E-Skills, Brains And Performance Of The Firms: ICT And Ability Of Firms To Conduct Successful Projects In Luxembourg

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ABSTRACT

This paper provides original empirical evidence on the causal links between e-skills, usage of Information and Communication Technologies (ICT) and firm's performance using a sample of Luxembourgian manufacturing and services firms. Firm performance is measured in terms of innovation (success of new projects settled). Our main findings are: (i) there's no relationship between the absorptive technology capacity of the firm (measured by ICT staff and Training) and the probability of the implementation of successful ICT projects, (ii) there is a positive effect of e-applications usage (ICT usage) on the probability of the implementation of successful new projects, and (iii) there is an asymmetric effect of usage of e-commerce and e-administration confirming findings of the recent literature.

Keywords: Innovation; Usage Of ICT; Depth Of ICT Adoption; Ordered Models; Innovative Projects

1. INTRODUCTION

*T*here is an increasing evidence on the fact that information and communication technologies (ICT) are fostering the international innovation at the macro-economic level (Cardona et al. 2013, Baquero, 2013) and the implementation of innovative projects by firms at the micro-economic level (Bertschek et al. 2013, Colombo et al. 2013, Ben Youssef et al. 2012a and 2012b, Peltier-Ben Aoun and Vincente Cuervo 2011). ICT have the potential to induce several structural changes inside the firm such as increasing its labour productivity, increasing its total factor productivity, modifying its internal organisation, changing of employees' behaviour and contextual performances, linking the firms to networks of knowledge and innovation and increase their ability to innovate.

First generations of ICT have played a major role in these changes. However, their innovative outcomes were contingent to the capacity of the firm to have the needed complementary assets like "brains" (human capital). Several papers have shown that ICT are complementary to human capital, technological absorptive capacity of the firm (Hollenstein and Worter, 2008, Bellon et al. 2006, Basant et al. 2006) and organizational change (Bresnahan et al. 2002, Bertschek, and Kaiser, 2004, Arvinatis and Loukis, 2009).

The picture seems changing nowadays and the latest generations of ICT are cheaper, have better output elasticity (Cardona et al. 2013), more impact on the productivity of the firm (Engelstätter and Sirbu, 2013, Colombo et al. 2013), better customized to the needs of the firms and have deeper impact on the firms' innovation capacity (Bertschek et al. 2013). Cloud computing is a perfect example of this radical change in the scope and purpose of the new ICT with powerful impact on productivity and innovation.

This paper contributes to the existing literature by providing original empirical evidence on the causal link between the innovative performance of the firm and human capital (ICT skills, e-skills) and usage of e-applications (ICT) using a sample of Luxembourgian manufacturing and services firms. The new waves of technologies make it

easier to use intensively ICTs and to catch more easily the innovation spillovers than in the past. Firms are engaging more efficiently in innovation and are implementing more successfully their projects.

The dataset stems from the 2008 survey on Information and Communication Technologies (ICT) Usage and e-Commerce in Enterprises in the case of Luxembourg (STATEC) in order to explore our hypothesis. We have only considered the firms that have implemented a new ICT project in the last two years (2006-2008). This leads to a sample size of 916 firms (1,305 firms if weighted). We use an Ordered Logit Model (Greene, 2008) estimated by maximum likelihood in order to examine the intensity of success of a new ICT project.

The paper provides two main results. First, our econometric analysis shows absence of correlation between the success of implementation of a project by the firm and the ICT absorptive capacity. Last waves of ICT seem less e-skills consuming. Second, the impact of e-applications use on the success of implementation of a new project by the firm is well established for several applications like e-selling, e-banking and e-administration. However, the relation is not established for all the applications. Moreover, firms seem using differently the different sides of the applications.

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 AND HYPOTHESIS

In this section we provide a brief discussion of the main channels through which new waves of ICT can modify the innovation ability of the firm. We discuss then the three hypotheses that will be tested.

2.1. An Increasing Intensity Of ICT Usage By Firms

The intensity of usage of ICT has significant impact on firm's performance. Asterbo (2004) has claimed the needs for scholars to focus more on intensity of usage (depth of adoption) and less on adoption of ICT itself. In fact the intensity of usage reveals how people are engaging in better coordination, more efficient production systems, more flexible practices within the firms, and management of more innovative projects. As the intensity of usage increases, the associated benefits increase.

The new waves of ICT have changed radically the intensity of use of these technologies. New waves of ICT are associated with an increase in the capacity of the bandwidth allowing the use of more advanced Internet usages to the firms. Several papers have showed that Broadband is associated with better economic performance to the firms (Colombo et al. 2013). 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 innovation activity induced by broadband usage may have been translated into productivity gains in later periods. Polder et al. (2010) take a firm-level perspective to analyze the role of ICT and R&D 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. By contrast, in the manufacturing sector, broadband is significant only for product and organizational innovation. For process innovation it is rather e-commerce that plays a significant role.

2.2. Complementary Assets Are Less Needed

Implementation and use of first generations of ICT were not associated necessarily with observed performance' improvement at the firm level. This fact was explained mainly by lack of adoption of new organizational practices (Bresnahan et al. 2002), lack of technological absorptive capacity of these technologies (Hollenstein, 2004; Bellon et al. 2006) and lack of e-skills (Ben Youssef et al. 2014). This effect is the main effect

stressed by disequilibrium theory of innovation[1] adoption. The adoption of a given innovation or technology depends on the technological absorptive capacity built by the firm over time. The more the firm is able to absorb the technology the more the depth of adoption is important. The accumulation of e-skills by the firm (The dedicated staff for ICT) and in general the average qualifications of the staff are considered as the main indicators for this absorptive capacity.

These problems seem to be partially solved by the newest generations of ICT, which are lowering the skills requirements and offering new possibilities for the firms. The newest waves of ICT have the potential to induce firms to more successful innovative process with less efforts and means. Firms are capitalizing on their experience in the management of last waves of technologies. Several contributions have shown and demonstrated that firms have built over the last two decades capabilities in matter of use of these technologies and as a consequence the impacts on the productivity and on the performances are more rapid and more visible.

One needs also to note that the ICT production providers are better taking into account the storage capacity constraints and security issues of the firms. Firms have non-limited storage capacities with the new Internet paradigm: Cloud computing. Taken together, the new waves of ICT are leading to more rapid impact on the performance of the firm than the last generations of ICTs and are fostering the ability of the firm to innovate and to set new projects successfully.

2.3. More Selection Of E-Applications

Thousands of e-applications are available for citizens and firms nowadays through several rivalry platforms. Identification of the value-adding innovation (application) and its effective usage is a learning process. Economic literature has identified recently that innovation like e-commerce has several facets and firms may use them differently. Hollenstein and Heinz (2008) have demonstrated that the degree of diffusion of the two types of e-commerce strongly differs. Firms may value differently the real costs and benefits of them at each point of the time. In some cases, there is rationality to not use these technologies and in some case to use them less! Since then their effects also may differ in term of performance of the firms. This is also the case of e-administration, e-banking, e-training... Firms may adopt differently the services associated to these innovations. The technologies that are more adopted are expected to have deeper impact on productivity and performance.

2.4. Hypotheses

From the previous discussion we can formulate the following three hypotheses:

Hypothesis 1: ICT need e-skills in order to improve the success to implement new projects.

This hypothesis discusses the absorptive capacity effect of new ICTs.

Hypothesis 2: Implementing successful projects depend on the intensity of usage of standard e-applications like e-banking, e-Commerce, e-administration…

Hypothesis 2 gives a clear argument in favour of equilibrium theory of intra-firm diffusion[2] of innovation and shows that the adoption of innovation is associated to expected returns.

Hypothesis 3: Implementing successful projects depend differently from one side or another of the e-applications.

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1 The first tradition is the epidemic models (Mansfield, 1963 and 1968). In this approach, it is assumed that the use of a innovation increases over time as the risk attached to further adoption is reduced through learning. Thus, it's assumed that the usage pattern is S shaped curve following a logistic curve.

2 Equilibrium theory of intra-firm diffusion suggests a non-linear and discontinuous diffusion pattern (Karshenas and Stoneman, 1995). *At each moment, technology use in time t will only extend to the point where the marginal expected profit gain from further adoption equals the cost of adoption (appropriately defined) of the new technology. Over time either the marginal gain and/or the cost of adoption may change and as they do so the level of use will change (Battisti and Stoneman, 2005)* ».

This hypothesis tests the asymmetric adoption process observed recently in many countries. This observation confirms also the equilibrium theory since the adoption is only linked to the expected returns.

3. DATABASE, SAMPLE CHARACTERISTICS AND ECONOMETRIC MODEL

3.1. Database

The data 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 and it includes valuable data on the type of competition faced by firms, which is a key factor to explain technological diffusion as indicated by Porter (1990). This dataset covers firms with at least 10 employees in manufacturing and services, except for financial activities[3]. We will only consider the firm whom has implemented a new ICT project in the last two years (2006-2008). This leads to a sample size of 916 firms (1,305 firms if weighted).

3.2. Dependent Variables

As mentioned above, in order to measure successful ICT projects we only consider firms who have implemented new ICT projects during the period 2006-2008 (period covered by the survey). The evaluation of the impact of this implementation is measured through a score. This score is groups 3 variables as follows:

RESS =1 if the implementation has moderate or significant impact on the release of resources in the firm, 0 otherwise.

REV = 1 if the implementation has moderate or significant impact on the increase of the revenue of the firm, 0 otherwise.

COST =1 if the implementation has moderate or significant impact on the reduction of the costs of communication in the firm, 0 otherwise.

We will not make the assumption that one effect is better for the firm than another. Moreover, we will not distinguish between moderate impact and significant impact. Indeed, due to the subjective value of the answer it is easy to understand that, what is considered as a moderate impact for one firm can be considered as a significant impact for another. Whereas, "feeling no impact" is considered as a common knowledge for every firm. We finally, only consider the binomial answer: "yes, I perceived" an effect or "No, I did not".

The dependent variable goes from the value 0 where the ICT project(s) implemented has(have) no impact on the previous possibilities to 3 where the ICT project(s) implemented has(have) an impact on all the previous possibilities. Thanks to the construction of the variable, it can be considered as an intensity of successful ICT projects. Due to the nature of our dependent variable we will use an ordered Logit model.

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

3.3. Independent Variables

Variables	Type
Market position	
Being part of a group	Dummy
Being Leader	Dummy
Having a local reputation	Dummy
Having National reputation	Dummy
Having an International reputation	Dummy
ICT Equipments	
Firm owns Intranet	Dummy
Firm owns Extranet	Dummy
Firm uses Mail	Dummy
Firm uses Visio-conference	Dummy
Firm uses Electronic Forum	Dummy
Firm uses Electronic Calendar	Dummy
Firm uses Project Management group	Dummy
Number of services offered by the internal home page[4]	Continuous (0-5)
Internet Activities	
Firm uses Internet to benefit from banking and financial services	Dummy
Firm uses Internet for training and education	Dummy
Interaction With Public Authorities	
Firm uses Internet for obtaining forms or information	Dummy
Firm uses Internet for returning filled in forms, for treating an administrative procedure or for submitting a proposal in a public electronic tender system	Dummy
It Security	
Firm has used consultants for security needs	Dummy
Firm has used internal resources for security needs	Dummy
Firm has used internal resources and consultants for security needs	Dummy
Firm staff is aware of security issues	Dummy
Automated Data Exchange	
Firm receives or sends e-invoices	Dummy
Firm sends orders to suppliers or receives orders from customers	Dummy
Firm sends or receives product information	Dummy
ICT Personnel	
ICT or IT are present in the firm	Dummy
ICT/IT functions requiring ICT specialist were completely or partially guaranteed by external service providers	Dummy
E-Commerce	
E-selling	Dummy
E-purchasing	Dummy

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4 This variable results from the construction of the aggregation of 5 questions. These are the following:

- if the Intranet provides the general policy or strategy of the enterprise, 0 otherwise.
- if the Intranet provides internal company newsletters or daily news, 0 otherwise.
- if the Intranet provides day-to-day / working documents (e.g. for meeting), 0 otherwise.
- if the Intranet provides products or services catalogues
  Cronbach's alpha results = 0.831

3.2.1 Control Variables

Economic Activity

The economic activity is defined through the NACE LUX rev1.1 classification and we have distinguished the following segmentation:

- Manufacturing
- Construction
- Trade Hotel and Restaurant
- Transport and Communications
- Financial activities and other services
- Real Estate activities

Size

- Between 10 and 49 employees
- Between 50 and 249 employees
- At least 250 employees

In order to test the first hypothesis, we will consider that usage of Internet for training and educations as well as having IT personnel are the variables reflecting the e-skills component. They must have significant and positive impact on implementing successfully projects.

In order to test for the second hypothesis we consider the following practices as the e-applications reflecting the usage of new ICTs: use of Internet for banking services (E-banking), adoption of E-Commerce (e-selling or e-puchasing), Internet for treating an administrative procedure (E-administration). Our assumption suggests a positive and significant sign.

Finally, to test the last hypothesis two practices will be split. First, e-commerce distinguishing between e-selling and e-purchasing. Second, the e-administration will be derived in downloading procedures or uploading documents. We expect that the sign may be positive or negative and the significance is not found for the two side of the innovation.

3.4. Model Specification

The Ordered Logit Model (see Greene, 2008) is a regression model for ordinal dependent variables. It can be thought of as an extension of the logistic regression model for dichotomous dependent variables, allowing for more than two (ordered) response categories[5]. The model cannot be consistently estimated using ordinary least squares; it is usually estimated using maximum likelihood.

The model is built around a latent regression in the same manner as the binomial Logit model. We begin with

$$y^* = x'\beta + \varepsilon$$

Where y^* is the exact but unobserved dependent variable (in our study the intensity of success of a new ICT project).

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[5] The model only applies to data that meet the proportional odds assumption, that the relationship between any two pairs of outcome groups is statistically the same. This means that the coefficients that describe the relationship between, say, the lowest versus all higher categories of the response variable are the same as those that describe the relationship between the next lowest category and all higher categories, etc. Because the relationship between all pairs of groups is the same, there is only one set of coefficients.

What we do observe is

$$Y = \begin{cases} 0 \ if \ y* \leq \mu_1 \\ 1 \ if \ \mu_1 \leq y* \leq \mu_2 \\ 2 \ if \ \mu_2 \leq y* \leq \mu_3 \\ 3 \ if \ \mu_3 \leq y* \leq \mu_4 \end{cases}$$

And we must have $0 \leq \mu_1 \leq \mu_2 \leq \mu_3$ for all the probabilities to be positive.

The μ are unknown parameters to be estimated with β. The feelings on the intensity of the success of the ICT project depends on certain measurable factors x' and certain unobservable factors ε. In principle, the firm could answer with their own $y*$ if asked to do so. Given only, four possible answers, they choose the cell that most closely represents their own feelings on the feeling. We then have

$$P(Y = 0) = \frac{1}{1 + \exp (Y_{i-\mu_1})}$$
$$P(Y = 1) = \frac{1}{1 + \exp (Y_{i-\mu_2})} - \frac{1}{1 + \exp (Y_{i-\mu_1})}$$
$$P(Y = 2) = \frac{1}{1 + \exp (Y_{i-\mu_3})} - \frac{1}{1 + \exp (Y_{i-\mu_2})}$$
$$P(Y = 3) = 1 - \frac{1}{1 + \exp (Y_{i-\mu_3})}$$

4. RESULTS

4.1. Descriptive Statistics

Table 1 gives a first outlook of our samples. We will not consider the size and economic activities representation, it will be discuss more deeply in table 3. Moreover, there is no significant difference from sample 1 and 2, so we will only comment sample1 (hereafter referenced as "sample" for ease to read).

Table 1. Descriptive Statistics

Variable	Sample 1[6]		Sample 2	
	%	**Std. Dev.**	**%**	**Std. Dev.**
Market Position				
Part of a group	37.2	0.484	42.5%	0.494
Leader	31.3	0.464	31.1%	0.463
Local notoriety	8.9	0.285	8.5	0.279
National notoriety	45.0	0.498	43.3%	0.496
International notoriety	45.3	0.498	47.5%	0.500
ICT Equipments				
Intranet	68.9	0.463	71.1%	0.454
Extranet	36.5	0.482	38.4%	0.487
Mail	93.6	0.244	94.2%	0.233
Visio or video conference	17.3	0.379	20.4%	0.403
Electronique Forum	20.3	0.403	21.1%	0.408
electronic group calendar	51.7	0.500	54.4%	0.498
Project Manager Group	27.5	0.447	29.6%	0.457
Number of services offered by the Intranet	1.57	1.804	1.70	1.857
Internet Activities				
Internet to benefit from banking/financial services	82.6	0.379	82.8	0.377
Internet for training	31.2	0.464	32.1%	0.467
Internet with public auth. to obtain a procedure	94.6	0.226	94.6%	0.225
Internet with public auth. to fulfill a procedure	59.9	0.490	60.5%	0.489
Automated Data Exchange				
ADE for billing	32.5	0.469	31.8%	0.466
ADE for orders	44.0	0.497	43.6%	0.496
ADE to exchange of information	55.9	0.497	59.1%	0.492
E-Commerce				
Sell via Internet (e-selling)	16.9	0.374		
Purchase via Internet (e-purchasing)	49.0	0.500		
ICT Personnel				
Presence of ICT/IT staff	38.0	0.486	42.4%	0.494
External Services for ICT functions	71.0	0.454	73.0%	0.444
Hire consultant for security purposes	35.3	0.478	34.0%	0.474
Use internal resources for security purposes	39.8	0.490	39.0%	0.488
Use internal resources and consultants for security purposes	12.2	0.328	15.2	0.359
staff awareness of security issues	66.4	0.473	68.4%	0.465
Control				
10-49 emp.	71.6	0.451	69.4%	0.461
50-249 emp.	21.6	0.412	23.1%	0.421
250 emp. And more	6.8	0.252	7.5	0.264
Manufacturing	11.9	0.324	10.7%	0.310
Construction	21.3	0.410	19.3%	0.395
Trade	25.2	0.434	22.9%	0.420
Hotel And Restaurants	1.5	0.121	1.4	0.115
Transport and communications	10.4	0.305	9.4	0.292
Financial activities	-	-	9.5	0.293
Real estate	29.7	0.457	27.0%	0.444
Observations	*1305*		*1445*	

Source: ICT survey 2008, STATEC, authors' calculation

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[6] Sample 1 is equal to sample 2 except that it does not include the financial sector and so the e-commerce can be included as determinants of success of ICT project.

About the general context on the market, we note that almost 40% of our sample is part of a group, and 90% have at least a national reputation. When considering the ICT equipment it appears that some technologies are fully adopted (Mail) or almost (Intranet), while some more specific and more recent are less diffused (e.g. Extranet, Visio or Video conference). Moreover, even if around 7 firms over 10 have introduced an Intranet, the number of services offered is on average around 2. So even if Luxembourgish firms are well equipped compared to the other EU countries there is still a gap to fill.

If we point our interest not anymore on ICT adoption but on ICT use the first descriptive results show some discrepancy. Firms use Internet first of all to benefit from banking and/or financial services. But it is still encouraging that a third of our sample uses Internet for training. Furthermore, almost all firms of our sample use Internet to obtain something (information, forms…) from public authorities. More than a half of our sample practices the automated exchange of data. The main reason to use this technology is to exchange information and then to receive or send orders, billing remaining the last motivation. Finally, we note that e purchasing is three times more widespread than e selling. We observe that as mentioned in the literature we cannot anymore consider ICT by their nature but we have to consider their uses. And it appears that the variety of use has deeply enlarged in these recent years.

Regarding the workforce in the firms, we observe that only 40% of these firms (who have implemented new ICT projects) employ ICT or IT specialists, but almost 70% of them declare resorting to external services to perform those ICT functions required for the firm. But when it comes to firm security, in 40% of the case they use internal resources to meet their needs and they are 66% of the firms that increase their employees' awareness of security issues.

All these first statistics show that, what we consider as determinant to explain the success of a new ICT project, i.e. the behavior of adoption and use are heterogeneous among our sample.
Table 2 shows the distribution of intensity score experienced by firms that have implemented new ICT projects over the past two years. The first but not least result is that not every firm which has implemented a new ICT project has seen an impact on its performance in the sense defined in the previous section.

Table 2. Intensity Of Performance Perceived

	0	1	2	3
(%)	13.0	23.8	25.8	37.2

Source: *ICT survey 2008, STATEC, authors' calculation*

Indeed, 13% of our sample did not perceived any impact contrary to the 37.2% of firms, which have declared a perceived impact in all categories censed before (representing the performance). This result confirm the fact it is more useful to consider the model in term of intensity instead of just considering the fact that the firm perceived something or not (with a simple binomial model such as a Logit or a Probit model).

4.2. Econometric Results

Table 3 summarizes results from the estimation of ordered logit models.

Table 3. Results From Ordered Logit Estimation

Dependent Variable: Intensity of success perceived from the implementation of an ICT project.

	Sample1	Sample2
Employment		
10-49	*Ref.*	*Ref.*
50-249	-0.18	-0.19
250 and more	-0.61	-0.30
Economic Activity		
Manufacturing	*Ref.*	*Ref.*
Construction	-0.49*	-0.49*
Trade	-0.27	-0.2
Hotels and restaurants	-0.05	0.13
Transports and communications	-0.24	-0.17
Housing and other services		-0.54
Finance	-0.36	-0.33
Market Position		
Group	0.33*	0.29*
Leader	-0.07	-0.12
Local notoriety	*Ref.*	*Ref.*
National notoriety	0.44**	0.46*
International notoriety	0.51*	0.54*
ICT Equipment		
Intranet	0.46**	0.42*
Extranet	-0.02	-0.01
Mail	-0.02	-0.02
Visio-conference	-0.08	-0.08
Electronic Forum	0.11	0.09
Electronic Calendar	0.31*	0.16
Project Management group	-0.19	-0.10
Intranet possibilities	-0.04	-0.01
Internet Activities		
Banking activities	0.43*	0.34*
Training activities	0.04	0.05
Interaction With Public Authorities		
Download document	-0.24	-0.12
Upload document	0.31*	0.3
It Security		
External	0.16	0.17
Internal	0.27	0.24
Both	0.19	0.26
awareness of security issues	0.53***	0.48
Automated Data Exchange		
invoice	0.74***	0.68***
order	-0.16	-0.10
product information	-0.26	-0.25
ICT Personnel		
IT/ICT personnel	0.22	0.25
External ICT staff	0.17	0.17
E-Commerce		
E-Selling	0.44*	
E-Purchasing	-0.05	
Cut point 1	-0.45	-0.4
Cut point 2	1.05*	1.03*
Cut point 3	2.22***	2.18***
Observation	**1305**	**1445**

Note: * signifiance at 10% level, ** signifiance at 5% level and *** signifiance at 1% level.

Source: ICT survey 2008, STATEC, authors' calculation

The first hypothesis about the absorptive capacity of the firm and successful project is not verified. In fact our results show that there's no relation between the proxies of absorptive capacity (Training, ICT staff) and the performance of the firms in terms of setting successful projects. Our main explanation is that the new technologies (ICTs) need marginal efforts in matter of training and staff and not substantial efforts contrarily to the lasts innovations. Setting a website nowadays may take few minutes with interactive solution ready to be hosted in a server. This was not the case some years ago, where the firm needs to employ Webmaster, to spend a lot of money for building its architecture and to make it livable. Social Medias and other applications are lowering the requirements in matter of "brains" for the firms allowing them to use these innovations more frequently. What is true for a website is also true for several other applications for the firms.

The second hypothesis, about the relationship between the intensity of use of e-applications (innovations) and successful ICT Project, is verified for most of e-applications. Our results show that the use of e-banking, e-administration (uploading documents) and e-selling improve the probability of setting successful project. This result confirms previous finding by Polder et al. (2010). In fact, as the constraints are lowered and the human capital requirements are lesser, firms are more engaged in using the e-applications. These applications allow them to acquire new competencies in matter of management of projects and these skills are transferable to other projects management. Another complementary explanation relies to the fact, that e-applications as e-banking, e-selling, e-administration permits to save costs and to use the resources for other projects, improving by this their probability of success. Thirdly, most of new projects are entirely or partly e-projects and are using e-skills. The intensive use of e-applications permits to accumulate those e-skills and to use them in others projects. Lastly, one needs to mention that the e-security matters. Firms engage more projects as their awareness about security increases. Most of the firms are increasing the security awareness of their employees and building e-skills in this particular area. The firm staff awareness of security issues has a positive and important impact on the probability of success on the implementation of a new project.

The third hypothesis is about the asymmetric and selective impact of e-applications. Our results show clearly that the impacts of the two side of one innovation have differentiated impacts on the performance of the firm. Our results find that while e-banking, e-commerce (e-selling) and e-government (upload document) have an impact on the performance of the firm, there is no impact for e- purchasing, e-training and downloading documents for e-administration issues. Several explanations can be given in order to explain such findings.

Firstly, as mentioned in Hollenstein and Woerter (2008) and Peltier-Ben Aoun and Vicente (2011) e-commerce cannot be studied as a whole. E-commerce has to be split in e-selling and e-purchasing. This is natural because by definition e-purchasing is a Business to Business (B2B) activity where e-selling is B2B and a Business to Consumer (B2C) process. Implementing e-purchasing seems easier than e-selling. E-selling requires a platform where the consumer or the other firm can purchase the goods or services offered by the firm. When a firm is involved in this type of e-commerce we can assume that it has deployed the skills and organization needed to favor this kind of process and that firm are more able to gain from the implementation of other ICT project.

Secondly, for e-administration, when a firm interacts with public authorities, it faces to different requirements for downloading information or documents than for filling in documents or submitting a proposal in a public electronic tender. The first one needs basic ICT (computer, Internet connection) while the second requires more extensive facilities. As we have observed for the e-commerce, there is an asymmetric behavior in interacting with the public authorities. A "downloading" behavior has no impact in the perceived effect of the implementation of a new ICT project whereas an "uploading" interaction with the public authorities has a positive impact with the possible success of a new ICT project.

5. CONCLUSION

Luxembourg is a country often depicted as well equipped in Information and Communication Technologies. Indeed, almost all firms, with at least 10 employees, own computers, are connected to the Internet and exchange mail. Moreover, more than 40% of those firms adopt the e-commerce (e-selling or e-purchasing). Nevertheless, we observe a decline in the adoption of since 2007. So, the diffusion of this new technology and its impact is not yet clear. In this paper, we focused our attention on the impact of different types of new technologies

related to the Internet such as e-banking, e-commerce, e-administration and e-training on the performance of the firm measured by the implementation of successful projects.

The first aim of this paper was to show that technological evolution is permitting better use of the technologies with lesser e-skills needs. Since then, the performance of the firm is less dependent on e-skills (ICT skills) and Brains (Human Capital). Our results confirm this intuition. Secondly, we show that most of e-applications used by the firms have an impact on the performance of the firm. However, while the firms are using a diversity of application, they are selective in using only one side of the innovation and not the others (e-commerce and e-administration). Our analysis emphasizes the asymmetric effect of some specific ICT such as E-commerce and E-administration. We explain this phenomenon by the fact that both activities require different logistics in the firm. We have shown the significant impact of e-selling and interacting with public authorities in order to fill in an application. While, e-purchasing and interact with the public authorities in order to download information or documents are not significant.

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REFERENCES

Arvanitis, S., and Loukis, E.N. (2009). Information and communication technologies, human capital, workplace organization and labour productivity: a comparative study related on firm-level data for Greece and Switzerland. *Information Economics and Policy* 21 (1), 43–61.

Astebro, T. B. (2004). Sunk costs and the depth and probability of technology adoption. *Journal of Industrial Economics* 52, 381–399.

Basant R., Commander S, Harrison R., and Menezes-Filho N. (2006). ICT Adoption and Productivity in Developing Countries: New Firm Level Evidence from Brazil and India", IZA DP No. 2294, September 2006.

Battisti, G. and Stoneman, P. (2005). The intra-firm diffusion of new process technology", *International Journal of Industrial Organization* 23, 1-22.

Baquero, M. (2013). Mobile communication networks and Internet technologies as drivers of technical efficiency improvement. Information Economics and Policy, 25, 126-141.

Bellon, B., Ben Youssef, A. and M'henni, H. (2006). The missing link between adoption and usage of ICT in the south Mediterranean countries". *Revue Française de Gestion* 166 –2006/7, 173-190. (*in French*)

Ben Youssef, A., Martin, L. and Omrani, N. *forthcoming*. (2014). *The complementarities between ICT Use, New Organizational Practices and Workers Contextual Performance: Evidence from Europe in 2005 and 2010". Revue d'Economie Politique.*

Ben Youssef, A., Castillo-Merino D., and Hadhri, W. (2012a). Adoption and Usage of ICT by Catalan Firms, «Internet Econometrics », New Palgrave MacMillan, Allegrezza & Dubrocard (ed.). Pp. 288-308.

Ben Youssef, A., Hadhri, W., and Mhenni, H., (2012b). Intra-firm diffusion of innovation: Evidence from Tunisian SME's regarding Information and Communication Technologies. Middle East Development Journal. Volume 3, Issue 3 : pp. 75-97.

Bertscheck, I. Cerquera, D., and Klein, G. (2013). More bits – more bucks? Measuring the impact of broadband internet on firm performance, Information Economics and Policy, 25, 190-203.

Bertschek, I., Kaiser, U., (2004). Productivity effects of organizational change: microeconometric evidence. Management Science 50 (3), 394–404.

Black, S.E., Lynch, L.M., (2004). What's driving the new economy? The benefits of workplace innovation. The Economic Journal 114 (493), 97–116.

Bocquet, R. & Brossard, O. (2007). The variety of ICT adopters in the intra-firm diffusion process: Theoretical arguments and empirical evidence, *Structural Change and Economic Dynamics* 18, pp: 409–437

Bresnahan, T., Brynjolfsson, E. & Hitt, L. (2002). Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-Level Evidence, *The Quarterly Journal of Economics*, vol. 117, n° 1, pp. 339-376.

Bresnahan, T., and Trajtenberg, M. (1995). General purpose technologies: "Engines of Growth'?. *Journal of Econometrics*, 65(1), pp. 83-108.

Cardona, M., Kretschmer, T., Strobel, T. (2013). The contribution of ICT to productivity – key conclusions from surveying the empirical literature. Information Economics and Policy, 25, 109-125.

Colombo, M., Groce, A-L., and Grilli, L. (2013). ICT services and small businesses' productivity gains: An analysis of the adoption of broadband Internet technology, Information Economics and Policy, 25, 171-189.

Greene, W.H. (2008). *Econometric Analysis*, Sixth Edition, Prentice International Hall Edition.

Hollenstein, H. (2004). The determinants of the adoption of information and communication technologies (ICT). An empirical analysis based on firm-level data for the Swiss business sector. *Structural Change and Economic Dynamics* 15, 315–342.

Hollenstein, H., and Woerter (2008). Inter- and intra-firm diffusion of technology: The example of E-commerce. An Analysis based on Swiss firm-level data. Research Policy, 37, 545-564.

Karshenas, M., Stoneman, P. (1995). Technological diffusion. In: Stoneman, P. (Ed.), Handbook of the Economics of Innovation and Technical Change. Basil Blackwell, Oxford.

Mansfield, E. (1963). Intra-firm Rates of Diffusion of an Innovation, The Review of Economics and Statistics, XLV, 348-359.

Mansfield, E. (1968). *Industrial Research and Technological Innovation: An Economic Analysis*, New York: Norton.

Peltier-Ben Aoun, L., & Vicente Cuervo, M. R. (2011), E-commerce diffusion: exploring drivers of adoption and intensity at firm-level. Mimeo *forthcoming*.

Polder, M., van Leeuwen, G., Mohnen, P., Raymond, W., (2010). Product, Process and Organizational Innovation: Drivers, Complementarity and Productivity Effects, UNU-MERIT Working Paper (2010-035).

Thomas, A. (2000). *Econometric of the qualitative variables*, Dunod, Paris.

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