsidize at least those costs.

information about use of ICT. Most of the other European countries are lacking data about the intensity of ICT usage and the Luxembourgian ICT survey is the only one that investigates the impact of new ICT projects for a representative sample of firms.

Our paper contains two novelties. First, while most of the literature is focused on the adoption or usage of ICT without considering the depth of adoption, we focus on the depth of adoption by considering the diversity of usages. Depth of adoption is generally measured by observing the time spent using the technologies or by observing the number of workers using a particular technology and in this paper we suggest an alternative strategy for measuring the depth of adoption by focusing on the variety of use. Second, most of the literature observes the impacts of ICT uses by measuring their short-term performances (revenue generation or productivity). We investigate both the long-term and short-term effects of the ICT use.

Our findings suggest that innovative ICT use allows firms to increase both short and long-term performances by using the multi-purposes characteristics of ICT and varying the intensity of usage of these technologies. The results also show that in order to obtain long-term effects, firms need to use intensively these technologies for a large set of their purposes.

The paper is organized as follows. Section 2 summarizes the related literature and examines some of the firms' features that, in the rest of the paper, will be used as explanatory variables of ICT use. Section 3 presents the sample's characteristics and introduces our econometric approach. Section 4 reports and discusses the results. Finally, section 5 concludes.

2. Background discussion

One of the main expected outcomes of the use of new ICT is to allow firms to acquire new clients and customers (enlarge the scope of their market and extend their market shares). The emergence of new ICT has pushed firms to adopt and use them in order to seek long-term returns and capture more important market shares. More generally, new ICT were perceived as market changer. While in some markets new actors base their entire strategies on ICT, it is more common to find firms adopting new ICT in order to capture new clients and new customers.

For example, many firms have adopted social networks to build communities and networks around their products and brand. Community management and other strategies based on social networks management become very important in order to strengthen the brand and to acquire new clients. Today web marketing is becoming as important as classical channels of marketing. New ICT are allowing better interactions between firms and their clients.

One of the features of the newest ICT is that they are allowing firms to enrich the characteristics of current products and services (especially in relation to information) and propose new services and products. Firms have extended their services and products lines by creating new needs and new ways of producing. For example, Bertschek et al. (2013) found that broadband Internet enabled firms to reorganize and reshape their business processes and to improve their products or services. This innovative activity induced by broadband has been translated into productivity gains. Polder et al. (2010) take a firm-level perspective to analyse the role of ICT for innovation success and productivity of Dutch firms. They find that the use of broadband Internet is particularly important for services firms where broadband is positively related to product and process innovation as well as to organizational innovation.

Moreover in the case of Cloud Computing, Xu (2012) shows how Cloud Computing can permit Cloud Manufacturing and may change the border of certain economic sectors.

However, the ability to use new generation of ICT depends strongly on the technological absorptive capacity built by the firm over time (Hollenstein, 2004). The more the firm is able to absorb ICT**,** the more it is able to use new waves of ICT. Several contributions in different socio-economic contexts have found a direct link between the technological absorptive capacity of the firm and its ability to use new generation of ICT (Ben Youssef et al. 2012; Arvinitas and Loukis, 2009). Moreover, Hall et al. (2012) show that the effect of ICT on firm's productivity depends on the complementarity between the investment in ICT and Research and Development. Crespi et al. (2014) extend this research line and include innovation activities as determinant of performance change of the firm. Overall, this research shows the important role played by the technological absorptive capacity in matter of transforming the ICT adoption and use to economic performance.

Depending on the objectives followed, firms can also choose to not adopt all the new available ICT. Firms may value differently the real costs and benefits of new ICT applications at each point of the time. In some cases, it is rational to not use all the available technologies since their effects differ in term of short-term performances of the firms. Several papers have found that firms may not use all the different facets of new ICT. For example, Hollenstein and Woerther (2008) have showed that the degree of diffusion of the two types of e-commerce (e-selling and e-purchasing) strongly differs. Peltier-Ben Aoun and Vincente Cuervo (2012) found that e-commerce adoption mainly takes place among innovative firms but they highlighted differences in the two sides of e-commerce. Indeed, e-purchasing involves more complex systems and so require higher skilled-workers compared to e-selling activity. Ben Youssef et al. (2015) have focused on the innovation outcomes associated with the Luxembourgish firms using the same survey as this paper. They found that there is an asymmetric effect of usage of e-commerce and e-administration. They also found that the diversity of usage of ICT applications is associated to the innovation capacity of the firm.

This paper extends previous findings by focusing on the differences between long-term returns (reach new clients) and short-term returns (revenue) of new ICT use in the context of Luxembourg.

3. Database, sample characteristics and econometric model

3.1. Database

The data set used in this study is the 2008 Survey on Information and Communication Technologies (ICT) usage and e-Commerce in Enterprises in the case of Luxembourg (STATEC, 2006, 2007). It contains information about ICT adoption and use. While this information has been collected since 2003, this wave (2006, 2007) is the only one, which contains information about the impact of new ICT. This dataset covers firms with at least 10 employees in manufacturing and services, except for financial activities[2]. These data therefore provides us with a representative sample of the population of 2183 firms (3099 firms if weighted by its firm size and economic activity) (Annex 1).

3.2. Dependent variables

2 Firms from financial sector are not concerned by the e-commerce part of the survey.

Three dependent variables are defined in order to study the impact of the intensity of ICT use on firm performances (short and long term returns). The first dependent variable refers to whether the firm decided to use (or not) new ICT. It is a dummy variable taking the value 1 when the firm declared having adopted during the period 2006-2007 adopted new ICT (equipment or applications) and 0 otherwise.

The other dependent variables measure the type of performance from a strategy of using new ICT in a broad sense. All three variables are dummy variables and take 1 if the effect is felt and 0 otherwise. The two types of impacts measured are:

1. Increase the revenue of the firm or not (short term performance)[3]
2. Reach new clients or not (long term performance)[4]

3.3. Explanatory variables

In view of the large body of the literature concerning the determinants of ICT adoption and use, we explore five types of determinants:

Firm size: firm size exerts a positive impact over adoption since large firms have more resources and are in a better position to take advantage of the scale economies derived from the new technology. This rank effect is observed in most of the empirical literature (Karshenas and Stoneman, 1995; Bartoloni and Baussola, 2001).

Belonging to a group: the fact that the firm belongs to a group of enterprises is expected to have a positive effect on ICT use. Firms belonging to a group are supposed to be able to spread the cost of the new innovations among more units (Haller and Siedschlag, 2010). At the same time since these technologies facilitate the coordination of work and networking, they are more likely to be adopted by networked firms (a group).

Economic sector: most of the literature found that Knowledge Intensive Based Services are more likely to adopt new technologies (Santos-Vijande et al. 2013; Hertog, 2000). However, Biagi (2013) highlight the higher impact of ICT in ICT-using sectors compared to the ICT-producing sectors.

Geographical market served by the firm: the association of this variable with new ICT is not clear in the literature. Although firms operating in international markets might be more likely to use new ICT because of the potential of these technologies to reduce transaction costs and to improve its visibility, the uncertainties about cross-border online trade might hamper the use of these ICT (Fabiani et al., 2005; Giunta and Trivieri, 2007; Hollenstein and Woerter, 2008).

[3] The firm declares the variable “increase in revenue”. The formulation is like the followings: In January 2008, what is the effect of ICT projects implemented in your business in the last two years? "Increasing revenue for the company." Three categories were proposed to the firms: None/moderate/significant. We have grouped moderate and significant as yes and none as no to have a binary variable (1/0). This is not a generic increase of revenue; this is an increase due to the implementation ICT projects.

[4] Reaching new clients is not always linked to the increase in revenue. Firms may make special offers for new clients by selling their products with no margins, or below its marginal costs. If firms acquire new clients and they buy the products at it normal price then it has an impact of revenue generation. The correlation exists but it in our analysis it is far from one. And moreover, this is the aim of the paper whether ICT projects has a direct impact in increasing revenue or a long term in capturing new clients.

Competition: usually firms in highly competitive markets are more likely to adopt new technologies than those in sheltered environments in order to gain an advantage over rivals (Porter, 1990). At the same time, as the rivals adopt a new technology, the competitors are more likely to adopt it by mimetic behaviour.

Absorptive capacity of the firm: economic literature have showed that firms having skills and ICT staff are more likely to adopt new ICT because they have already the needed skills and they have capitalized on the experience of previous technologies (Arvinitas and Loukis, 2009; Hollenstein and Woerter, 2008)

3.4. Model Specification

We assume that integrating, updating or changing the way of using ICT has a cost. This cost can be direct (e.g. price to buy the new technology) or indirect (e.g. need for new devices to support the update, need for new skills…). The fact that before implementing an ICT, the firm decides to do so or not constitute a selection process. The decision sequence requests a two stages approach in which it is assumed that firms decide to implement (or not) a new ICT and then, conditional on their decision, they evaluate the type of impact perceived.

First stage: selection stage

Our estimation strategy restrict the original sample to the sub-sample of the firms that have implemented a new ICT. Restricting the sample to those firms may raise sample selection issues because the restricted sample becomes endogeneously determined. That is to say that the residuals in the selection equation are correlated with the residuals of the model estimated over the restricted sample (Wooldridge 2002, chap17 p: 562 eq. 19 & 20). In order to handle this situation, we estimate the model together with a selection equation which is defined over the full sample:

$$W_i^* = R_i'\delta + v_i\,, \quad W_i = 1[(W_i^* > 1)] \qquad \text{(eq.1)}$$

Where , $W_i = 1$ if the firm has introduced an innovation in ICT and , $W_i = 0$ otherwise.

R_i' is a vector of exogeneous regressors and v_i its residuals.

Second Stage: impacts of innovative ICT on firm's performances

We model the following bivariate probit model:

$$Y_{i1} = \begin{cases} 1 \text{ if } X_i'\beta + \varepsilon_{i1} > 0 \\ 0 \text{ Otherwise} \end{cases} \qquad \text{(eq.2)}$$

$$Y_{i2} = \begin{cases} 1 \text{ if } Z_i'\gamma + \varepsilon_{i2} > 0 \\ 0 \text{ Otherwise} \end{cases} \qquad \text{(eq.3)}$$

We define two dependent variables as follows:

Y_{i1}: *increase of revenue* and Y_{i2}: *reach new clients*. X_i and . Z_i are the vector of explanatory variables and $\varepsilon_{i1}, \varepsilon_{i2}$ the error terms.

In this model we assume that :

$$corr(\varepsilon_{ij}, \varepsilon_{ik}) = \rho_{jk} \neq 0 \qquad \forall j,k = 1,2 \quad (j \neq k)$$

$$corr(\varepsilon_{ij}, \varepsilon_{ik}) = 1 \quad \forall j,k = 1,2 \quad (j = k)$$

From this model we will test the joint hypothesis of endogeneity of the Y_{ij} and the existence of sample selection bias i.e.:

$$H_0: corr(v_i, \varepsilon_{ir}) = 0 \qquad \forall \mathrm{r} = 1,2$$

This model is estimated using the cmp version 6.7.0. Stataroutine provided by David Roodman.

4. Results

We start by making general comments about the adoption of these new ICT by firms before making more comments on the impacts of the use of these technologies on firms' performances.

Concerning the adoption model (first column in Table 1), our findings confirm the rank effect according to which big firms are better positioned to adopt and use new ICT compared to small firms (Karshenas and Stoneman, 2005, Bartoloni and Bausola, 2010). At the same time, we find that firms belonging to a group and consequently needing to communicate intensively with other affiliates adopt the newest generation of ICT. In addition, our findings show that there is a notoriety effect. Firms that are worrying about their reputation and would like to maintain their notoriety are more likely to adopt the new generations of ICT. Since our first estimation correcting for selection emphasizes that there is no selection bias[5], we move to the result of the Bivariate Probit model.

The second part of our work focuses on the firm's performance (short-term measure of performance through firm revenues and a long-term measure of performances through reaching new customers.)

The second model presents the results for increasing revenues. We found that firms that have adopted the newest generations of ICT and have customized their products are more likely to increase their revenues. New ICT enable firms to better discriminate among the customers and to increase their "monopoly power". However, we find that a firm's size has no impact on a firm's performances. There are no differences between large or small firms; large firms do not generate more revenues when they adopt new ICT. Our findings confirm however that firms that have the dedicated human capital for ICT are more likely to increase their revenues. The absorptive capacity effect is confirmed in this work. Taken as a whole, our work confirms the finding by previous studies on the positive impacts of ICT on firms' short-term performance.

The third model examines how new ICT are allowing to reach new clients. Enlarging the market needs an intensive usage of new ICT. In fact, the firm needs to customize its website, its products and put new e-commerce solutions in place. Our results show again that a firm's

[5] Since ρ(innov, revenue) and ρ(innov, increase) are not significant.

size does not matter. There is no need to be big in order to benefit from new ICT and attract more customers.

Attracting new clients requires using all the possibilities offered by the new technologies. For example, firms need to have a community management scheme in order to reach clients in social media. They need to use several applications of the new technologies in order to increase the consumer's interest and attention. The intensity of ICT use should be high enough in order to capture these new customers. Our findings confirm that in order to have deep impact and performance of ICT, firms need to adopt a "pack (or bundle) of technologies". Prior literature has shown that the adoption by pack was associated with an internal impact by leading to a change in the internal organization of the firm (Bresnahan et al. 2002, Black and Lynch, 2004; Caroli and Van Reenen, 2001). We find in this work that adoption by "pack" has also an external effect by allowing reaching new customers.

The surprising finding is that the probability to reach new clients is not influenced by the technological absorptive capacity of the firms. Firms do not need to have specific and dedicated human capital for this aspect! New ICT seem to need lesser-dedicated human capital. Moreover, our results show a negative effect of belonging to a group. This suggests that acquiring new clients with new ICT needs the firm to be very reactive and to practice very pro-active commercial strategies. In the case where the firm belongs to a group, this strategy may be determined at the group level and the changes may take time. Another alternative explanation may be linked to the fact that firms belonging to a group are less worried about acquiring new customers than other firms. Since they belong to a group, the group has a large database of clients and customers regarding the different products that they are selling and they can easily use the database for the aim of enlarging their market prior to invest in capturing new ones.

5. Concluding remarks

The objective of this article was to examine how the use of new ICT impacts firms' performances. We have considered two variables related to performances: a short-term measure of performance by considering the revenues of the firms and a long-term measure of performance through the variable reaching new customers.

Our findings contain four original results regarding the impact of the use of these new ICT on firms' performances. First, the use of the latest generation of ICT can increases firms' revenues (short term returns) if the ICT usage serves to customize their products and if they have the dedicated IT staff. This detail can stimulate the adoption of the new ICT waves. Second, the use of the latest generation of ICT enables long run returns if they are used for several purposes such as developing a catalogue online, setting up e-commerce solutions and customizing the website. Third, while the new waves of ICT seems to need dedicated human capital and technological absorptive capacity for increasing revenue, this facet is not valid for reaching new customers. Fourthly, belonging to a group has no impact on increasing the revenue of the firm when it uses new ICT, although it has a negative effect on capturing new customers.

Our findings have important managerial implications in terms of adoption and use of new waves of ICT. The construction of competitive advantages based on new ICT needs that the firms investigate the purposes of the available ICT. Adoption and use of ICT applications depend strongly on the horizon of the construction of the competitive advantage. Long-term competitive advantage needs to adopt a "pack of technologies/applications", which could

induce an internal change by modifying the internal division of labour and tasks as well as an external change by allowing reaching new markets and new customers.

Table 1: Average Marginal Effects from Bivariate Probit with/without sample selection

	Bivariate Probit with sample selection			Bivariate Probit	
	Innovator in ICT	**Increase revenue**	**Reach new clients**	**Increase revenue**	**Reach new clients**
Customized product		**0.165** *	0.090	**0.159** **	0.091
		[-0.070]	[-0.054]	[0.050]	[0.051]
Online Catalogue		-0.044	**0.098** *	-0.027	**0.106** **
		[-0.036]	[-0.042]	[0.035]	[0.034]
Order/book/pay online		0.051	**0.113** *	0.041	**0.106** *
		[-0.05]	[-0.051]	[0.045]	[0.045]
Customized website		0.048	**0.165** *	0.053	**0.163** **
		[-0.061]	[-0.067]	[0.053]	[0.055]
IT and/or ICT staff		**0.157** **	0.008	**0.154** ***	0.011
		[-0.056]	[-0.038]	[0.036]	[0.037]
Leader	**0.112** *				
	[-0.032]				
Local notoriety	*Ref.*				
National notoriety	**0.110** *				
	[-0.028]				
International notoriety	**0.110** *				
	[-0.031]				
10-19 employees	*Ref.*	*Ref.*	*Ref.*	*Ref.*	*Ref.*
20-49 employees	**0.095** *	0.002	-0.044	0.012	-0.037
	[-0.023]	[-0.054]	[-0.041]	[0.037]	[0.037]
50-249 employees	**0.112** *	-0.02	-0.071	0.005	-0.053
	[-0.029]	[-0.067]	[-0.051]	[0.045]	[0.044]
250 employees and more	**0.336** *	-0.116	-0.05	-0.125	-0.063
	[-0.067]	[-0.113]	[-0.102]	[0.077]	[0.075]
Manufacturing	*Ref.*	*Ref.*	*Ref.*	*Ref.*	*Ref.*
Knowledge Intensive Services	**0.085** *	-0.029	-0.025	-0.028	-0.023
	[-0.037]	[-0.062]	[-0.057]	[0.055]	[0.054]
Less KIS	-0.005	0.035	0.046	0.034	0.046
	[-0.035]	[-0.058]	[-0.054]	[0.054]	[0.053]
Construction	-0.059	-0.022	-0.026	-0.033	-0.032
	[-0.037]	[-0.075]	[-0.064]	[0.059]	[0.057]
Group	**0.114** *	0.057	-0.074	0.053	**-0.070** *
	[-0.025]	[-0.065]	[-0.038]	[0.035]	[0.035]
Correlation of residuals					
ρ(innov, revenue)	-1.081				
	[-0.913]				
ρ (innov, clients)	-0.710				
	[-0.451]				
ρ (revenue, clients)	**0.897** *			**0.706*** **	
	[-0.200]			[0.062]	
Obs.	**2179**			**1353**	

* p<0.05 ** p<0.01 *** p<0.001

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ANNEX 1: SAMPLE CHARACTERISTICS

	Whole population (%)	ICT innovator only (%)
Employment		
10-19 employees	45.3	36.1
20-49 employees	33.5	35.8
50-249 employees	18.3	22.8
250 employees and more	2.9	5.3
Economic activity		
Manufacturing	10.3	11.4
Knowledge Intensive Services (KIS)	25.9	32.7
Less KIS	36.3	35.1
Market position		
Group	27.1	37.0
Leader	22.1	30.7
Local notoriety	14.8	10.1
group	47.2	45.6
International notoriety	38.0	44.3
ICT "related" variables		
IT and/or ICT staff	20.7	37.2
Customized product	10.9	13.0
Catalogue online	32.0	39.5
Order/book/pay online	15.0	19.2
Customized website	7.6	11.5
Observations	**2179**	**1353**