Determinants of Information Technology Diffusion: a Study at the Firm Level for Portugal

Maria Fraga O. Martins and Tiago Oliveira
Universidade Nova de Lisboa, Portugal
mrfom@isegi.unl.pt
toliveira@isegi.unl.pt

Abstract. Recently, many studies have shown that IT played a major role in the resurgence in the growth of US output and productivity after 1995. Some studies for European countries also confirm this idea that IT and productivity are strongly related. The contribution of IT to economic growth can only be realized when and if these technologies are widely diffused and used. Within this context, understanding the factors affecting the decision to adopt and the extent of IT use by adopters is crucial not only for applied economists, but also to creators and producers of such technologies. Using a data set for Portuguese firms, our estimation results suggest that the significant drivers of intra firm diffusion are: firm size, workers skills, technological capacities and outsourcing partner usage.

Keywords: information technologies, diffusion, adoption, cluster analysis, profit model

1. Introduction

Recent contributions to the literature have shown that IT (Information Technology) intensive firms are more productive (Black and Lynch 2001, Bresnahan *et al.* 2002, Brynjolfsson and Hitt 2000, Dedrick *et al*. 2003, Martins and Raposo 2005) and that IT adoption is important to promote economic growth (Jorgenson 2001, Litan and Rivlin 2001, Pilat and Lee, 2001). In these circumstances, a critical question arises: what are the factors that influence IT adoption and diffusion at the firm level? Some recent studies have focused on the determinants of the time period of IT adoption, also called the inter firm IT diffusion. Another approach proposed in the literature is related to the study of the factors influencing the extent of IT use/ level of IT adoption, also called the intra firm IT diffusion (Battisti et al. 2004, Hollenstein 2004, Teo and Pian 2003, Teo and Pian 2004). In the first part of our study, we analyzed this two important features of IT diffusion for one of the most used and diffused IT: the Internet. Then, we focused our attention on the determinants of the extent of IT use by firms, i.e., intra firm diffusion.

The two main purposes of this study are the following: (1) to examine Internet diffusion patterns, by exploring both inter firm and intra firm diffusion aspects, and (2) to explain, empirically, the determinants of intra firm IT diffusion by considering seven additional IT: email, extranet, intranet, EDI, WAP, LAN and WAN. To achieve this two research objectives we used a rich data set of 487 firms operating in five economic sectors in Portugal. The understanding of the determinants of the extent of IT use, at a firm level, may be a useful tool in addressing the right type of policy measures to increase the rate of productivity growth. This is a particularly needed in the case of Portugal that for several reasons is a country that has been suffering from a serious lack of competitiveness in comparison with other industrialized economies.

Our work is a contribution to the empirical literature on the determinants of IT adoption and diffusion, taking Portugal as a country of application, for which there exists no published studies on the subject. Our paper is organized as follows. The next section investigates the diffusion patterns of the Internet, in terms of the so called inter firm and intra firm diffusion. Then, we analyze the extent to which certain characteristics related to firms' internal and external behavior, influence the intra firm IT diffusion process. Finally, we presented majors findings and conclusions.

2. Diffusion patterns of the Internet

2.1 Data and measures

To accomplish the research objectives, we match data from two National surveys: the Survey on ICT usage by firms and the Annual Business Survey, both conducted by the Portuguese National Institute of Statistics (INE). The ICT usage survey records on all Portuguese business, is stratified by economic sector (NACE classification) and by firm size and is carried out annually since 2001. This survey is a part of an EU/OCDE procedure initiative to produce comparable data for ICT adoption and ICT usage in Europe. In our study, data from ICT usage survey 2002 are used because it is the only one where information on the year of IT adoption is gathered. Since 2003, we only have information on whether the firm is an adopter or not. In order to have complete information, namely on human resources qualification (a very important factor in our work),

Reference this paper as:
Martins, F.O.M and Oliveira, T. "Determinants of Information Technology Diffusion: a Study at the Firm Level for Portugal." *The Electronic Journal Information Systems Evaluation* Volume 11 Issue 1, pp. 27 - 34, available online at www.ejise.com

data from ICT usage survey has been matched to the data from Annual Business Survey. The latter is also stratified by economic sectors and firm size and provides information on general characteristics of firms, including employee' level of education. The matching procedure is based on linking the ID numbers which identify firms in both surveys. Matching data for 2002 gives a cross-section of 487 observations.

In order to identify the different patterns of Internet diffusion, namely in terms of inter firm and intra firm diffusion features, we group the 487 firms using Cluster Analysis. Following the recent literature on IT diffusion models, we considered the following variables in the multivariate analysis: Inter firm diffusion: number of years since first adoption of the Internet; Intra firm diffusion: the proportion of employees working regularly with the Internet; variables related to firm's technological characteristics: IT skills (Gibbs et al. 2004, Giunta and Trivieri 2007, Zhu et al. 2003), broadband, outsourcing partner usage (Hong and Zhu 2006) and perceived obstacles (Hollenstein 2004, Hong and Zhu 2006); variables related to firm's specific characteristics: firm size (Lee and Xia 2006, Gibbs et al. 2004, Giunta and Trivieri 2007, Hollenstein 2004, Zhu et al. 2003), workers educational level (Giunta and Trivieri 2007, Hollenstein 2004), R&D (Giunta and Trivieri 2007); variables related to external pressure factors: competitive pressure (Gibbs et al. 2004).

Some variables are measured directly from the surveys: IT skills is a binary variable equal to one if firm has IT workers and zero otherwise; *firm size*, is measured by binary variables referring to 3 size classes based on the number of employees, S_1 (small firms with 10 to 49 employees), S_2 (medium-sized firms with 50 to 249 employees), S_3 (large firms with more than 250 employees); *workers education level* , EDUC, is measured by the proportion of employees with university degree; *broadband*, BB, that reflects IT technological capacities is measured by a binary variable that is equal to one if firm has broadband and zero otherwise; *outsourcing partner usage* are captured by two binary variables related to the way firms solve their IT challenges: OUT_1 is equal to one if firm solve IT problems with internal resources, and zero otherwise, and OUT_2 is equal to one if firm solve IT problems with external resources and zero otherwise; *R&D profile* is represented by two binary variables PERPROD and PERPROC, that reveal if firm is process or product innovator. Other variables were constructed with the information provided by the surveys: COMP_PRESSURE, measures the proportion of firms that uses IT more than the mean in the particular sector of activity (10 sectors are considered); *obstacles or barriers to IT adoption*, are measured by three variables resulting from a factor analysis on nine perceived barriers of IT adoption that explain 59% of the total variance: COST (implementation costs are to high), KNOW HOW (knowledge and management difficulties) and TECH (technological uncertainty).

Economic sectors were used only as descriptive variables: CAE_1 (manufacturing), CAE_2 (distribution and retail trade), CAE_3 (hotels and accommodation), CAE_4 (transport, storage and communication) and CAE_5 (business services-real state, rentals and business activities).

2.2 Diffusion patterns

Cluster analysis was conducted using SAS software to explore options for grouping the different firms. The objective of cluster analysis is to find homogeneous groups and to maximize the difference between groups. Unlike most parametric statistical techniques, cluster analysis does not explicitly provide a clearly acceptable or unacceptable solution. Sharma (1996) recommends that one should use different approaches, compare the results for consistency and use the method that results in an interpretable solution. As the variables used in our analysis were measured in different scales and some of them are qualitative, we stated cluster analysis using Gower's method to compute the initial matrix (Gower 1971). It is the most convenient matrix that should be used when there is a mixture of continuous and discrete variables.

The hierarchical cluster analysis method was chosen as a first step. The clusters were determined with complete-linkage method, Ward method and Centroid method. Based on these results, we identify the "optimal" number of clusters as being equal to five. As suggested by Sharma (1996), we used the results from hierarchical methods (Ward method) as an initial solution for the non hierarchical cluster analysis, based on K-means methodology. The solution achieved with five clusters was considered as optimal because it is interpretable and results from combining the different approaches, as suggested by Sharma (1996). Summary statistics for each of the clusters are provided in Table 1.

Table 1: Summary statistics for cluster analysis

VARIABLES		Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Number of firms	487	132	63	138	61	93
		27%	13%	28%	13%	19%
Inter firm diffusion	3,52	2,94	4,24	4,13	2,75	3,45
% employees using Internet	27,0	12,27	54,63	35,84	36,84	9,67
IT skills	0,49	0,23	0,65	0,80	0,18	0,47
BB	0,48	0,14	0,90	0,90	0,43	0,12
OUT1	0,31	0,14	0,49	0,59	0,23	0,06
OUT2	0,28	0,22	0,46	0,28	0,25	0,24
COST	0,00	0,01	-0,18	0,05	-0,07	0,07
KNOW-HOW	0,00	-0,07	-0,07	0,11	-0,15	0,09
CONFIDENCE	0,00	-0,07	0,17	0,00	0,02	-0,03
S1	0,13	0,00	0,00	0,00	1,00	0,00
S2	0,40	1,00	1,00	0,00	0,00	0,00
S3	0,47	0,00	0,00	1,00	0,00	1,00
EDUC	12,93	7,70	24,24	16,50	16,26	5,23
PERCPROD	34,17	30,71	37,77	37,48	36,92	29,91
PERCPROC	36,19	35,09	37,69	37,18	34,59	36,32
COMP_PRESSURE	48,98	47,15	49,99	52,53	46,94	46,96
CAE1	0,38	0,39	0,14	0,48	0,13	0,54
CAE2	0,32	0,44	0,35	0,22	0,61	0,11
CAE3	0,02	0,00	0,02	0,03	0,02	0,05
CAE4	0,08	0,05	0,10	0,14	0,08	0,05
CAE5	0,19	0,13	0,40	0,14	0,16	0,25

The diffusion patterns of the five clusters are illustrated in Figure 1 and can be described as following:

CLUSTER 1. This group is characterized by firms that are later adopters of the Internet and that don't use it intensively. These firms have a low percentage of qualified workers, and only 23% have IT workers; most of them don't use broadband; perceived obstacles, namely those related to uncertainty are relevant barriers. This group of firms is composed by medium size firms coming from the manufacturing and distribution.

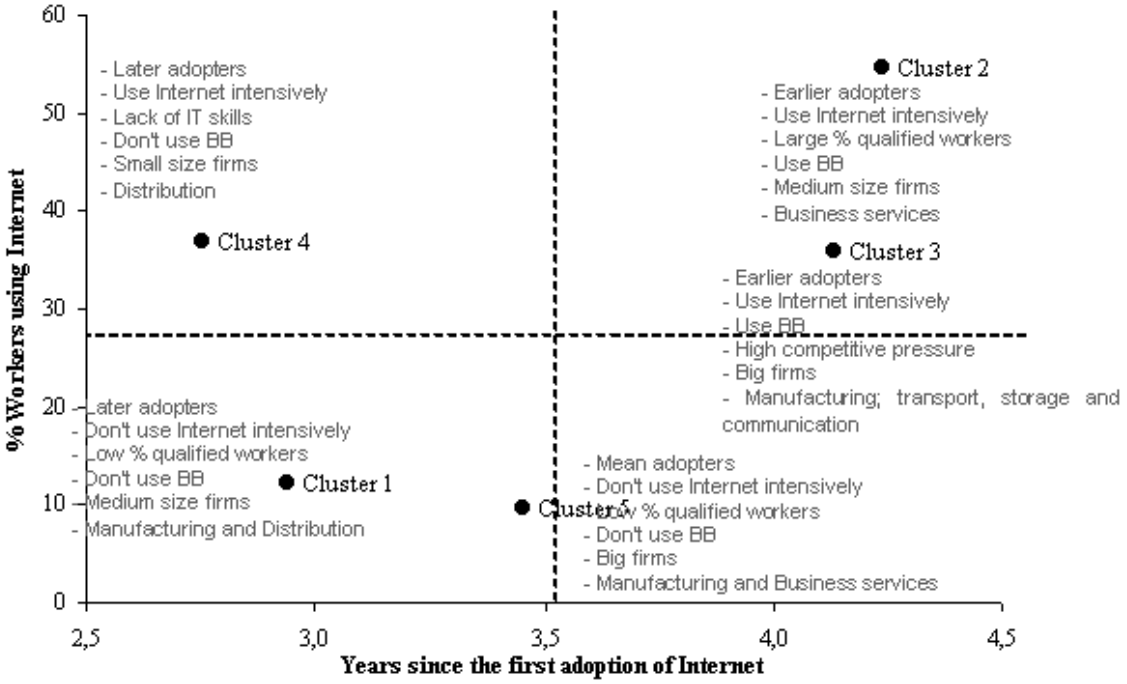

Figure 1: Patterns of Internet inter firm and intra firm diffusion

CLUSTER 2. Firms from this group are earlier adopters and use the Internet intensively. They have a large percentage of qualified workers and most of them have IT workers and use broadband; R&D activities are important and the most important perceived obstacle is the one related to implementation costs. Most of the firms come from business services and have medium size.

CLUSTER 3. This group is represented by firms that are earlier adopters and use the Internet intensively. They have qualified workers and most of them have IT workers and use broadband; R&D activities are relevant. They suffer from competitive pressure. Most of the firms from cluster 3 are big firms and come from manufacturing, transport, storage and communication sectors.

CLUSTER 4. Firms from this cluster are later adopters and use intensively the Internet. They have qualified workers but there is a lacking of IT skills. Know-how is perceived as a very important factor to Internet use. This group concerns small size firms from distribution sectors.

CLUSTER 5. This set of firms is characterized by "mean" adopters of the Internet and the intensity of its use it at very low level. The quality of the workforce is clearly below the mean: only 5% of the employees have a university degree and IT skills are deficient. Most of firms from cluster 5 are big firms from manufacturing and business services.

The major findings related to the pattern of Internet diffusion for Portuguese firms can be described as follows:

1. *Finding 1*. Firms that took up Internet earlier and made more intensive use of it, tended to be medium and big size firms, with skilled workers, that have invested in IT human capital and that have good technological capacities;
2. *Finding 2.*Earlier adopters are not necessarily those who use more intensively the Internet. There is a group of small firms that are later Internet adopters but us it intensively, probably because they have a huge percentage qualified workers;
3. *Finding 3.* The qualification of the workforce is an important facilitator of both time period of Internet adoption and intensity of its use. This finding is very important in the Portuguese context given that 80% of the workers have only 9 years of education.

Given that the Internet participation in our sample is at its saturation level - 97% of the firms are already Internet users - , in the second part of our work we assess the impact of different factors on two aspects of the intra firm diffusion process: the intensity of Internet use by workers and the extent of IT use by firms.

3. Determinants of intra-firm IT diffusion

3.1 Conceptual framework

As we have already mentioned, in last few years, research has made great progress in understanding and modeling the factors that lead to the first adoption of IT, the so called inter firm diffusion. However, if we are interested in the benefits generated by a certain technology within an economy, it is also important to understand the factors that determine the extent of IT use by adopting firms, after first adoption, i.e., the intra firm diffusion. Battisti and Stoneman (2003) have shown that the inter firm effect is more important in the early stages and that the intra firm effect is more relevant in the latter stages of the whole diffusion process.

This second part of our study explores the determinants of the intra firm diffusion process. We analyzed the impact of technological, strategic and external factors on the intensity of Internet use by workers and on the extent of IT use by firms. For the later concept, we will distinguish between a firm that is a basic IT user (uses only internet and e-mail) and a firm that is an enhanced user, which means that uses at least internet, email and two other IT. We considered the following technologies: intranet, EDI, WAP, LAN and WAN.

In our conceptual framework, we admit that the firm's extent of IT use in time t, the intra firm diffusion, is determined by firm specific profitability conditions and firm specific technological capacities (Forman 2005, Battisti et. al 2004). The idea is that firms face risks in adopting IT and that these risks affect their purchases of such technologies.

Thus, in determining the extent to which to use IT, a firm with specific technological capacities, compare benefits of further use against cost of use. Within this framework, factors influencing intra firm IT diffusion were classified into: internal factors and external pressure factors.

3.1.1 Internal factors

Broadband (technical capacity)
Firms using broadband have better technical capacities to support IT. Hence, the following is postulated:
H1. Broadband is positively associated with the intensity of Internet use by workers and positively associated to the probability of being an enhanced user.

IT skills
IT skills usually included employees' skills of using the Internet and related technologies (Zhu et al. 2003). IT skills are essential for firms to develop successfully IT applications. This complementary factor has been identified in many studies as a crucial element of IT implementation (Black and Lynch 2001; Brynjolfsson and Hitt 2000).

In our context, IT skills are defined by the number of employees that work exclusively in tasks related to IT activities. We would expect that, controlling for other factors: firms with more IT skills are more likely to be enhanced users. We also suggest that IT skills have a positive impact on the intensity of Internet use. The following is hypothesized:
H2. The level of IT skills is positively correlated with the intensity of Internet use by workers and positively associated to the probability of being an enhanced user.

Perceived obstacles
Research on IT adoption and implementation suggests that, when the technology is complex, as is the case for e-commerce technologies, perceived obstacles are particularly relevant because, in this case, the adoption process may be complicated and costly (Hong and Zhu 2006). A different behavior may occur in the case of the Internet, which is a simple technology, relatively inexpensive and easy to implement. We examined several perceived obstacles related to Internet adoption and implementation, namely: implementation costs, lack of IT skills, security, and technology excessively complex. Hence, we admit that:
H3. Perceived obstacles are probably negatively associated with the intensity of internet use and with the probability of being an enhanced user.

Outsourcing partner usage
Based on previous research (Hong and Zhu 2006), we included outsourcing partner usage as a possible predictor of IT intra firm diffusion. Firms that count on partners or contractors for IT implementation tasks, are more likely to use it intensively and more likely to be enhanced users. Hence, outsourcing may be viewed as a facilitator of features of intra firm diffusion. This leads to the following hypothesis:
H4. Greater partner usage is positively associated with both intensity of internet use and the probability of being an enhanced user.

Firm size
Firm size is one of the most commonly studied determinants of IT adoption and diffusion. In a recent study, Lee and Xia (2006) have analyzed, through a meta-analysis, the association between firm size and IT innovation adoption and concluded that although a positive relationship generally existed, the relationship was moderated by five variables: type of IT innovation, type of firm, stage of adoption, scope of size, and type of size measurement.

Three major arguments support the positive role of firm size in determining IT innovations. The first two are due to Schumpeter: firms that are large are more likely to undertake innovation both because appropriability (the benefits of the new IT) is higher for larger firms and because the availability of funds for these firms is greater. The third argument is that many IT innovations, like Internet, are scale-enhancing and therefore larger firms adopted them sooner (and more intensively) because they capture economies of scale more quickly (Zhu et. al 2003; Gibbs et al. 2004)

However, large size may also slow down the rate of IT diffusion: firstly, larger firms have multiple levels of bureaucracy and this can impede decision-making processes about new ideas and projects. Secondly, it may be relatively more expensive for larger firms to use intensively the IT innovation because they have to reconvert a large number of their employees. Finally, IT innovations often require close collaboration and

coordination that can be easily achieve in small firms. Based on these empirical results, we postulate the following:
H5. Firm size is positively or negatively associated with the intensity of Internet use and with the probability of being an enhanced user.

Quality of human resources
The presence of skilled labor in a firm increases its ability to absorb and make use of an IT innovation, and therefore is an important determinant of IT diffusion. Since usually the successful implementation of a new IT requires complex skills, we would expect that, maintaining other characteristics constant, firms with better educated workers are more likely to be enhanced users and use Internet more intensively. We hypothesized the following:
H6. Workers' educational level is positively associated with the intensity of Internet use and with the probability of being an enhanced user.

3.1.2 External pressure factors

Competitive pressure or epidemic factors
Many empirical studies show that competitive pressure is a powerful diver of IT adoption and diffusion (Gibbs et al. 2004; Hollenstein 2004; Zhu et al.2003). We would expect that, holding other factors constant, the probability of being an enhanced is positively influenced by the level of IT diffusion in the whole industry. Therefore, we assume that:
H7. Competitive pressure is positively related to the intensity of Internet use and to the probability of being an enhanced user.

We control, as usually, for economic sector specific behavior, including dummies for the five aggregate sectors of activity.

3.2 Model specification and empirical results

3.2.1 Measurements and variables

Dependent variables. For the extent of Internet use by workers we used, as in the first part of this study, a variable measuring the percentage of employees working regularly with the Internet, INTUSE. For the extent of IT use by firms we construct a variable, Y, that is equal to zero if the firm is a basic user and equal to one if the firm is an enhanced user.

Independent variables. The factors considered, broadband, IT skills, outsourcing partner usage, perceived obstacles, firm size (the reference group is small size), quality of the human resources, competitive pressure and economic sector dummies (reference sector is CAE3 and CAE5) have already been defined.

3.2.2 Model specification

For the intensity of Internet use by workers, the following linear model is specified:

$$(1)\ INTUSE=X'\alpha+u$$

where INTUSE is the dependent variable, X represents the vector of independent variables, and α is a vector of unknown parameters to be estimated. As usual, u stands for a random variable, the error term. Model (1) was estimated by Ordinary Least Squares, assuming the classical hypotheses of the multivariate regression model.

For the extent of IT use by firms, we used a binary choice model, the Probit Model, because the dependent variable is dichotomous (Y=0 if the firm is a basic user and Y=1, if the firm is an enhanced user). The specification is the following:

$$(2)\ P(Y=1/X)= \Phi(X'\beta)$$

where Y is the binary dependent variable, X is the vector of independent variables already defined, β is an unknown parameter to be estimated and Φ is the cumulative normal distribution. Model (2) was estimated, as usual by Maximum Likelihood.

Testing H1-H7 is equivalent to testing whether the coefficients α and β are significantly different from zero. Positive and significant coefficients imply that the corresponding variable is an intra firm diffusion facilitator. Negative and significant coefficients indicate that the corresponding variables are inhibitors.

3.2.3 Empirical results

Estimation results for Model (1) and Model (2) are shown in Table 2. We considered two significance levels 5% and 10% level. As can be seen, most of the independent variables are relevant to explain the intra firm diffusion pattern. The estimated coefficients have the expected signs: broadband, IT Skills and outsourcing partner usage have a positive effect on both the intensity of Internet use and the probability of being an enhanced user. Perceived barriers are important and act as an inhibitor, but only for the intensity of Internet use.

Table 2: Estimation results for the determinants of intra firm diffusion model

Variables	Linear Regression Intensity of Internet use	Probit Model Probability of enhanced user
Constant	20,743*	-1,834*
Broadband	12,313*	0,729*
IT Skills	7,945*	0,692*
Outsourcing partner usage		
OUT1	1,576	0,602*
OUT2	-7,117*	-0,205
Perceived Obstacles		
COSTS	-5,874*	-0,047
KNOW-HOW	0,648	0,067
TECH	2,170	0,131
Size		
S2	-9,671*	0,205
S3	-13,773*	0,779*
EDUCATION	0,870*	0,035*
Competitive Pressure	0,004	0,010
Economic Sectors		
CAE1	-9,690*	0,568*
CAE2	-9,685*	0,945*
CAE4	-2,656*	0,585**
R^2	0,49	
Number of firms	487	487

* Statistically significant at the 5% level and ** at the 10% level. Robust standard errors are used.

As expected, the probability of being an enhanced user is positively influenced by workforce qualifications and by firm size. Workers educational attainment is also a facilitator of the intensity of Internet use. External competitive pressure factors or epidemic factor are not relevant in this context. The same result was obtained by Battisti *et. al* (2005). The authors also find that, for the intra firm diffusion model, the most important factors are those related to firms' internal factors.

As a whole, the pattern of the two intra firm diffusion models is quite similar. The outstanding differences refers, firstly to the impact of firm size; whereas size-effects are positive in the case of the extent of IT use by firms, for the intensity of Internet use, this impact is negative. This result means that, holding all other factors unchanged, smaller firms are more likely to be intensive Internet users. Secondly, the effects of the perceived barriers are only relevant for the intensity of the Internet use by workers, indicating that investments needs to convert the human capital to the new technology are particularly important.

4. Concluding remarks

The purpose of this paper was to offer a contribution to the empirical literature on the determinants of IT adoption and diffusion at the firm level. This topic is of particular interest because it has been recognized that a greater use of IT by firms enhances their productivity and, when amply diffused, increases the growth rate of the economic system as a whole.

Our econometric results for Portuguese firms confirm the importance of key variables tested in prior IT adoption and diffusion studies. Specifically, our findings confirm that, technological capacities, IT skills, outsourcing partner usage, perceived obstacles, size and the quality of human resources played an important role in the intra firm IT diffusion process. The results also indicate that larger firms are more likely to be enhanced users, probably due to greater resources and economies of scale. Nevertheless, small firm adopters may possess certain advantages that allow them to use the Internet more intensively. Other variables did not have a significant impact in intra firm diffusion. Perceived obstacles did not have a

significant effect on the extent of IT use by firms. One possible explanation is that perceived obstacles may impact initial adoption but not the extent of IT use. This result makes sense because firms that have adopted basic technologies (Internet and email), may have already overcome such barriers and so they become less important in distinguish between a basic and an enhanced user. Additionally, competitive pressure did not have a significant impact on both features of intra firm diffusion. Again, it is possible that competitive pressure has an effect on initial adoption but not on the extent of use after adoption.

As a whole, our results suggest that traditional policy drivers such as incentives for procurement should be complemented with incentives that give the adequate qualifications to the workforce. With the new technology costs decreasing, the major constraint for Portuguese firms does not seem to lie on lack of financial resources but rather on qualified human resources, able to absorb the new IT and make the best use of them.

Acknowledgements

We would like to thank INE, UMIC and OCES for providing us with the data.

References

Battisti, G., Canepa, A., & Stoneman, P. (2004) "Profitability, Externalities and Policy in the Inter and Intra Firm Adoption of New Technology: The Example of E-Business Activities in the UK", Paper presented at the 8th Conference of the European Network on Industrial Policy, Birmingham.

Battisti, G., Hollenstein, H., Stoneman, P., & Wörter, M. (2005) "Inter and Intra firm Diffusion of ICT in the United Kingdom (UK) and Switzerland", Working Paper nº 111, Swiss Institute for Business Cycle Research.

Battisti, G., & Stoneman, P. (2003)"Inter- and intra-firm effects in the diffusion of new process technology", *Research Policy, Vol 32*, pp 1641-1655.

Black, S. and Lynch, L. (2001) "How to Compete: The Impact of Workplace Practices and Information Technology on Productivity", *Review of Economics and Statistics*, Vol 83, pp 434-445.

Beatty, C. R., Shim, J.P. and Jones, M.C. (2001) "Factors Influencing Corporate Web Site Adoption: a time-based Assessment", *Information and Management*, Vol 38, pp 337-354.

Bresnahan, T. F., Brynjolfsson, E. and Hitt, L. M. (2002)"Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-level Evidence", *Quarterly Journal of Economics*, Vol 117**,** pp 339-376.

Brynjolfsson E. and Hitt L. (2003) "Computing Productivity: Firm-level Evidence, *Review of Economics and Statistics*, Vol 84, No. 4, pp 793-808.

Dedrick, J., Gurbaxani, V. and Kenneth L. Kraemer (2003)"Information Technology and Economic Performance: A Critical Review of the Empirical Evidence", *ACM Computers Surveys*, Vol 35, No.1, pp 1-28.

Forman, C. (2005) "The Corporate Digital Divide: Determinants of Internet Adoption", *Management Science*, Vol. 51, No. 4, pp. 641-654.

Martins, M.R.F. and Raposo, P. (2005) "Measuring the Productivity of Computers: A Firm Level Analysis for Portugal", *Electronic Journal of Information Systems Evaluation,* Vol. 8 Iss.4.

Gibbs, L. J. and Kraemer, K. L. (2004) "A Cross-Country Investigation of the Determinants of Scope of E-commerce Use: An Institutional Approach", Electronic Markets, Vol 14, No.2, pp 124-137.

Giunta, A. and Trivieri, F. (2007) "Understanding the Determinants of Information Technology Adoption: Evidence from Italian Manufacturing Firms", *Applied Economics*, forthcoming.

Gower, J. C. (1971)"A general coefficient of similarity and some of its properties", *Biometrics,* Vol 27, pp 857-872.

Hollenstein, H. (2004)"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,* Vol 15, pp 315-342.

Hong, W., & Zhu, K. (2006) "Migrating to internet-based e-commerce: Factors affecting e-commerce adoption and migration at the firm level", *Information & Management,* Vol 43, pp 204-221.

Jorgenson, D. W. (2001)"Information Technology and the U.S. Economy", *American Economic Review,* Vol 91, No.1, pp1-32.

Litan, R.E. and Rivlin, A.M. (2001) "Projecting the Economic Impact of the Internet", *American Economic Review, Papers and Proceedings*, Vol 91, No.2, pp 313-417.

Pilat, D., & Lee, F. C. (2001). Productivity growth in ICT-producing and ICT-using industries: a source of growth differentials in the OECD? STI, in OECD (Ed.). Paris.

Sharma, S. (1996). *Applied Multivariate Techniques*. New York: John Wiley & Sons, Inc.

Teo, S.H.T. and Tan, M.(1998) "An empirical Model of Adopters and Non-Adopters of the Internet in Singapore", *Information & Management*, Vol 34, pp 339-345.

Teo, S.H.T. and Pian, Y. (2003) "A contingency perspective on Internet adoption and competitive advantage", *European Journal of Information Systems*, Vol 12, pp 78-92.

Teo, S.H.T. and Pian, Y.(2004) "A Model of Web Adoption", *Information & Management*, Vol 41, pp 457-468.

Zhu, K., Kraemer, K., & Xu, S. (2003) "Electronic business adoption by European firms: a cross-country assessment of the facilitators and inhibitors", *European Journal of Information Systems,* Vol 12, No. 4, pp 251-268.

