



The Adoption of ICT: Firm-Level Evidence from Irish Manufacturing Industries

Stefanie Haller and Iulia Traistaru-Siedschlag*

Abstract: This paper examines factors driving ICT adoption at firm level. We use a novel data set including information on ICT and e-commerce in Irish manufacturing firms over the period 2001-2004 and estimate a model derived from the new technology adoption literature that relates ICT adoption indicators to two sets of factors: characteristics of firms and characteristics of the environment in which firms operate. Our research results indicate that the adoption of ICT in Irish manufacturing has been uneven across firms, industries and space. On average, other things equal, firms with more skilled workers, operating in ICT producing and ICT using industries, located in the capital city region have been relatively more successful in adopting and using ICT. To a certain extent, patterns of ICT adoption have been different for domestic and foreign-owned firms, in particular with respect to the effects of international competitive pressure and firm size.

Key words: ICT adoption, Human capital, Industrial structure, Information spillovers.

JEL classification: L21, O31, O33

**Correspondence:* The Economic and Social Research Institute, Whitaker Square, Sir John Rogerson's Quay, Dublin 2, Ireland. Telephone: +353-1-8632000; Fax: +353-1-8632100; Stefanie.Haller@esri.ie; Iulia.Traistaru@esri.ie.

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Firm-Level Evidence from Irish Manufacturing Industries

1 Introduction

Information and Communication Technology (ICT) is increasingly seen as a new general - purpose technology (GPT), an “enabling technology” which is pervasively used across firms and industries; it results in new products and services, as well as new production and organisation methods (Bresnahan and Trajtenberg, 1995; Helpman and Trajtenberg, 1998). The main characteristics of ICT as a new GPT, namely the potential for widespread use and complementary innovations which it fosters, raise the attractiveness of ICT adoption.

Furthermore, ICT is at the core of the “new” knowledge-based economy and there is growing evidence suggesting that ICT-linked knowledge, innovation and ongoing technological change are strong determinants of productivity and growth differentials and the ability of countries to benefit from globalisation (Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Bassanini and Scarpetta, 2002; OECD, 2004; Timmer and van Ark, 2005).

The impact of ICT investment on productivity and growth is found to be stronger at firm-level in comparison to industry and country-levels (Brynjolfsson and Hitt, 2000, 2003; Lehr and Lichtenberg, 1999; Matteucci et al, 2005). At the firm level, ICT use leads to improvements in product design, marketing, production, finance and the organisation of firms (Hollestein, 2004). Furthermore, ICT is an innovation driver by facilitating the creation of new products and services (Becchetti et al, 2003; Carlsson, 2004; Hollestein, 2004). ICT use increases the productivity of R&D activities in downstream sectors, so ICT use is the source of “innovation complementarities” (Bresnahan and Trajtenberg, 1995).

The focus of this paper is on the adoption of ICT at firm level. Specifically, the question we are investigating in this paper is: what factors affect the chances of adoption and diffusion of ICT at the firm level? We use a novel data set including survey information

on e-commerce and ICT in Irish manufacturing firms and relate a number of ICT adoption indicators to determinants suggested by the existing theoretical and empirical literature on new technology adoption. To our knowledge this is the first paper analysing the adoption and diffusion of ICT at firm level in Ireland.

Uncovering the factors driving ICT adoption and diffusion is important and relevant for both research and policy. First, in contrast with a well established theoretical literature on new technology adoption and diffusion, firm-level empirical evidence on ICT adoption and diffusion is very limited. Second, from the policy perspective, to the extent that a wide and fast diffusion of ICT is desirable, it is essential to understand what factors are likely to increase the adoption and diffusion of ICT across firms, industries and space.

Our research results indicate that the adoption of ICT in Irish manufacturing has been uneven across firms, industries and space. On average, other things equal, firms with more skilled workers, operating in ICT producing and ICT using industries, located in the capital city region have been relatively more successful in adopting and using ICT. To a certain extent, patterns of ICT adoption have been different for domestic and foreign-owned firms in particular with respect to the effects of international competitive pressure and firm size.

The remainder of this paper is structured as follows. In Section 2 we discuss the related theoretical and empirical literature and testable hypotheses about the factors driving ICT adoption at firm level. In Section 3, we describe our data set, the ICT indicators and explanatory variables that we use in our empirical analysis. Section 4 outlines our empirical strategy and model specifications and in Section 5 we discuss our main results. Finally, we summarise our findings and policy implications in Section 6.

2 Theoretical and Empirical Background

The theoretical starting point for our analysis is the well-established literature on new technology adoption. This literature points to delays in the adoption of new technologies and differences in adoption rates across firms, industries and countries¹. To understand the adoption and diffusion of ICT as a new technology it is therefore essential to uncover the factors that explain this delay and the variation in the rates of its adoption.

The existing theoretical models focus on a number of factors explaining this delay and the variation in the adoption rates including: uncertainty about the characteristics of the new technology (Jensen, 1982), strategic considerations, such as differences in profit rates before and following the technology adoption depending on market structure (Reinganum, 1981), learning by doing processes (Jovanovic and Lach, 1989; Jovanovic and MacDonald, 1994), and differences in human capital (Nelson and Phelps, 1966; Rosenberg, 1972; Chari and Hopenhayn, 1991).

The related empirical studies have looked at two groups of factors affecting new technology adoption: 1) firm characteristics such as sectoral specialization, firm size, skill composition of work force, and organisational structure; and 2) characteristics of the local industrial structure such as network externalities, information and knowledge spillovers, and competitive pressure.

Helpman and Trajtenberg (1998) analyse the adoption of GPT and point to sectoral specialisation as an explanatory factor. They show that GPT adoption is quicker the higher the productivity growth with respect to the old technology. To the extent that ICT has a quicker impact on productivity in ICT intensive industries, this suggests that ICT adoption may be quicker in ICT intensive industries relative to the rest of industries. Several empirical studies support this hypothesis. Love et al., (2005) show that the level of investment in information technology differs across industries. Cheung and Huang (2002) find evidence of major differences in the usage of the Internet across industries in Singapore.

¹ For a recent survey of new technology diffusion models see Geroski (2000).

Another stylised fact supported by a large empirical literature is that the adoption of new technologies is more likely the larger the size of firms. Firm size is commonly used in the empirical literature on new technology adoption because it is easy to observe and it serves as a proxy for several things (Geroski, 2000): large firms can earn larger profits from adopting new technology in comparison with small firms; given the high risks and costs of early adoption they might be in a better position to adopt new technology because they may have less financial constraints and they may be less risk averse; they might be more motivated and able to innovate in order to pre-empt smaller rivals; large firms might offer a larger scope for innovation complementarities. A positive correlation between firm size and the ICT adoption is found in a large number of empirical studies (Fabiani et al, 2005; Morgan et al., 2006; Teo and Tan, 1998; Thong, 1999). However, a number of studies have also found a weak or not significant relationship between firm size and the adoption of ICT (Lefebvre et al, 2005; Love et al., 2005; Teo et al., 1997). Furthermore, Hollestein (2004) shows that this relationship might be non-linear. He finds that in the case of a sample of Swiss firms, firm size was positively correlated with early, and intensive use of ICT² only in firms with up to 200 employees. He also finds that medium-sized companies use the Internet more intensively in comparison to large firms.

Following the seminal paper by Nelson and Phelps (1966), a large empirical literature has focused on the relationship between human capital and new technology adoption. Chun (2003) provide empirical evidence showing that highly educated workers are more likely to implement new technologies such as information technology. Bartel and Sicherman (1999) find that industries with higher rates of technological change require highly skilled workers. Caselli and Coleman (2001) find that the educational attainment was an important determinant of the level of investment in computers in a sample of OECD countries over the period 1970-1990. Murphy and Traistaru - Siedschlag (2007) analyse the output growth at industry level in a sample of twenty OECD countries over 1980-2002 and find that in countries with a high *ex-ante* human capital stock and in countries with a high human capital improvement, ICT producing manufacturing industries grew faster relative to non-ICT industries.

² The intensity of ICT use was measured by two variables: the number of ICT elements adopted (digital assistants; laptop; PC, workstations, terminals; e-mail; Internet; EDI; LAN/WAN; Intranet; Extranet) and the share of employees using the Internet.

Firm-level evidence suggests that firms using advanced technology require high-skilled workers (Doms et al, 1997). Furthermore, the presence of high-skilled workers fosters innovation and facilitates the ICT adoption and use at firm level (Arvanitis, 2005; Bresnahan et al., 2002, Fabiani et al., 2005; Falk, 2005; Bayo-Moriones and Lera-López).

Another result of the empirical literature is that productivity gains are larger in firms that adopt ICT and change their internal organisation: For example, as shown by Caroli and van Reenen (2001), ICT adoption is associated with more horizontal structures, fewer hierarchical levels, a higher extent of team work and greater worker participation. Bresnahan et al. (2002) find that the use of information technologies is complementary to innovations in workplace organisation such as broader job responsibilities for line workers, more decentralised decision-making, and more self-managing teams. Further, information technology and new organisation models are complements to worker skills. Black and Lynch (2001, 2004) find that firms in the US that improved their internal organisation to incorporate more high performance practices in conjunction with ICT experienced high productivity growth.

The second group of factors affecting the adoption of new technologies includes characteristics of the environment in which firms operate such as firm density, information and knowledge spillovers, network externalities, and competitive pressure.

Given the uncertainty about the profitability of new technology, observing the adoption decision of other firms might play an important role in the decision to adopt new technologies. It follows that information spillover effects from the interactions with among firms might be important for the adoption of ICT. Baptista (2000) finds that, in the case of a sample of firms from the engineering and metalworking industries in the United Kingdom, proximity to early adopters of new technology was positively related to learning effects that fostered the adoption of new technology. Moreover, there is evidence suggesting that technology diffusion is geographically localised and information spillovers decline as distance between firms increases (Jaffe et al, 1993; Jaffe and Trajtenberg, 1999; Eaton and Kortum, 1999; Keller, 2002).

Another important aspect of the environment in which firms operate that is relevant for ICT adoption relates to the network nature of ICT. On one hand, being part of a network

increases the awareness of the new technology and reduces the risks associated with adopting and using it (Gourlay and Pentecost, 2002). In addition, network externalities are positively related to the number of users of the new technology (Oulton, 2002). On the other hand, the larger the number of firms, the more likely is the occurrence of coordination failures that can slow down the adoption rate (Cooper and John, 1988).

In relation to the role that networks play in the adoption of ICT it has been shown that given the increased need for co-ordination of activities, being part of a multinational increases the probability of adopting ICT. Galliano et al (2001) show that multinational ownership is positively associated with ICT adoption. However, Teo and Ranganathan (2004) find no difference between foreign-owned and domestic plants with respect to the adoption of business-to-business (B2B) electronic commerce in Singapore.

Competitive pressure has been identified as an incentive to innovate and adopt new technology (Porter, 1990; Gattignon and Robertson, 1989). Firms facing stronger competition are more inclined to innovate and adopt new technologies, such as ICT, in order to strengthen their performance and survival rate. Several studies show that competitive pressure is positively associated with ICT adoption (Dasgupta et al., 1999; Hollenstein, 2004; Kowtha and Choon, 2001). In contrast, other papers find no significant effect of competitive pressure on ICT adoption (Lee, 2004; Teo et al; Thong, 1999).

It has been argued that firms exposed to international competition are more inclined to innovate and adopt new technologies. Hollenstein (2004) and Bayo-Moriones and Lera-López (2007) find evidence showing that firms that export are more likely to use the Internet.

Our analysis relates to a few empirical studies investigating the ICT adoption at firm level. Fabiani et al (2005) find that in the Italian manufacturing, the ICT adoption is positively associated with firm size, human capital, presence of large firms, and changes in organisational structures. Hollenstein (2004) looks at Swiss firms and finds similar results. In addition, he finds evidence for the positive effects on ICT adoption of information spillovers between firms, and competitive pressure. Bayo-Moriones and Lera-López (2007) find that establishment size, multinational ownership and highly-skilled workforce are positively associated with ICT adoption in a sample of Spanish

firms. Furthermore, quality control systems and team-based organisation or work are found to play an important role in ICT diffusion within firms.

3 The Data

Our dataset is obtained by combining information from two sources. One data source is the ‘Survey on E-commerce and ICT’ that has been conducted as part of an EU-wide effort to gain information on ICT use since 2002 on an annual basis by the Central Statistics Office (CSO). It targets a population of 8,000 enterprises. The principal variables collected refer to the level of Internet usage, types of connection to Internet, reasons for using the Internet, sales and purchases via the Internet, and barriers to e-commerce. The second data source is the annual Census of Industrial Production that is also collected by the CSO. The census collects information on turnover, exports, purchases, acquisitions and sales of capital assets, indirect taxes, employment, earnings and other labour costs for all enterprises and local units with 3 or more employees in NACE Rev. 1 sectors 10-41.³

The two datasets can be merged through the establishment identifier at the enterprise level. The most recent information available from the Census of Industrial Production is for 2004, hence the merged dataset covers the period 2002-2004 for most variables. All information related to transaction volumes over the Internet or electronic data interchange (EDI) in the Survey on E-Commerce and ICT is collected for the year prior to the survey year. As a result this information is available for 2001-2004. The match covers roughly 50 percent of the enterprises in each year and is representative of the population with respect to the size distribution, the industry classification and the regional distribution of manufacturing activity. As the sample for the e-commerce survey is re-drawn every year only a fraction of the enterprises in the previous year’s sample is covered in the following year.

The final working sample includes the core manufacturing industries, i.e. NACE Rev. 1.1 sectors 15-36⁴. Sector 23 (Manufacture of coke, refined petroleum products and nuclear fuel) is excluded for reasons of confidentiality. We also excluded Sector 16 (Tobacco) as the small number of observations together with the heterogeneity of observations leads to the exclusion of this sector in some estimations.

³ The possibility for controlled access to the two anonymous micro data sets on the premises of the CSO is provided for in the Statistics Act 1993.

⁴ The list of industries and codification is given in Appendix 1.

Furthermore, we checked the data for outliers. For each variable, we define as outliers firms that fall outside the top and bottom quarter to half percentile. We accumulate outliers and delete all firms that have one or more outliers according to this definition.

We construct five measures for ICT adoption at firm level including three discrete variables and two continuous variables:

- *ucomp*: 1 if the firm uses computers, 0 otherwise;
- *netord*: 1 if the firm accepts or has received orders via the Internet, 0 otherwise;
- *servind*: an index of services offered online (marketing of the enterprise's products; facilitating access to product catalogues and price lists; customised page for repeat clients; delivering digital products; providing after sales support); the index takes values ranging from 0 to 5; the index is equal to 1 if only one of these services is offered, 2 if two services are offered, 3, if three services are offered, 4, if four services are offered, 5, if all of these services are offered; the index is equal to 0 if none of these services are offered online.
- *empucomp*: the share of employees using a computer in the total number of employees;
- *esal*: the share of sales (turnover) due to transactions over the Internet including a website, email, and electronic data interchange (EDI).

We employ a taxonomy of ICT industries developed first by Stiroh (2002) for the US and validated in the case of European countries by O'Mahony and van Ark (2003). We distinguish three groups of industries depending on whether they produce or use ICT: ICT producing manufacturing, ICT using manufacturing, and non-ICT manufacturing. Details are given in Appendix 2.

Table 1 provides summary statistics related to our discrete variables, namely the use of computers (*ucomp*), whether the company accepts/has received online orders (*netord*) and the composite index of the number of services offered online (*servind*). Table 1 shows that by 2004 nearly all firms in the sample are using computers and over 50 percent of the firms in the sample offer at least one service online. The share of firms accepting orders online has also increased over the analysed period to just over 16 percent in the sample.

Table 2 provides summary statistics on the share of employees using a computer (*empucom*), the share of sales transacted electronically (*esal*) including both transactions over the Internet as well as transactions via electronic data interchange⁵, turnover (*to*), average wages per employee (*wpe*) by year, size class, industry group and region. ICT use is higher in the larger firms and there is a clear time trend over the three- or four-year period. Both the share of employees using computers and the share of sales due to Internet transactions are the largest in the capital city region. The industries classified as ICT-producing are also ahead of the ICT-using and the non-ICT sectors in terms of ICT adoption and use.

4 Empirical Strategy and Model Specification

Given the factors that are found relevant for new technology adoption in the literature, we employ measures for firm size, human capital, international competitiveness, firm and industry characteristics as explanatory variables in our regressions. We measure firm size with turnover (*to*) is the natural log of turnover). To proxy human capital we use the average wages per employee (*wpe*). In addition, we control for the skill composition of employees by including the share of managerial and technical staff in all employees (*mantech*), and the share of clerical staff including sales representatives in all employees (*clerical*). Export-intensity (*exint*), is included as a measure of international competitiveness. We include a dummy variable which indicates whether a firm is a multi-plant firm (*multi*). A further explanatory variable is the age of the firm (*age*). We expect a positive sign on all explanatory variables except *age*.

Furthermore, we control for unobserved industry-, region- and time-specific effects (λ_j , λ_r , λ_t , respectively are dummy variables for industries, regions and years). In addition, we use the ICT taxonomy explained above to distinguish sector-specific effects depending on whether industries produce or use ICT intensively. Definitions and sources of all variables are given in Appendix 3.

The basic model specification estimated for each of the five ICT adoption indicators (Y_{ijrt}) is as follows:

⁵ Note this variable is based mainly on the information from the E-Commerce survey. There is also a question on the share of turnover due to transactions over the Internet, EDI and email in the Census of Industrial Production. This information has been used to fill in missing years where possible and also for consistency checks between the two datasets.

$$Y_{ijrt} = \alpha + \beta_1 \ln to_{ijrt} + \beta_2 mantech_{ijrt} + \beta_3 clerical_{ijrt} + \beta_4 \ln wpe_{ijrt} + \beta_5 exint_{ijrt} + \beta_6 multi_{ijrt} + \beta_7 age_{ijrt} + \lambda_j + \lambda_r + \lambda_t + \varepsilon_{ijrt} \quad (1)$$

We estimate equation (1) using a probit estimator when our dependent variables are bivariate as is the case with *ucomp* and *netord*. We estimate equation (1) using an ordered probit estimator if our dependent variable is the index of online services offered, *servind*. If our dependent variables are continuous taking values between zero and one as is the case for *empucomp* and *esal*, we estimate a fractional logit model. This model was developed by Papke and Wooldridge (1996). It is the most suitable approach for this type of data as it overcomes many of the flaws associated with Tobit or OLS models. Papke and Wooldridge (1996) propose a non-linear function for estimating the expected values of dependent variables y_i conditional on a vector of covariates, x_i , as follows:

$$E(y_i|x_i) = G(x_i, \beta) \quad (2)$$

where G is any cumulative distribution function and betas are the true population parameters. They chose the following logistic distribution:

$$E(y_i|x_i) = \frac{\exp(x_i, \beta)}{1 + \exp(x_i, \beta)} \quad (3)$$

and suggest the use of the following Bernoulli log-likelihood function to obtain the quasi-maximum likelihood estimator, $\hat{\beta}$:

$$L_i(\beta) = y_i \log[G(x_i, \beta)] + (1 - y_i) \log[1 - G(x_i, \beta)] \quad (4)$$

As pointed out above, location and spillover effects from interactions between firms are likely to be two important determinants of ICT adoption at firm level. Firms might benefit from technology spillovers only if they are located near (i.e. within the same region) other firms adopting ICT or if they are part of the same industry. Hence, we calculate horizontal indexes considering the ICT adoption activities of the other enterprises located in the same region and industry. The spillover measures are thus measures of horizontal spillovers. Then, for say, industry j , region r at time t the index is:

$$Indreg_{jrt} = \frac{Y_{jrt}^a}{Y_{jrt}}, \quad (5)$$

where a indicates the number of enterprises that are using ICT. To capture horizontal spillovers from firms located in different regions (indicated as \bar{r}) but in the same industry we also calculated:

$$Ind_{j\bar{r}t} = \frac{Y_{jt}^a - Y_{jrt}^a}{Y_{jt} - Y_{jrt}}. \quad (6)$$

When the share of employees using computers (*empucomp*) is the dependent variable we calculate these spillover terms based on the number of firms using computers; when the share of turnover due to online transactions is the dependent variable they are based on the number of firms accepting electronic orders.

In all our regressions the standard errors are adjusted for clustering at the firm level. To fully account for potential endogeneity resulting from unobserved firm characteristics, such as managerial ability, a dynamic panel estimator such as the GMM estimator proposed by Arellano and Bond (1991) would be appropriate. However, our panel data set is too short. Furthermore, a fixed effects estimator only picks up effects for those firms where there has been a change in status from one period to the next. This is the case for only 12-20 percent of the firms in our sample depending on the chosen discrete dependent variable. This is not satisfactory because it entails throwing away a lot of information. Regarding the continuous dependent variables, the large panel variation in combination with a short dimension does not make the fixed effects estimator very appealing. Hence, our estimates can be interpreted as upper bound effects.

5 Empirical Results

The estimates obtained in the case of the discrete variables are shown in Table 3. Whether firms use computers or not is a positive function of their size, the share of clerical employees and their export intensity. The older a firm is the less likely it is to use computers. Industry specific effects are jointly significant. The number of services offered online is positively associated with firm size, the share of highly skilled employees (managerial and technical staff as well as clerical employees) and the export intensity of a firm. Firm age has a negative impact here as well.

When it comes to firms which received/accepted online orders, this is a positive function of the share of clerical employees and the export intensity. Here the geographical location also play a substantial role; firms in all regions except in the West and Mideast have a significantly lower probability of receiving/accepting online orders than firms located in the capital city region. In all three regressions the time dummies indicate a positive time trend in the adoption of ICT.

Table 4 shows the estimates obtained using the ICT-taxonomy instead of industry dummies. With this broader industry classification, average wages per employee and the share of managerial and technical employees also have a significant positive coefficient when the dependent variable is whether a firm uses computers or not. We note that both the probability of a company using computers and the probability of a company offering more services online is higher in the ICT-producing and ICT-using sectors relative to the non-ICT sector. It is also higher in the ICT-producing than in the ICT-using sectors although the difference between the two coefficients is not statistically significant⁶.

When the probability of a company accepting/receiving online orders is the dependent variable, the significance levels of the right-hand side variables do not change substantially. Surprisingly, in this specification also the coefficient on age is positive, which may be plausible if firm age is associated with reputation building. Here, only being in an ICT-using sector increases significantly the probability of a firm accepting/having received orders online relative to being in a non-ICT sector.

⁶ The test statistics for the null hypothesis of equality of coefficients for ICT producing and ICT using industries are as follows: *ucomp*: $\chi^2=0.9$ [p=0.34]; *servind*: $\chi^2=0.34$ [p=0.56]; *netord*: $\chi^2=0.1$ [p=0.75]

There has been a lot of discussion about the ‘duality’ of the Irish economy in the sense that the foreign firms have very different business motivations and characteristics in comparison to the population of domestic firms (Barry and Bradley, 1997). To account for these differences, we distinguish between domestic and foreign firms and estimate the models explaining the number of services offered online and whether a firm accepts/has received online⁷. The results are shown in Table 5.

In the case of the number of services offered online, the results for the domestic and the foreign firms do not differ very much, both with respect to size and sign of the coefficients. The only notable difference is in the case of the coefficient on export intensity which is only significant for the domestic firms. This result may reflect the fact that the domestic firms have on average much smaller export intensities in comparison to foreign firms and the share of non-exporters among the domestic firms is much larger.

When the dependent variable is whether a firm accepts/has received orders online, the differences between the domestic and the foreign firms are more substantial. The share of clerical employees and the export intensity are important determinants of ICT adoption only in the case of the domestic firms. In the case of the foreign firms, the probability of accepting/receiving orders online is negatively associated with the average wage and positively associated with the share of managerial and technical employees. This might suggest that only those foreign firms that are managed from within Ireland also operate their online sales from the island, while for the bulk of foreign firms this is probably done from their headquarters. Both domestic and foreign firms located outside the capital city region are less likely to accept/receive orders online.

We now turn to ICT adoption measured by continuous variables. The results from the fractional logit model for the share of employees using computers shown in Table 6 indicate again a high importance of the human capital for ICT adoption. In particular, the share of managerial and technical employees and the share of clerical employees have large positive and highly significant coefficients. A high export intensity is also associated with a larger share of employees using computers. The firm’s age has a small

⁷ The regression for whether a firm uses computers are not replicated as the number of foreign firms that do not use computers is too small to warrant reliable estimation results.

negative effect here as well. The industry dummies are jointly significant. When the ICT categories are included instead of the industry dummies, the region dummies pick up somewhat more of the variation. A location outside the capital city region is associated with a negative impact on the share of employees using computers. The share of employees using computers is significantly higher in ICT producing and ICT using industries relative to non-ICT industries. The difference between the ICT-producing and the ICT-using sectors is significant at the 5 percent level⁸.

The third and fourth columns in Table 6 show the results obtained from the augmented model to include spillover effects. In the case of the model specification including industry specific effects, the term for industry-region spillovers is positive and significant. This suggests that there are agglomeration effects which implies that location in an industry and region where a large share of firms is using computers has a positive effect on the share of employees using computers in a firm. Being in the same industry, but not in the same region where a large share of firms are using computers has a positive and significant effect only when we account for ICT intensity at industry level. This result suggests that industry-specific spillover effects pick up non-observed industry characteristics not controlled for when using the ICT taxonomy. The difference between ICT producing and ICT using industries is only marginally significant⁹.

Table 7 shows the estimates for the share of turnover due to online transactions. The results indicate that firm size and export intensity are positively associated with the ICT adoption. Multi-plant firms are associated with lower shares of turnover transacted online. This could reflect the fact that the largest shares of multi-unit enterprises are in NACE sectors 24 (Manufacture of chemicals, chemical products and man-made fibres) and 26 (Manufacture of other non-metallic mineral products), which have among the lowest shares of turnover due to online transactions of all sectors.¹⁰ The coefficients on the regions all have a negative sign, but only for a few of them the effect is significant. While the industry dummies are jointly significant in the first column, the ICT category dummies do not suggest that there are differential effects from being in one ICT

⁸ The test statistics for the null hypothesis of equality of coefficients for ICT producing and ICT using industries is $\chi^2 = 0.89$ [p=0.02]

⁹ The test statistics for the null hypothesis of equality of coefficients for ICT producing and ICT using industries is $\chi^2 = 3.16$ [p=0.08]

¹⁰ However the share of multi-unit enterprises in NACE sector 15 (Food and Beverages) is also substantial and the average share of turnover due to online transactions is close to the average of the manufacturing sector as a whole.

grouping rather than another. When the variables controlling for spillover effects are included, those determinants that were significant before retain their significance. In addition, there is a strong positive effect from locating in an industry and region with a large share of firms accepting/having received orders online.

In Table 8 we present the estimates of the share of employees using computers when we allow the relationships to differ for domestic and foreign firms. We augment the model by including interacted variables with a dummy which takes the value 1 in the case of foreign owned firms and 0 otherwise. The coefficients for the domestic firms are largely similar to those in the regression when all firms are included. For the foreign firms the effects of firm size and human capital differ in comparison to domestic firms. Large foreign firms have a higher share of employees using computers. The effect of the share of managerial and technical employees is even stronger for the foreign-owned firms with respect to the number of employees using computers. Finally, export intensity does not play such a big role for the foreign firms, in fact it is negative, but small and only marginally significant. When we control for spillover effects we find that the size of domestic firms is negatively associated with the share of employees using computers.

We also re-estimate the share of turnover due to online transaction allowing for different slopes for domestic and foreign firms. The results are shown in Table 9. One can see that the positive and significant coefficient on firm size when foreign ownership is not accounted for is driven by the large foreign firms only. Otherwise there are no noticeable differences between the domestic and the foreign firms in these regressions. The χ^2 -test on the joint significance of the interaction with the foreign ownership dummies confirms this observation.

6 Concluding Remarks

In this paper we examine factors driving the adoption of ICT at firm level using data from a sample of 3,400 firms in the Irish manufacturing industries over 2001-2004. We use an analytical framework suggested by the theory of new technology adoption and relate indicators of ICT adoption such as the usage of computers, services offered online, online transactions to two sets of factors. These are characteristics of firms (size, age, industry specialization, skills composition of employees) and characteristics of the environment in which firms operate (geographical location, information spillovers, international competitive pressure).

Our main findings can be summarised as follows. The likelihood of using computers was positively associated with firm size, the share of clerical employees and export intensity. The share of employees using computers was positively associated with the variables used to proxy human capital (the share of highly skilled employees, the average wage per employee) as well as export intensity. The share of employees using computers was relatively smaller in firms located outside the capital city region and in non-ICT industries. Further, we find that in industries and regions with a high share of firms using computers the share of employees using computers is higher. Moreover, the share of turnover due to online transactions was higher in industries and regions with a large share of firms that carry out their transactions online. This evidence points to the importance of information spillovers from interactions between firms in the adoption of ICT. Older firms were less likely to use computers. The larger the firm the more services they are likely to offer online. Firms located in the capital city region were more likely to carry out their transactions online. We find evidence showing that ICT adoption has increased over time. Firms in ICT producing and ICT using industries were more likely to use computers and offered a larger number of services online. Firms in ICT using industries are more likely to carry out their transactions online.

To a certain extent, patterns of ICT adoption have been different for domestic and foreign-owned firms. First, while international competitive pressure proxied by export intensity was positively associated with ICT adoption in the case of domestic firms, it does not have a significant effect in the case of foreign firms. Second, while firm size is positively associated with the share of employees using computers in the case of foreign firms, it is negatively associated with firm size in the case of domestic firms. The effect

of the firm size on the share of online transaction is also different for domestic and foreign firms. However, firm size had a positive effect on the number of services offered online in domestic firms and no significant effect in the case of foreign firms.

These findings suggest that the adoption of ICT in Irish manufacturing has been uneven across firms, industries and space. On average, other things equal, firms with more skilled workers, operating in ICT producing and ICT using manufacturing, located in the capital city region have been relatively more successful in adopting and using ICT. These results are in line with the theoretical and empirical literature on new technology adoption which points to delays in the adoption of the new technology and differences in adoption rates across firms, industries and space.

Whether and to which extent a wider and faster ICT diffusion is desirable is beyond the scope of this paper. The literature on public policy related to technology diffusion (Stoneman and Diederer, 1994) points to three sources of market failure which might justify policy intervention to speed up the diffusion of ICT: imperfect information, market structure and externalities to adoption. Furthermore, policy intervention can be made on the ground that the market may not provide a satisfactory distribution of the benefits of ICT across firms, industries, space, and time.

Our results suggest three important policy implications. First, there seems to be a lack of factors conducive to the adoption of ICT in particular in the case of the firms located outside the capital city region and which operate in non-ICT industries which might lead to a “digital divide”. Second, the positive relationship between human capital and ICT adoption indicates that education policy is complementary to policy supporting ICT diffusion. Third, ICT adoption can be fostered by encouraging interactions with firms that are using ICT intensively.

References

- Arellano, M. and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", *Review of Economic Studies*, 58(2): 277–297.
- Arvanitis, S. (2005) "Computerization, Workplace organization, Skilled Labour and Firm Productivity: Evidence for the Swiss Business Sector", *Economics of Innovation and New Technology* 14(4), 225-249.
- Barry, F. and J. Bradley (1997) "FDI and Trade: The Irish Host-Country Experience", *Economic Journal*, vol. 107, no. 445, 1798-1811.
- Bartel, A. and N. Sicherman (1999) "Technological Change and Wages: An Interindustry Analysis", *Journal of Political Economy*, 107, 285-325.
- Baptista, R. (2000) "Do Innovations Diffuse Faster Within Geographical Clusters?", *International Journal of Industrial Organization*, 18(3), 515-535.
- Bassanini, A. and S. Scarpetta (2002) "Growth, Technological Change, and ICT Diffusion: Recent Evidence from OECD Countries", *Oxford Review of Economic Policy*, vol. 18 (3), 324-344.
- Bayo-Moriones, A. and F. Lera-López (2007) "A Firm Level Analysis of Determinants of ICT Adoption in Spain", *Technovation*, Vol. 27, 6-7, 352-366.
- Becchetti, L., D.A. Londono Bedoya, L. Paganetto, L. (2003) "ICT Investment, Productivity and Efficiency: Evidence at Firm Level using a Stochastic Frontier Approach", *Journal of Productivity Analysis*, 20(2), 143-167.
- Black, S. and L. Lynch (2001) "How to Compete: The Impact of Workplace Practices and Information Technology on Productivity", *Review of Economics and Statistics*, vol. 83(3), 434-45.
- Black, S. and L. Lynch (2004), "What's Driving the New Economy?: The Benefits of Workplace Innovation", *The Economic Journal*, 114, 97-116.
- Bresnahan, T.F. and M. Trajtenberg (1995) "General Purpose Technologies: 'Engines of Growth'", *Journal of Econometrics*, 65, 83-108.
- Bresnahan, T. E. Brynjolfsson, and L.M. Hitt (2002) "Information Technology, Workplace Organization, and the Demand for Skilled Labour: Firm Level Evidence", *Quarterly Journal of Economics*, 117(1), 339-376.
- Brynjolfsson, E. and L. Hitt (2000) "Beyond Computation: Information technology, Organizational Transformation and Business Performance", *Journal of Economic Perspectives*, 14, 23-48.
- Brynjolfsson, E. and L. Hitt (2003) "Computing Productivity: Firm Level Evidence", *The Review of Economics and Statistics*, 85(4), 793-808.

- Carlsson, B. (2004) "The Digital Economy: What is New and What is Not?", *Structural Change and Economic Dynamics*, 15(3), 245-264.
- Caroli, E. and J. van Reenen (2001) "Skill-biased organisational change? Evidence from a panel of British and French establishments", *Quarterly Journal of Economics*, 116, 1449-1492.
- Caselli, F. and W. Coleman (2001) "Cross-country Technology Diffusion: The Case of Computers", *American Economic Review*, 91(2), 328-335.
- Chari, V.V. and H. Hopenhayn (1991) "Vintage Human capital, Growth and the Diffusion of New Technology", *Journal of Political Economy*, 99, 1142-1165
- Cheung, W. M. and W. Huang (2002) "An Investigation of Commercial Usage of the World Wide Web: A Picture from Singapore", *International Journal of Information Management*, 22 (5), 377-388.
- Chun, H. (2003) "Information Technology and the Demand for Educated Workers: Disentangling the Impacts of Adoption versus Use", *The Review of Economics and Statistics*, 85, 1-8.
- Cooper, J. and A. John (1998) "Coordinating coordination failures in Keynesian models", *Quarterly Journal of Economics*, 103, 441-464.
- Dasgupta, S., D. Agarwal, A. Ioannidis, S. Gopalakrishnan (1999) "Determinants of Information Technology Adoption: An Extension of Existing Models to Firms in a Developing Country", *Journal of Global Information Management*, 7(3), 30-40.
- Doms, M., T. Dunne, K. Troske (1997) "Workers, Wages and Technology", *The Quarterly Journal of Economics*, 112(1), 253-290.
- Eaton, J. and S. Kortum (1999) "International Technology Diffusion: Theory and Measurement", *International Economic Review*, 40(3), 537-70.
- Fabiani, S., F. Schivardi, S. Trento (2005) "ICT Adoption in Italian Manufacturing: Firm Level Evidence", *Industrial and Corporate Change*, 14(2), 225-249.
- Falk, M. (2005) "ICT-linked Firm Reorganisation and Productivity Gains", *Technovation*, 25(11), 1229-1250.
- Galliano, D., P. Roux, M. Filippi (2001) "Organisational and Spatial Determinants of ICT Adoption: The Case of French Industrial Firms", *Environment and Planning*, 33(9), 1643-1663 .
- Gattignon, H. and T. S. Robertson (1989) "Technology Diffusion: An Empirical Test of Competitive Effects", *Journal of Marketing*, 53(1), 35-49.
- Geroski, P.A. (2000) "Models of Technology Diffusion", *Research Policy*, 29, 603-625.
- Gourlay, A. and E. Pentecost (2002) "The Determinants of Technology Diffusion: Evidence from the UK Financial Sector", *Manchester School*, 70(2), 185-203.

- Helpman, E. and M. Trajtemberg (1998) "Diffusion of General Purpose Technologies", in E. Helpman (ed.), *General Purpose Technologies and Economic Growth*, Cambridge, MA: MIT Press.
- Hollenstein, H. (2004) "Determinants of the Adoption of Information and Communication Technologies", *Structural Change and Economic Dynamics*, 15(3), 315-342.
- Jaffe, A., M. Trajtemberg, and R. Henderson (1993) "Geographical Localization of Knowledge Spillovers as Evidenced by Patent Citations", *Quarterly Journal of Economics*, 108(3), 577-98.
- Jaffe, A. and M. Trajtemberg (1999) "International Knowledge Flows: Evidence from Patent Citations", *Economics of Innovation and New Technology*, 8(1-2), 105-36.
- Jensen, R. (1982) "Adoption and Diffusion of an Innovation of Uncertain Profitability", *Journal of Economic Theory*, 27, 182-193.
- Jorgenson, D.W. and K. Stiroh (2000) "Raising the Speed Limit: US Economic Growth in the Information Age", *Brookings Papers on Economic Activity*, 1, 125-211.
- Jovanovic, B. and S. Lach (1989) "Entry, Exit and Diffusion with Learning by Doing", *American Economic Review*, 79, 690-699.
- Jovanovic, B. and G.M. MacDonald (1994) "Competitive Diffusion", *Journal of Political Economy*, 102, 24-52.
- Keller, W. (2002) "Geographical Localisation of International Technology Diffusion", *American Economic Review*, 92(1), 120-142.
- Kowtha, N.R. and T.W. Choon (2001) "Determinants of Website Development: A Study of Electronic Commerce in Singapore", *Information and Management*, 39(3), 227-242.
- Lehr, B. and F. Lichtenberg (1999) "Information Technology and its Impact on Productivity: Firm Level Evidence from Government and Private Data Sources, 1977-1993", *Canadian Journal of Economics*, 32, 335-62.
- Lee, J. (2004) "Discriminant Analysis of Technology Adoption Behaviour: A Case of Internet Technologies in Small Business", *Journal of Computer Information Systems* 44(2), 146-157.
- Lefebvre L., E. Lefebvre, E. Elia, H. Boek (2005) "Exploring B-to-B E-Commerce Adoption Trajectories in Manufacturing SMEs", *Technovation* 25(12), 1443-1456.
- Love, P.E.D., Z. Irani, C. Standing, C. Lin, J.M. Burn (2005) "The Enigma of Evaluation: Benefits, Costs and Risks of IT in Australian Small-Medium-Sized Enterprises", *Information and Management* 42(7), 947-964.

- Matteucci, N., M. O'Mahony, C. Robinson, T. Zwick (2005) "Productivity, Workplace Performance and ICT: Industry and Firm-Level Evidence for Europe and the US", *Scottish Journal of Political Economy*, 52(3), 359-386.
- Morgan, A., Colebourne, D., B. Thomas (2006) "The Development of ICT Advisors for SME Business: An Innovative Approach", *Technovation* 26(8), 980-987.
- Murphy, G. and I. Traistaru-Siedschlag (2007) "The Effects of Human Capital on Output Growth in ICT Industries: Evidence from OECD Countries", ESRI Working Paper No. 184.
- Nelson, R.R. and E. S. Phelps (1966) "Investing in Humans, Technological diffusion, and Economic Growth", *American Economic Review*, 56, 69-75.
- OECD (2004) *The Economic Impact of ICT, Measurement, Evidence and Implications*, Paris: OECD.
- Oliner, S.D. and D.E. Sichel (2000) "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?", *Journal of Economic Perspectives*, 14, 3-12.
- O'Mahony, M. and van Ark, B. (eds.) (2003). *EU productivity and competitiveness: An industry perspective Can Europe resume the catching-up process?*, Luxembourg: European Commission.
- Oulton, N. (2002) "ICT and Productivity Growth in the United Kingdom", *Oxford Review of Economic Policy*, 18, 363-79.
- Papke, L.E., Wooldridge, J. (1996). "Econometric methods for fractional response variables with an application to 401(k) plan participation rates", *Journal of Applied Econometrics* 11, 619-632.
- Porter, M. (2004) *The Competitive Advantage of Nations*, New York: Free Press.
- Reinganum, J.F. (1981) "On the Diffusion of new Technology: A Game Theoretic Approach", *Review of Economic Studies*, 48, 395-405.
- Rosenberg, N. (1972) "Factors Affecting the Diffusion of Technology", *Explorations in Economic History*, vol. 10(1), 3-33.
- Stiroh, K.J., 2002, "Information Technology and the US Productivity Revival: What Do the Industry Data Say?", *American Economic Review*, 92(5), 1559-1576.
- Stoneman, P. and P. Diederer (1994) "Technology Diffusion and Public Policy", *The Economic Journal*, vol. 104, no.425, 918-930
- Teo, T.S.H., and C. Ranganathan (2004) "Adopters and non-adopters of business-to-business electronic commerce in Singapore", *Information and Management* 42(1), 89-102.
- Teo, T.S.H. and M. Tan (1998) "An Empirical Study of Adopters and Non-Adopters of the Internet in Singapore", *Information and Management* 34(6), 339-345.

- Teo, T.S.H., M. Tan, and W.K. Buk (1997) "A Contingency Model of Internet Adoption in Singapore", *International Journal of Electronic Commerce* 2(2), 95-118.
- Thong, J.Y.L (1999) "An Integrated Model of Information Systems Adoption in Small Business", *Journal of Management Information Systems* 4(15), 187-214.
- Timmer, M. and B. van Ark (2005) "Does Information and Communication Technology Drive EU-US Productivity Growth Differentials?", *Oxford Economic Papers*, 57, 693-716.

**Table 1: Indicators of ICT Adoption:
Summary Statistics of Discrete Variables**

	Firms	% of firms using computers	% of firms offering x services online						Firms	% firms accepting/having received orders online
			0	1	2	3	4	5		
2001									1,852	10.64
2002	1539	88.04	61.96	18.02	12.81	4.86	1.77	0.57	2,216	10.92
2003	1937	91.32	59.69	18.88	14.10	5.33	1.35	0.65	1,694	14.46
2004	1403	96.16	47.77	25.63	17.34	6.44	1.99	0.82	1,267	16.10
Total	4879	91.57	57.19	20.44	14.56	5.48	1.66	0.67	7,029	12.63

Note: The number of firms per year differs for the different indicators because all information related to e-commerce is collected for the year prior to the year when the Survey on E-commerce and ICT was conducted (see Section 3 for more details on data from the Survey on E-commerce and ICT)

**Table 2: Firms Characteristics and ICT Adoption:
Summary Statistics of Continuous Variables**

	Firms	Turnover		wages per employee		share of employees using computers		share of turnover due to online transactions	
		Mean	StdDev	Mean	StdDev	Mean	StdDev	Mean	StdDev
Size									
<20	3,577	948.7	1,604.6	20.1	0.4	30.3%	28.8%	1.3%	7.1%
20-49	1,670	4,723.3	6,559.9	24.5	0.3	34.2%	28.2%	1.1%	4.7%
50-249	1,260	24,833.5	68,674.0	28.1	0.3	37.0%	27.3%	1.9%	9.3%
250-499	219	250,473.3	661,212.2	32.6	0.3	52.9%	28.4%	3.4%	16.0%
>=500	109	1,105,312.5	2,299,294.8	35.1	0.2	61.2%	27.1%	8.1%	22.9%
NUTS3 region									
border	925	7,873.4	27,312.7	19.8	0.4	25.1%	23.7%	1.9%	9.1%
midlands	400	7,867.0	15,901.5	22.1	0.4	27.4%	22.8%	0.6%	3.9%
west	600	12,143.6	46,107.7	21.2	0.4	36.4%	30.4%	1.3%	6.0%
dublin	1,734	27,704.8	215,100.6	26.4	0.4	42.2%	31.8%	1.9%	8.3%
mid-east	720	28,877.4	185,638.3	24.3	0.4	32.8%	27.1%	1.7%	9.2%
midwest	601	58,334.3	700,540.4	22.9	0.4	34.7%	28.6%	1.1%	5.1%
southeast	901	27,402.3	203,475.2	22.5	0.4	28.8%	25.6%	1.0%	7.8%
southwest	954	75,061.1	624,006.6	23.2	0.4	34.7%	29.5%	1.6%	9.7%
ICT classification									
ICT-producing	321	250,887.9	1,099,404.8	27.1	0.3	57.3%	30.4%	4.6%	17.6%
ICT-using	2,505	8,128.4	65,700.0	23.2	0.4	39.6%	31.1%	1.6%	8.1%
non ICT	4,009	29,186.3	315,377.2	23.1	0.4	28.7%	25.5%	1.2%	6.7%
Year									
2001	1,801	13,178.7	106,636.6	21.0	0.4			1.2%	7.5%
2002	2,149	22,926.8	256,551.5	22.4	0.4	32.5%	29.1%	1.2%	6.8%
2003	1,650	41,824.5	404,599.3	24.7	0.4	33.6%	28.6%	1.9%	8.9%
2004	1,235	61,448.8	554,370.3	26.4	0.4	36.7%	28.6%	2.1%	9.6%
Total	6,835	31,880.7	344,927.5	23.3	0.4	34.0%	28.8%	1.5%	8.1%

Table 3: Determinants of ICT Adoption: Estimates of Probit Regressions with NACE 2-digit Industry Dummies

Dependent Variable	does firm use computers	no of services offered online	firm accepts/has received orders online
Into	1.560 (0.000) ***	1.158 (0.000) ***	0.986 (0.550)
lnwpe	1.181 (0.163)	1.051 (0.522)	1.072 (0.426)
mantech	1.649 (0.105)	2.863 (0.000) ***	1.382 (0.103)
clerical	4.814 (0.000) ***	3.811 (0.000) ***	1.981 (0.000) ***
age	0.995 (0.021) **	0.997 (0.023) **	1.002 (0.128)
exint	1.381 (0.066) *	1.477 (0.000) ***	1.315 (0.003) ***
multi	1.311 (0.643)	1.114 (0.332)	0.905 (0.484)
border	0.895 (0.382)	0.906 (0.204)	0.849 (0.088) *
midlands	0.874 (0.402)	0.863 (0.150)	0.671 (0.000) ***
west	1.182 (0.296)	1.028 (0.752)	0.981 (0.853)
midwest	1.122 (0.440)	0.912 (0.260)	0.860 (0.132)
midwest	0.856 (0.280)	0.892 (0.228)	0.790 (0.023) **
southeast	1.040 (0.762)	0.822 (0.010) **	0.702 (0.000) ***
southwest	0.981 (0.885)	0.867 (0.051) *	0.743 (0.002) ***
2002			1.036 (0.423)
2003	1.271 (0.000) ***	1.010 (0.732)	1.212 (0.000) ***
2004	1.692 (0.000) ***	1.195 (0.000) ***	1.247 (0.000) ***
constant	0.060 (0.000) ***	8.611 (0.000) ***	0.245 (0.000) ***
Ind χ^2 [p]	49.26 [0.00]	93.40 [0.00]	50.58 [0.00]
Obs	5096	5217	6835
Firms	2849	2893	3236
LogL	-1073.9	-5686.0	-2407.7
R ² pseudo	0.27	0.08	0.05

Odds ratios and p-values reported. ***, **, * indicate significance at 1%, 5%, 10%, respectively.

Ind χ^2 [p] - χ^2 test for the joint significance of the industry dummies [p-value].

Omitted categories: region: Dublin, year: 2001 in the last column, 2002 otherwise, ICT category:

non-ICT manufacturing.

Table 4: Determinants of ICT Adoption: Estimates of Probit Regressions with ICT Taxonomy Dummies

Dependent Variable	does firm use computers	no of services offered online	firm accepts/ has received orders online
Into	1.537 (0.000) ***	1.132 (0.000) ***	0.989 (0.642)
lnwpe	1.286 (0.023) **	1.110 (0.191)	1.022 (0.802)
mantech	2.388 (0.005) ***	2.659 (0.000) ***	1.338 (0.129)
clerical	6.440 (0.000) ***	3.599 (0.000) ***	2.327 (0.000) ***
age	0.995 (0.014) **	0.997 (0.007) ***	1.003 (0.042) **
exint	1.417 (0.040) **	1.531 (0.000) ***	1.238 (0.013) **
multi	1.374 (0.592)	1.117 (0.308)	0.911 (0.516)
border	0.810 (0.096) *	0.913 (0.243)	0.819 (0.037) **
midlands	0.791 (0.138)	0.875 (0.184)	0.637 (0.000) ***
west	1.107 (0.519)	1.046 (0.599)	0.941 (0.556)
mideast	1.035 (0.819)	0.925 (0.347)	0.823 (0.056) *
midwest	0.821 (0.166)	0.923 (0.397)	0.757 (0.007) ***
southeast	0.967 (0.795)	0.857 (0.039) **	0.670 (0.000) ***
southwest	0.902 (0.439)	0.872 (0.059) *	0.727 (0.001) ***
2002			1.041 (0.367)
2003	1.251 (0.000) ***	1.011 (0.701)	1.200 (0.000) ***
2004	1.648 (0.000) ***	1.200 (0.000) ***	1.248 (0.000) ***
constant	0.062 (0.000) ***	6.947 (0.000) ***	0.251 (0.000) ***
ICT producing	1.817 (0.091) *	1.434 (0.000) ***	1.082 (0.525)
ICT using	1.295 (0.001) ***	1.349 (0.000) ***	1.126 (0.041) **
Obs	5181	5217	6835
Firms	2894	2893	3236
LogL	-1108.6	-5733.0	-2446.7
R ² pseudo	0.25	0.07	0.03

Odds ratios and p-values reported. ***, **, * indicate significance at 1%, 5%, 10%, respectively. Omitted categories: region: Dublin, year: 2001 in the last column, 2002 otherwise, ICT category: non-ICT manufacturing.

**Table 5: Determinants of ICT Adoption: Estimates of Probit Regressions
distinguishing between domestic and foreign firms**

Dependent Variable	no of services offered online		firm accepts/has received orders online	
	domestic firms	foreign firms	domestic firms	foreign firms
Into	1.195 (0.000) ***	1.152 (0.000) ***	0.999 (0.964)	1.010 (0.827)
lnwpe	0.982 (0.825)	1.353 (0.171)	1.126 (0.213)	0.662 (0.081) *
mantech	2.825 (0.000) ***	2.991 (0.003) ***	1.207 (0.411)	2.269 (0.059) *
clerical	3.468 (0.000) ***	3.267 (0.016) **	2.029 (0.000) ***	1.811 (0.285)
age	0.997 (0.022) **	0.994 (0.032) **	1.002 (0.192)	1.001 (0.745)
exint	1.969 (0.000) ***	0.922 (0.601)	1.533 (0.000) ***	0.940 (0.750)
multi	1.270 (0.059)		0.832 (0.252)	
border	0.812 (0.015)	1.381 (0.106)	0.771 (0.014) **	1.180 (0.519)
midlands	0.771 (0.026)	1.153 (0.551)	0.689 (0.003) ***	0.525 (0.052) *
west	1.026 (0.782)	0.959 (0.837)	1.049 (0.662)	0.613 (0.058) *
midwest	0.901 (0.242)	0.900 (0.614)	0.860 (0.173)	0.896 (0.668)
midwest	0.914 (0.384)	0.980 (0.927)	0.799 (0.059) *	0.902 (0.662)
southeast	0.776 (0.003) ***	1.083 (0.643)	0.721 (0.002) ***	0.594 (0.043) **
southwest	0.886 (0.133)	0.809 (0.195)	0.740 (0.002) ***	0.813 (0.377)
2002			1.065 (0.207)	0.904 (0.351)
2003	1.018 (0.561)	1.043 (0.549)	1.272 (0.000) ***	1.044 (0.713)
2004	1.205 (0.000) ***	1.203 (0.023) **	1.288 (0.000) ***	1.118 (0.367)
constant	9.603 (0.000) ***	13.629 (0.000) ***	0.178 (0.000) ***	1.439 (0.669)
Ind χ^2 [p]	80.89 [0.00]	43.39 [0.00]	53.53 [0.00]	22.33 [0.17]
Obs	4385	832	5678	1108
Firms	2460	446	2757	474
LogL	-4507.4	-1113.0	-1965.4	-395.8
R ² pseudo	0.08	0.07	0.06	0.08

Odds ratios and p-values reported. ***, **, * indicate significance at 1%, 5%, 10%, respectively.

Ind χ^2 [p] - χ^2 test for the joint significance of the industry dummies [p-value].

Omitted categories: region: Dublin, year: 2001 in the last column, 2002 otherwise, ICT category: non-ICT manufacturing.

**Table 6: Determinants of ICT Adoption:
Estimates of Fractional Logit Regressions**

<i>Dependent Variable: share of employees using computer</i>				
	ind dummies	ICT dummies	spillovers and industry dummies	spillovers and ICT dummies
Into	0.024 (0.020)	0.027 (0.020)	0.013 (0.020)	0.017 (0.020)
lnwpe	0.570 (0.089) ***	0.683 (0.087) ***	0.563 (0.089) ***	0.607 (0.086) ***
mantech	1.912 (0.222) ***	2.386 (0.220) ***	1.887 (0.224) ***	2.200 (0.221) ***
clerical	2.287 (0.180) ***	2.856 (0.180) ***	2.232 (0.179) ***	2.591 (0.175) ***
age	-0.004 (0.001) ***	-0.003 (0.001) *	-0.004 (0.001) **	-0.003 (0.001) *
exint	0.370 (0.079) ***	0.416 (0.076) ***	0.329 (0.079) ***	0.324 (0.076) ***
multi	0.087 (0.113)	0.026 (0.114)	0.089 (0.112)	0.042 (0.112)
ind-reg sp			1.934 (0.221) ***	2.319 (0.225) ***
ind sp			0.158 (0.246)	0.895 (0.238) ***
border	-0.291 (0.079) ***	-0.423 (0.081) ***	-0.268 (0.079) ***	-0.347 (0.080) ***
midlands	-0.289 (0.104) ***	-0.398 (0.099) ***	-0.257 (0.106) **	-0.306 (0.102) ***
west	0.007 (0.098)	-0.036 (0.098)	0.026 (0.098)	0.007 (0.096)
mid east	-0.113 (0.091)	-0.213 (0.089) **	-0.149 (0.090)	-0.225 (0.088) **
midwest	-0.121 (0.095)	-0.197 (0.098) **	-0.082 (0.094)	-0.151 (0.096)
southeast	-0.189 (0.083) **	-0.274 (0.081) ***	-0.185 (0.083) **	-0.256 (0.081) ***
southwest	-0.033 (0.078)	-0.108 (0.079)	-0.014 (0.078)	-0.081 (0.078)
2003	0.039 (0.034)	0.022 (0.034)	-0.022 (0.035)	-0.075 (0.035) **
2004	0.051 (0.040)	0.025 (0.040)	-0.088 (0.045) **	-0.189 (0.044) ***
constant	-3.465 (0.251) ***	-3.884 (0.248) ***	-5.161 (0.356) ***	-6.350 (0.330) ***
Ind χ^2 [p]	265.73 [0.00]		171.02 [0.00]	
ICT producing		0.754 (0.120) ***		0.614 (0.122) ***
ICT using		0.448 (0.051) ***		0.387 (0.051) ***
Obs	4689	4689	4689	4689
Firms	2707	2707	2707	2707
LogL	-2055.4	-2096.6	-2038.7	-2060.6
χ^2	1144.9	903.7	1235.6	1072.1

Standard errors in parenthesis. ***, **, * indicate significance at 1%, 5%, 10%, respectively.

Ind χ^2 [p] - χ^2 test for the joint significance of the industry dummies [p-value].

Omitted categories are: region: Dublin, year: 2002, ICT category: non-ICT manufacturing.

ind-reg sp: share of firms in the same industry and region that use computers; ind sp: share of firms in the same industry but not in the same region that use computers. Industry-year cells with only one firm are excluded from the estimation.

**Table 7: Determinants of ICT Adoption:
Estimates of Fractional Logit Regressions**

<i>Dependent Variable: share of turnover due to online transactions</i>				
	ind dummies	ICT dummies	spillovers and industry dummies	spillovers and ICT dummies
Into	0.162 (0.080) **	0.203 (0.101) **	0.207 (0.081) **	0.227 (0.084) ***
lnwpe	-0.242 (0.287)	-0.488 (0.308)	-0.317 (0.292)	-0.391 (0.300)
mantech	0.967 (0.607)	0.799 (0.594)	0.560 (0.625)	0.375 (0.578)
clerical	-0.139 (0.515)	0.104 (0.581)	-0.716 (0.496)	-0.622 (0.539)
age	-0.004 (0.005)	-0.003 (0.005)	-0.006 (0.005)	-0.005 (0.005)
exint	1.234 (0.248) ***	0.928 (0.276) ***	0.860 (0.242) ***	0.722 (0.250) ***
multi	-0.766 (0.450) *	-0.921 (0.462) **	-1.329 (0.467) ***	-1.390 (0.468) ***
ind-reg sp			5.729 (0.398) ***	5.458 (0.365) ***
ind sp			0.213 (0.890)	0.323 (0.745)
border	-0.077 (0.324)	-0.209 (0.312)	0.081 (0.307)	-0.073 (0.304)
midlands	-0.736 (0.419) *	-0.934 (0.416) **	-0.515 (0.379)	-0.686 (0.383) *
west	-0.212 (0.281)	-0.403 (0.293)	-0.666 (0.326) **	-0.785 (0.329) **
midwest	-0.614 (0.304) **	-0.759 (0.310) **	-0.682 (0.307) **	-0.738 (0.302) **
southeast	-0.496 (0.457)	-0.608 (0.443)	-0.451 (0.392)	-0.495 (0.381)
southwest	-0.148 (0.411)	-0.213 (0.422)	0.096 (0.396)	0.031 (0.409)
2002	-0.023 (0.127)	0.001 (0.131)	-0.055 (0.138)	-0.042 (0.142)
2003	0.321 (0.145) **	0.331 (0.149) **	0.040 (0.154)	0.045 (0.159)
2004	0.311 (0.145) **	0.376 (0.146) ***	0.048 (0.158)	0.052 (0.163)
constant	-4.889 (0.724) ***	-4.721 (0.657) ***	-5.931 (0.732) ***	-5.960 (0.664) ***
Ind χ^2 [p]	51.19 [0.00]		33.81 [0.02]	
ICT producing		0.406 (0.334)		0.175 (0.310)
ICT using		0.330 (0.252)		0.169 (0.241)
Obs	6188	6188	6188	6188
Firms	3041	3041	3041	3041
LogL	-386.4	-402.1	-336.3	-346.2
χ^2	164.0	110.7	539.3	395.8

Standard errors in parenthesis. ***, **, * indicate significance at 1%, 5%, 10%, respectively.

Ind χ^2 [p] - χ^2 test for the joint significance of the industry dummies [p-value].

Omitted categories are: region: Dublin, year: 2001, ICT category: non-ICT manufacturing.

ind-reg sp: share of firms in the same industry and region that accept/have received orders online; ind sp: share of firms in the same industry but not in the same region that accept/have received orders online. Industry-year cells with only one firm are excluded from the estimation.

Table 8: Determinants of ICT Adoption:
Estimates of Fractional Logit Regressions with Foreign Interaction
Terms

<i>Dependent Variable: share of employees using computer</i>				
	ind dummies	ICT dummies	spillovers and industry dummies	spillovers and ICT dummies
Into	-0.033 (0.024)	-0.035 (0.024)	-0.051 (0.024) **	-0.051 (0.023) **
lnwpe	0.582 (0.093) ***	0.701 (0.092) ***	0.579 (0.092) ***	0.621 (0.089) ***
mantech	1.645 (0.254) ***	2.083 (0.255) ***	1.613 (0.257) ***	1.869 (0.257) ***
clerical	2.276 (0.192) ***	2.858 (0.192) ***	2.203 (0.191) ***	2.556 (0.187) ***
age	-0.003 (0.001) *	-0.001 (0.001)	-0.003 (0.001) *	-0.001 (0.001)
exint	0.349 (0.098) ***	0.355 (0.098) ***	0.296 (0.098) ***	0.279 (0.097) ***
multi	0.062 (0.120)	0.005 (0.121)	0.065 (0.121)	0.020 (0.122)
fo	-1.261 (0.874)	-0.843 (0.854)	-1.525 (0.860) *	-1.604 (0.848) *
fo_Into	0.128 (0.045) ***	0.153 (0.044) ***	0.145 (0.045) ***	0.170 (0.044) ***
fo_lnwpe	0.155 (0.315)	-0.002 (0.298)	0.171 (0.308)	0.129 (0.295)
fo_mantech	1.220 (0.460) ***	1.238 (0.460) ***	1.231 (0.466) ***	1.303 (0.463) ***
fo_clerical	0.137 (0.514)	-0.132 (0.512)	0.297 (0.519)	0.170 (0.514)
fo_age	-0.005 (0.004)	-0.007 (0.004) *	-0.005 (0.004)	-0.006 (0.004) *
fo_exint	-0.376 (0.198) *	-0.377 (0.194) *	-0.315 (0.199)	-0.296 (0.195)
ind-reg sp			1.992 (0.221) ***	2.376 (0.226) ***
ind sp			0.154 (0.239)	0.856 (0.234) ***
border	-0.287 (0.080) ***	-0.419 (0.082) ***	-0.259 (0.080) ***	-0.336 (0.080) ***
midlands	-0.279 (0.104) ***	-0.388 (0.100) ***	-0.243 (0.106) **	-0.290 (0.101) ***
west	0.007 (0.096)	-0.031 (0.096)	0.028 (0.096)	0.018 (0.095)
midwest	-0.097 (0.091)	-0.200 (0.089) **	-0.133 (0.090)	-0.210 (0.087) **
midwest	-0.127 (0.095)	-0.210 (0.098) **	-0.084 (0.095)	-0.156 (0.096)
southeast	-0.186 (0.083) **	-0.270 (0.081) ***	-0.179 (0.082) **	-0.246 (0.080) ***
southwest	-0.049 (0.078)	-0.122 (0.078)	-0.027 (0.077)	-0.090 (0.078)
2003	0.034 (0.034)	0.020 (0.034)	-0.030 (0.035)	-0.079 (0.035) **
2004	0.048 (0.040)	0.025 (0.040)	-0.096 (0.045) **	-0.192 (0.044) ***
constant	-3.035 (0.263) ***	-3.481 (0.262) ***	-4.733 (0.361) ***	-5.903 (0.336) ***
Ind χ^2 [p]	246.37 [0.00]		153.74 [0.00]	
ICT producing		0.667 (0.127) ***		0.540 (0.129) ***
ICT using		0.437 (0.051) ***		0.375 (0.050) ***
fo χ^2 [p]	26.06 [0.00]	27.76 [0.00]	29.43 [0.00]	34.30 [0.00]
Obs	4689	4689	4689	4689
Firms	2707	2707	2707	2707
LogL	-2046.0	-2085.4	-2028.3	-2048.8
χ^2	1277.4	1065.2	1359.2	1213.8

Standard errors in parenthesis. ***, **, * indicate significance at 1%, 5%, 10%, respectively.

Ind χ^2 [p] - χ^2 test for the joint significance of the industry dummies [p-value].

fo χ^2 [p] - χ^2 test for the joint significance of the foreign interaction terms [p-value].

Omitted categories are: region: Dublin, year: 2002, ICT category: non-ICT manufacturing.

ind-reg sp: share of firms in the same industry and region that use computers; ind sp: share of firms in the same industry but not in the same region that use computers. Industry-year cells with only one firm are excluded from the estimation.

Table 9: Determinants of ICT Adoption:**Estimates from Fractional Logit Regressions with Foreign Interaction Terms**

<i>Dependent Variable: share of turnover due to online transactions</i>				
	ind dummies	ICT dummies	spillovers and industry dummies	spillovers and ICT dummies
lnto	-0.025 (0.092)	0.043 (0.103)	0.039 (0.102)	0.105 (0.103)
lnwpe	0.152 (0.319)	-0.058 (0.312)	0.038 (0.338)	-0.064 (0.333)
mantech	0.137 (0.809)	-0.229 (0.828)	0.043 (0.732)	-0.254 (0.760)
clerical	0.317 (0.372)	0.505 (0.367)	-0.317 (0.437)	-0.345 (0.425)
age	-0.002 (0.005)	0.000 (0.005)	-0.004 (0.005)	-0.003 (0.005)
exint	1.363 (0.315) ***	1.215 (0.309) ***	0.788 (0.299) ***	0.693 (0.282) **
multi	-0.823 (0.489) *	-0.984 (0.484) **	-1.389 (0.530) ***	-1.387 (0.479) ***
fo	-0.325 (2.480)	1.313 (2.771)	-0.099 (2.465)	1.176 (2.908)
fo_lnto	0.360 (0.139) ***	0.313 (0.156) **	0.326 (0.151) **	0.234 (0.151)
fo_lnwpe	-0.962 (0.900)	-1.302 (0.982)	-1.019 (0.920)	-1.182 (1.053)
fo_mantech	1.609 (1.393)	2.030 (1.447)	0.962 (1.370)	1.405 (1.425)
fo_clerical	-1.646 (2.116)	-1.448 (2.103)	-1.147 (1.817)	-0.772 (1.897)
fo_age	0.000 (0.012)	0.000 (0.013)	0.002 (0.011)	0.004 (0.011)
fo_exint	0.091 (0.591)	-0.355 (0.589)	0.643 (0.616)	0.497 (0.610)
ind-reg sp			5.762 (0.422) ***	5.464 (0.377) ***
ind sp			0.157 (0.923)	0.242 (0.757)
border	-0.078 (0.316)	-0.202 (0.314)	0.084 (0.299)	-0.063 (0.308)
midlands	-0.682 (0.413) *	-0.892 (0.412) **	-0.477 (0.375)	-0.658 (0.378) *
west	-0.173 (0.276)	-0.344 (0.280)	-0.639 (0.335) *	-0.755 (0.333) **
midwest	-0.174 (0.341)	-0.276 (0.378)	-0.179 (0.296)	-0.326 (0.306)
midwest	-0.678 (0.319) **	-0.751 (0.307) **	-0.760 (0.334) **	-0.777 (0.322) **
southeast	-0.505 (0.461)	-0.595 (0.456)	-0.464 (0.402)	-0.490 (0.388)
southwest	-0.196 (0.412)	-0.217 (0.424)	0.078 (0.398)	0.028 (0.412)
2002	-0.047 (0.130)	-0.016 (0.134)	-0.091 (0.141)	-0.056 (0.147)
2003	0.316 (0.146) **	0.324 (0.150) **	0.018 (0.158)	0.045 (0.163)
2004	0.287 (0.148) *	0.367 (0.147) **	0.041 (0.162)	0.071 (0.167)
constant	-4.504 (0.667) ***	-4.812 (0.680) ***	-5.562 (0.713) ***	-5.968 (0.704) ***
Ind χ^2 [p]	54.84 [0.00]		34.40 [0.02]	
ICT producing		0.292 (0.330)		0.007 (0.336)
ICT using		0.294 (0.251)		0.107 (0.248)
fo χ^2 [p]	11.39 [0.08]	7.99 [0.24]	8.98 [0.17]	6.48 [0.37]
Obs	6188	6188	6188	6188
Firms	3041	3041	3041	3041
LogL	-382.6	-398.5	-333.3	-343.9
χ^2	197.3	131.9	558.6	408.1

Standard errors in parenthesis. ***, **, * indicate significance at 1%, 5%, 10%, respectively.

Ind χ^2 [p] - χ^2 test for the joint significance of the industry dummies [p-value].

fo χ^2 [p] - χ^2 test for the joint significance of the foreign interaction terms [p-value].

Omitted categories are: region: Dublin, year: 2001, ICT category: non-ICT manufacturing.

ind-reg sp: share of firms in the same industry and region that accept/have received orders online; ind sp: share of firms in the same industry but not in the same region that accept/have received orders online. Industry-year cells with only one firm are excluded from the estimation.

Appendix 1: Industry NACE Rev 1.1 Classification, 2-digit level

- 15 Manufacture of food products and beverages
- 16 Tobacco
- 17 Manufacture of textiles
- 18 Manufacture of wearing apparel; dressing and dyeing of fur
- 19 Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
- 20 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
- 21 Manufacture of pulp, paper and paper products
- 22 Publishing, printing and reproduction of recorded media
- 23 Manufacture of coke, refined petroleum products and nuclear fuel
- 24 Manufacture of chemicals and chemical products
- 25 Manufacture of rubber and plastic products
- 26 Manufacture of other non-metallic mineral products
- 27 Manufacture of basic metals
- 28 Manufacture of fabricated metal products, except machinery and equipment
- 29 Manufacture of machinery and equipment n.e.c.
- 30 Manufacture of office machinery and computers
- 31 Manufacture of electrical machinery and apparatus n.e.c.
- 32 Manufacture of radio, television and communication equipment and apparatus
- 33 Manufacture of medical, precision and optical instruments, watches and clocks
- 34 Manufacture of motor vehicles, trailers and semi-trailers
- 35 Manufacture of other transport equipment
- 36 Manufacture of furniture; manufacturing n.e.c.

Appendix 2: Taxonomy of ICT Industries

ICT Producing Manufacturing

Office machinery (30)
Insulated wire (313)
Electronic valves and tubes (321)
Telecommunication equipment (322)
Radio and television receivers (323)
Scientific instruments (331)

ICT Using Manufacturing

Clothing (18)
Printing & publishing (22)
Mechanical engineering (29);
Other electrical machinery & apparatus (31-313)
Other instruments (33-331)
Building and repairing of ships and boats (351)
Aircraft and spacecraft (353)
Railroad equipment and transport equipment nec (352+359)
Furniture, miscellaneous manufacturing (36)

Non-ICT Manufacturing

Food, drink & tobacco (15-16)
Textiles (17)
Leather and footwear (19)
Wood & products of wood and cork (20)
Pulp, paper & paper products (21)
Mineral oil refining, coke & nuclear fuel (23)
Chemicals (24)
Rubber & plastics (25)
Non-metallic mineral products (26)
Basic metals (27)
Fabricated metal products (28)
Motor vehicles (34)

Appendix 3: Description of Variables

Variable	Description	Source
ucomp	1 if enterprise uses computers; 0 otherwise	E-Commerce Survey
servind	index of services offered online: marketing the enterprise's products, facilitating access to product catalogues and price lists, customised page for repeat clients, delivering digital products, providing after sales support	E-Commerce Survey
netord	1 if enterprise accepts/has received orders via the Internet; 0 otherwise	E-Commerce Survey; corrected if equal to 0 and esal had a positive value
empucomp	share of employees using a computer in total employees	E-Commerce Survey
esal	share of turnover due to transactions over the Internet including a website, email and electronic data interchange (EDI)	E-Commerce Survey complemented with information from the CIP
age	firm age, current year less start-up year, where the earliest start-up year recorded is 1900	CIP
clerical	share of clerical workers in total employees	CIP
exint	export intensity: share of exports in total sales	CIP
ln to	log of turnover, where turnover is reported in multiples of 1000€ and deflated to constant 2000 values using the producer price index reported by the CSO	CIP
ln wpe	log of earnings and wages per employee, where wages and earnings are reported in multiples of 1000€ and deflated to constant 2000 values using the consumer price index reported by the CSO	CIP
mantech	share of managers and technicians in total employees	CIP
multi	1 if enterprise comprises several plants; 0 otherwise	CIP
NUTS3 regions	border, midlands, west, Dublin, mideast, midwest, southeast, southwest	CIP

CIP: Census of Industrial Production;

E-Commerce Survey: Survey of E-Commerce and ICT

Year	Number	Title/Author(s) ESRI Authors/Co-authors Italicised
2007	203	EU Enlargement and Migration: Assessing the Macroeconomic Impacts Ray Barrell, <i>John Fitz Gerald</i> and Rebecca Riley
	202	The Dynamics of Economic Vulnerability: A Comparative European Analysis <i>Christopher T. Whelan</i> and <i>Bertrand Maitre</i>
	201	Validating the European Socio-economic Classification: Cross-Sectional and Dynamic Analysis of Income Poverty and Lifestyle Deprivation <i>Dorothy Watson</i> , <i>Christopher T. Whelan</i> and <i>Bertrand Maitre</i>
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Gavin Murphy and Iulia Traistaru-Siedschlag
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