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ICT Use in Irish General Practices: An Intra-Practice Adoption Study

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Abstract

The importance of Information and Communications Technology (ICT) to support the delivery of health care is widely recognised. Given the potential of ICT to improve efficiency and quality of care, it is necessary to understand health care organisations' decision-making concerning ICT adoption and use. In this paper, we explore the factors that influence the intensity of ICT use by general practices in Ireland.

Irish GPs, as self-employed private practitioners, enjoy certain independence in the running of their practices. The autonomy enjoyed by Irish GPs not only influences how they respond to commercial and market incentives, but also provides them with the freedom to learn from interactions with others and previous adoption decisions. Drawing on an encompassing theoretical model incorporating equilibrium, disequilibrium and learning-by-using elements, we explore how commercial considerations and informational stimuli influence ICT use in Irish general practices.

The data source used in this study is the *Medical Equipment and IT in General Practice* survey data, which provides information relating to practice characteristics and ICT use for a sample of 601 general practices in Ireland. We use Ordered Probit analysis to examine intensity of ICT use for both administrative and patient care purposes. We find some evidence that GP and practice characteristics influence the extent to which a practice uses ICT. Also, educational and interaction activities positively influence ICT use. Furthermore, we find strong support of the influence of learning-by-using effects on intensity of ICT use.

Keywords: ICT; Adoption of innovation model; General practice

Biographical Notes: Dr. Jane Bourke is a Lecturer in Economics at University College Cork and holds a PhD from Warwick Business School. Jane's research interests are in the areas of innovation & technological change, adoption and diffusion of innovations, and health economics.

1: Introduction

The importance of Information and Communications Technology (ICT) adoption to support the delivery of health care is widely recognised (Kvist and Kidd, 1998; Macgregor *et al.*, 2009). There is also increasing evidence of the benefits of using ICT in primary care, such as improved consistency and quality of care and reduction in patient risk, as well as improved practice management (Kvist and Kidd, 1998; Misan, 2003; Macgregor *et al.*, 2009). Across Europe, basic ICT infrastructure, such as computers and internet connections, is available in most general practices, with the electronic storage of administrative and medical patient data and the use of a computer during consultation with patients becoming more and more a daily experience in practices (Dobrev *et al.*, 2008). Given the potential of ICT use to improve efficiency and quality of care, it is necessary to understand what influences health care organisations' decision-making concerning ICT use. This paper aims to identify the motivations for such decision-making in general practices.

General practice in Ireland provides the health care setting for our investigation. Irish GPs are by and large self-employed private practitioners who enjoy considerable autonomy in relation to practice investment and development (Department of Health and Children, 2001; Wren, 2003). Consequently, there is substantial variation in the extent to which practices are equipped with respect to medical equipment and ICT (Bourke and Bradley, 2010). The National Health Information Strategy commits to modernise ICT infrastructure in the health sector and to optimise development and utilisation of health information (Department of Health and Children, 2004). However, a European-wide survey of ICT use by general practices categorised Irish general practices as 'average' performers in terms of ICT use (Dobrev *et al.*, 2008).

Previous literature has focused on describing the design of clinical ICT systems, the uses of such systems within the practice and the differences in ICT adoption between rural and urban practices (Macgregor *et al.*, 2009). However, research on what motivates GPs in their ICT usage is somewhat limited. Drawing on the innovation literature, our study takes an economic approach to identifying the influences on ICT use in Irish general practices. General practices use ICT for a variety of reasons ranging from billing patients and writing referral letters to keeping consultation records and coding diseases. Almost all Irish general practices are computerised, although there is substantial variation in the ICT applications used (Meade *et*

al., 2009; Bourke and Bradley, 2010). Therefore, we are concerned with the extent of ICT use in Irish general practices, or in the language of the adoption and diffusion literature, intra-practice ICT adoption.

Previously, three complementary theoretical approaches have been used to explain adoption decision-making. Disequilibrium models reflect the learning and informational influences on adoption (Rogers, 2003); equilibrium models take account of how organisational characteristics and strategic interactions influence adoption (Karshenas and Stoneman, 1993); while learning-by-using models reflect how cumulative learning experience from previous adoption decisions influence adoption (McWilliams and Zilbermanfr, 1996). Recent studies have drawn on these theoretical propositions in examinations of adoption of health care innovations. Examples include McCullough's (2008) investigation into the influence of hospital characteristics, hospital competition and strategic behaviour on the adoption of hospital information systems in the US and Bourke and Roper's (2012) examination of the influence of commercial, strategic, learning and informational stimuli on prescribing innovation by Irish GPs. Furthermore, recent innovation literature has argued that an understanding of the extent of use of new technologies is of as much importance as understanding the initial decision to use the technology (Mansfield, 1963; Battisti and Stoneman, 2003; Hollenstein, 2004; Battisti and Stoneman, 2005; Battisti *et al.*, 2007). A small number of studies have extended the main theoretical approaches to adoption decision-making to examinations of intensity of adoption; and two specifically examine intensity of ICT adoption by businesses (Hollenstein, 2004; Battisti *et al.*, 2007). In line with Bourke and Roper's (2012) and McCullough's (2008) studies and drawing on developments in the innovation literature, we investigate the influence of disequilibrium, equilibrium and learning-by-using effects on intensity of ICT use in Irish general practices.

The rest of the paper is organised as follows. Section 2 outlines the conceptual framework for our study, emphasising the potential for informational, experiential and organisational influences on the intensity of ICT use by general practices. Section 3 describes our primary data source - the *Medical Equipment and IT in General Practice* survey data which provides information relating to practice characteristics and ICT use for a sample of 601 general practices in Ireland. Section 4 outlines our econometric approach, and Section 5 presents our results. Section 6 discusses our results in the context of previous literature and the Irish general practice environment. Section 7 concludes.

2: Conceptual Framework

Irish general practices enjoy considerable strategic freedom with respect to practice development. Health economics literature frequently profiles GPs as economic agents who respond to economic incentives and are aware of the competitive structure of their environment (Scott, 2000; Kann *et al.*, 2010), indicating the potential for commercial motivations and strategic behaviour influencing practice development decisions. In fact, there is previous evidence of Irish GPs adjusting their prescribing behaviour in response to economic incentives (Walley *et al.*, 2001). A number of studies have suggested that for any medical or health care function to be truly viable, there must be a balance between medical and business efficiency (Lievens and Jordanova, 2004; Bonneville and Pare, 2006; Rahimi and Vimarlund, 2007). As self-employed health care practitioners, Irish GPs are assumed to maximise utility functions that are increasing in profits and service delivery.

The benefits of ICT use in general practice include consistency and quality of patient care, as well as improved practice management (Kvist and Kidd, 1998; Misan, 2003; Macgregor *et al.*, 2009). Djellal and Gallouj (2007), in a survey of the literature on innovation in hospitals, highlight a distinction between using information technology in a hospital setting for administration and for medical care itself. Therefore, we distinguish between ICT use for administrative and patient care purposes to reflect both commercial and health care provision factors. Previous literature suggests that organisational, informational and experiential factors influence adoption and intensity of adoption decision-making (Arvantis and Hollenstein, 2001; Battisti *et al.*, 2007; Battisti and Stoneman, 1997; Battisti and Stoneman, 2003; Hollenstein, 2004; Karshenas and Stoneman, 1993). Consequently, our empirical approach, in line with Bourke and Roper (2012), is to apply the disequilibrium, equilibrium and learning-by-using models of adoption to our examination of intra-practice ICT adoption. Bourke and Roper (2012) provide a detailed explanation of these complementary models of adoption and justify their application to an examination of adoption decision-making by Irish GPs. Below we provide a brief synopsis of this study's theoretical framework.

In the disequilibrium models of adoption, information is asymmetric and adoption is driven by information flows. Epidemic theories of diffusion assume information asymmetries between different potential adopters resulting from factors such as location and interaction with external agents, and the basic hypothesis of these theories is that non-adopters are more

likely to innovate, the more widespread is adoption by other member of their social system (Baptista, 1999; Rogers, 2003). Equilibrium models assume that information in the economy is perfect and therefore, differences in the timing of adoption therefore occur not because of the spread of information but because of the gains from adoption relative to its costs. The equilibrium models of adoption purport that firm characteristics (rank effects) and strategic behaviour (stock and order effects) influence timing of adoption (Karshenas and Stoneman, 1993). Recent literature has also focused on learning-by-using effects when modelling adoption decisions, whereby a firm increases its stock of knowledge based on its previous experience with technologies. Previous studies report that learning from the adoption of complementary technologies, complementarities between various functional groups of the same technology and the use of previous technology vintages positively impact on adoption decisions (Stoneman and Kwon, 1994; Colombo and Mosconi, 1995; McWilliams and Zilberman, 1996; Stoneman and Toivanen, 1997; Arvantis and Hollenstein, 2001).

Previous research has viewed the disequilibrium, equilibrium and learning-by-using models of adoption to be complementary (Colombo and Mosconi, 1995; Arvantis and Hollenstein, 2001), and more recently researchers have incorporated these models of adoption to examinations of adoption decision-making in health-care settings (McCullough, 2008; Bourke and Roper, 2012). In an examination of adoption of hospital information systems (IS) in the US, McCullough (2008) finds that adoption of IS is driven by variation in hospital characteristics (rank effect), although not driven by whether a hospital is considered an academic hospital (epidemic effect). Interestingly, McCullough's (2008) finding that multihospital systems are earlier adopters of IS may indicate the presence of an epidemic or learning-by-using effect. In a study examining the adoption of new prescription drugs by Irish GPs, Bourke and Roper (2012) find that GP and practice characteristics (rank effect) and practice locations (epidemic effect) influence adoption decision-making. Bourke and Roper report overwhelming support for learning-by-using effects, with GPs with broader prescribing portfolios being early adopters of new drugs. Bourke and Roper also find evidence of stock and order effects influencing prescribing behaviour, however they conclude that empirically these effects are also likely to be capturing information acquisition and learning as well as strategic behaviour in this particular context (Bourke and Roper, 2012).

As previously discussed, a number of studies argue that the theoretical propositions made in the adoption literature (inter-firm diffusion) should also be applied to studies of intensity of

adoption (intra-firm diffusion) (Battisti, 2000; Battisti and Stoneman, 2003; Hollenstein, 2004). As most general practices in Ireland use ICT to some extent (Meade *et al.*, 2009; Bourke and Bradley, 2010b), it is more important to understand what leads some practices to be more intensive ICT users than others rather than ICT use in the first instance.

The autonomous nature of Irish general practice suggests the potential for commercial, informational and experiential influences on adoption decision-making. Previous research has highlighted how information stimuli, such as interaction with external agents and further education, influence the diffusion of health care innovations (Coleman *et al.*, 1966; Baker and Thompson, 1995; Tamblyn *et al.*, 2003; McCullough, 2008; Meade *et al.*, 2009). In addition to informational stimuli, recent studies have identified commercial and experiential factors influencing adoption of health care technologies by health care professionals and organisations (McCullough, 2008; Bourke and Roper, 2012). Building on this work, we apply an encompassing equilibrium, disequilibrium and learning-by-using model of adoption to our examination of intensity of ICT use in Irish general practices.

3: Data

Our empirical analysis is based on survey data, collected through a self-administered postal questionnaire -*Medical Equipment and IT in General Practice*- distributed to all general practices in Ireland in Spring 2010 (see Bourke and Bradley (2010) and Bourke and Bradley (2012) for a full description of the survey data). Designing a sample frame of all general practices in Ireland is complicated by the fact that there is no official register of Irish GPs (O'Dowd *et al.*, 2006). Under the Medical Practitioners Act (1978), it was not possible to distinguish GPs from other types of Medical Practitioner on the General Register. A new Medical Practitioners Act (2007) requires GPs to register as a GP specialist. Therefore, up to recently, it was difficult to determine exactly how many GPs are practicing in Ireland. However, it is estimated that there are approximately 2,500 GPs in Ireland and approximately 1650 general practices in Ireland (Wren, 2003; O'Dowd *et al.*, 2006; Competition Authority, 2010; Layte *et al.*, 2009). The Golden Pages website, the Irish telephone directory for businesses, provided the sample frame of for this study. The final sample frame, with duplicates and ineligible practices removed, comprised of 1417 practices.

A survey pack was distributed to 1417 general practice and 601 completed questionnaires returned, representing a response rate of 42%. As it is estimated that there are approximately 1650 general practices in Ireland (Wren, 2003; Competition Authority, 2010) (Wren, 2003; Competition Authority, 2010), we estimate that a sample size of 601 represents a third of the general practices in Ireland. Our data was specifically collected for this empirical investigation and contains information concerning practice structure, support staff, educational and training activities, clinics, and use of medical equipment and ICT (Bourke and Bradley, 2010; Bourke and Bradley, 2012). Inductive interviews with GPs and previous literature helped identify the ICT applications for inclusion in the questionnaire. It is also important to note that previous survey research examining variation in the use of ICT in Irish general practices tend to be atheoretical and mainly descriptive in nature (O'Dowd *et al.*, 2006; Meade *et al.*, 2009).

The percentage of practices using each ICT application, for both administrative and patient care purposes, is presented in Table 1. It is clear that there is some variation in terms of the ICT applications used by practices, with a high proportion of practices using ICT for purposes such as repeat prescriptions, patient registration and referral letters compared with audit/quality assurance and coding of diseases.

<<Insert Table 1 here>>

These variables allow us to measure intensity of ICT use for both administrative and patient care functions. In line with Hollenstein (2004), we decided to rescale the count data into ordered categories, because the various ICT applications are not equally important in economic terms. Therefore, practices are categorised within a three-level ordinal measure of intensity of ICT use for administrative and patient care purposes: basic; intermediate; and enhanced users. The statistical significance of the threshold parameters in the ordered Probit models reported in Table 4 also validate the appropriateness of the categorisation of the dependent variables. Descriptive statistics for the ordered dependent variables are presented in Table 2.

<<Insert Table 2 here>>

In the disequilibrium model of adoption tradition, epidemic effects are measured by practice location and learning opportunities and interactions. In relation to practice location, we include rural-urban classification and HSE administrative regions in the models. Epidemic effects are also measured by whether the practice is a training practice, holds a clinic delivered by a health care professional, and how often it is visited by suppliers of medical equipment. We also include measures of professional and academic involvement, such as being a committee member of a professional organisation, affiliation with an academic institution, involvement in research projects, completed/completing an Irish College of General Practitioners (ICGP) course or its' equivalent, and attendance at Continuing Medical Education (CME) meetings, i.e. continuing professional development training for GPs in active general practice. See Table 3 for descriptive statistics for all independent variables.

<<Insert Table 3 here>>

There is a lack of consensus in the literature in terms of the impact of epidemic learning effects on intra-firm diffusion (Hollenstein and Woerter, 2004; Battisti and Stoneman, 2005). However, in line with Mansfield's (1963) hypothesis that intra-firm diffusion is influenced by epidemic effects and previous empirical research which purports the influence of epidemic effects on health technology adoption (Coleman *et al.*, 1966), we expect interaction with external agents and educational activities to positively influence intensity of ICT use among general practices.

In the equilibrium model of adoption tradition, rank effects are measured by a number of variables, such as number of GPs, (log of) number of patients, proportion of public patients to total patients, nursing and administrative support, age profile of GPs in practice and male dominated practices. Previous research identifies physician characteristics influencing the timing of adoption of health care innovations with respect to hospital information systems and new drugs (McCullough, 2008; Bourke and Roper, 2012), therefore we expect practice characteristics to influence intensity of ICT use. However, it is also worth noting that previous findings in relation to the influence of rank effects on intensity of ICT use by firms are not conclusive (Hollenstein, 2004; Battisti *et al.*, 2007). Ideally, we would like to examine if intensity of ICT use is motivated by strategic behaviour. Previous studies report evidence of strategic behaviour influencing the timing of adoption of new prescription drugs by Irish

GPs and ICT by American hospitals (McCullough, 2008; Bourke & Roper, 2012). However, given the nature of the survey data, we are unable to capture stock and order effects. We do not ask when practices adopt each of the ICT applications as it is unlikely that respondents can distinguish between adoption dates for such an extensive list of ICT applications. Information on timing of adoption is necessary to capture stock and order effects.

We also include learning-by-using effects in our examination of intensity of ICT use for administrative and patient care purposes. We create two dummy variables: one which captures whether practices are using ICT for at least three administrative functions; and the second which captures whether practices are using ICT for at least three patient care functions. The learning-by-using administration ICT variable will be included in the analysis examining the factors impacting on the probability of the extent of ICT use for patient care purposes. Similarly, the learning-by-using patient care ICT variable will be used in the analysis examining the factors impacting on the probability of the extent of ICT use for administrative purposes. As previously mentioned, our survey also collects information on medical equipment use. Therefore, we are also able to create a variable which captures learning-by-using effects in relation to medical equipment. From six items of medical equipment, we determine which practices use three or more of these items of medical equipment. We include this variable to examine whether learning-by-using from a portfolio of medical equipment impacts on intensity of ICT use, essentially capturing cross-technology effects.

While there is little evidence of learning-by-using effects being incorporated in intra-firm diffusion studies, Battisti and Stoneman (2005) report that use of complementary technologies impacts on firms' extent of use with respect to computer numerical control (CNC) machines. Previously Bourke and Roper (2012) found strongly significant and consistently signed learning-by-using effects on the timing of first prescription by Irish GPs of six new drugs. These findings are in line with previous research in relation to the adoption of new technologies by firms (Stoneman and Kwon, 1994; Colombo and Mosconi, 1995; Arvantis and Hollenstein, 2001). Therefore, we expect learning-by-using effects, in relation to ICT and medical equipment, to positively influence intensity of ICT use in general practices.

Finally, before discussing our empirical results it is important to acknowledge the potential for a survey-based study such as this one to suffer from common method variance or bias (CMB). CMB is the variance due to the general measurement methods rather than due to the measured key explanatory variables themselves (Podsakoff *et al.*, 2003; Sharma *et al.*, 2010) and may lead to biased estimates of the effects of key variables of interest in survey-based studies (Sharma *et al.*, 2010). Formally, we have checked for CMB using the Harmon's one factor test (Podsakoff and Organ, 1986) and the marker variable technique (Malhotra *et al.*, 2006; Lindell and Whitney, 2001). Harmon's one factor test consists of running a factor analysis of all key variables in the model. If the first unrotated factor accounts for a relatively small share of the total variance (not more than 50%), then CMB is not likely to be a significant problem. In our data, Harmon's one factor test suggests this single factor explains only about 40% of the total variation of the main variables in our model. For robustness, we also implemented the marker variable technique (Lindell and Whitney, 2001; Sharma *et al.*, 2010). This approach is based on comparison of pairwise correlations in the case of key variables in the dataset. In this technique, a 'marker variable' is sometimes identified as a variable that is theoretically unrelated to at least one variable in the study; or if such a marker variable cannot be identified a priori, the variable with the lowest correlation with other variables is chosen as the 'marker' (Sharma *et al.*, 2010). In this last case, the smallest positive correlation in the correlation matrix of variables used in the study is considered as a proxy for CMB. We identified the importance of the internet in informing prescribing decisions as a marker variable, as it displays the lowest correlation with the variables in both ordered Probits (0.001). Taking this correlation as a measure of the CMB and subtracting it from the other pairwise correlations does not significantly affect the correlations between the variables used in our regression analysis (Sharma *et al.*, 2010). Also, other marker variables that we tried yield similar results. Based on both the Harmon's one factor test and the marker variable technique, we can conclude that CMB is not an important problem here.

4. Econometric Methodology

Our choice of econometric methodology is influenced by the ordinal nature of our intensity of ICT use dependent variables, which categorise ICT users as basic, intermediate or enhanced users. Therefore, in line with Hollenstein (2004), we use an ordered Probit model to examine the determinants of intensity of ICT use for both administrative and patient care functions in

Irish general practices. The ordered Probit model can be used to model a discrete dependent variable that takes ordered multinomial outcomes for each individual i , for example $y_i = 1, 2, \dots, m$ (Jones *et al.*, 2007).

The ordered Probit model can be expressed as:

$$y_i = j \text{ if } \mu_{j-1} < y_i^* < \mu_j, \quad j = 1, \dots, m.$$

where the latent variable, y^* , is assumed to be a linear function of a vector of explanatory variables x , plus a random error term ε :

$$y_i^* = x_i\beta + \varepsilon_i, \quad \varepsilon_i \sim N(0,1)$$

and $\mu_0 = -\infty, \mu_j \leq \mu_{j+1}, \mu_m = \infty$. Given the assumption that the error term is normally distributed, the probability of observing a particular value of y is:

$$P_{ij} = P(y_i = j) = \Phi(\mu_j - x_i\beta) - \Phi(\mu_{j-1} - x_i\beta)$$

where $\Phi(\cdot)$ is the standard normal distribution function. It is important to note that the coefficient values from the ordered Probit model should not be given a quantitative interpretation (Jones *et al.*, 2007). However, marginal effects can be calculated for each of the categorical outcomes which can be interpreted quantitatively.

Ideally, we would like to use a simultaneous equations model to examine intensity of ICT use as the two dependent variables are likely to be determined simultaneously by the choices made by GPs. However, given the ordinal nature of the dependent variables, we are not aware of an estimation technique that would allow us to estimate these models simultaneously while retaining the current structure of the variables.

5: Results

Ordered Probit models are used to examine the determinants of intensity of ICT use for administrative and patient care purposes in Irish general practices. Initial baseline models were estimated; subsequently, in a 'stepwise' fashion, variables with z-statistics of less than $|0.5|$ were excluded from the models. In a robustness check, comparison of significant coefficients in initial models and preferred models suggests that the exclusion of a number of insignificant variables has no effect on direction of significant coefficient values. The statistical significance of the threshold parameters in the preferred ordered Probit models indicate the appropriateness of the models given the ordered categories of the dependent variables. In interpreting ordered Probit estimates, we are restricted to interpreting the sign and significance of the coefficients (Jones *et al.*, 2007). These results are briefly discussed below.

<<Insert Table 4 here>>

The ordered Probit estimations for intensity of ICT use for administrative and patient care purposes, presented in Table 4, illustrate interesting results in relation to epidemic, rank, and learning-by-using effects. There is evidence of epidemic effects, some common to both types of ICT use, others relevant to only one type of ICT use. Practices in the HSE South region use ICT more extensively for both types of ICT use, with practices in the HSE West region using ICT more intensively for administrative purposes. Visits from IT suppliers and being a training practice positively influence intensity of ICT use for both purposes. An academic affiliation positively impacts ICT use for administrative purposes, whereas being a committee member, actively involved in research projects, completed or completing an ICGP course and attendance at CME meetings all positively impact on intensity of ICT use for patient care purposes.

There is evidence of rank effects, however there is a clear distinction with respect to the rank effects variables influencing intensity of ICT use for administrative purposes and those influencing intensity of ICT use for patient care purposes. The number of GPs in a practice positively impacts on intensity of ICT use for administrative purposes, and the proportion of public patients relative to total patients negatively impacts on intensity of ICT use for administrative purposes. However, in relation to intensity of ICT use for patient care

purposes, nursing support has a positive influence, whereas male dominated practices and practices with older GPs negatively influence intensity of ICT use.

There is more consistent evidence of learning-by-using effects with respect to both types of ICT use. Learning from using ICT for administrative purposes positively impacts on intensity of ICT use for patient care purposes and, likewise, learning from using ICT for patient care purposes positively impacts on intensity of ICT use for administrative purposes. Interestingly, learning from using a portfolio of medical equipment only influences intensity of ICT use for administrative purposes.

From the results discussed above, it is clear that disequilibrium, equilibrium and learning-by-using effects influence general practices' intensity of ICT use for administrative and patient care purposes. As previously mentioned, we are restricted to interpreting the sign and significance of the ordered Probit coefficients. Marginal effects determine the probability of a practice being in the different categories of ICT use. However, prior to calculation of marginal effects, we consider the possibility of an endogenous relationship existing between the learning-by-using dummy variables and the dependent variables in both ordered Probit models. We check for endogeneity as per the Cameron and Trivedi (2009) approach. We identify a strong set of instruments for both the learning-by-using dummy variables ($F_{(3,544)} = 14.4$; $F_{(4,594)} = 28.25$). Inclusion of the fitted values of these instruments in the original regression yields insignificant coefficients, indicating that endogeneity is not an issue and an instrumental variable approach is not required (Cameron and Trivedi, 2009). Therefore, we proceed with the learning-by-using dummy variables in the respective models.

Next, marginal effects for each of the three outcomes - basic user, intermediate user, and enhanced user, for intensity of ICT use for administrative and patient care purposes are presented in Table 5 and discussed in detail below.

<<Insert Table 5 here>>

In support of Mansfield's (1963) hypothesis that intra-firm diffusion is influenced by epidemic effects, we find evidence of epidemic effects with respect to intensity of ICT use. As IT supplier visits increases, so too does intensity of ICT use for both administrative and patient care purposes. The greater the number of visits from suppliers, the less likely a

practice is to be a basic or intermediate user of ICT for both administrative and patient care purposes and the more likely it is to be an enhanced user for both types of ICT use. However, it is worth noting that the size of marginal effects are quite small, indicating low economic significance in relation to interaction with suppliers and intensity of ICT use. Being a training practice positively impacts on intensity of ICT use. If a practice is a training practice, it is 8 and 11% more likely to be an enhanced ICT user for administrative and patient care purposes respectively. In addition, we find further evidence of epidemic effects, albeit in relation to one or other type of ICT use. In relation to ICT use for administrative purposes: practices with an academic affiliation are 7% more likely to be enhanced users. In relation to ICT use for patient care purposes: practices with a committee membership are 6% more likely to be enhanced users; practices actively involved in research projects are 11% more likely to be enhanced users; and practices where a GP is completing or completed an ICGP course are 7% more likely to be enhanced users. As attendance at CME meetings increases, practices are more likely to be enhanced users. However, the size of the marginal effects is negligible.

Our findings also indicate evidence of a locational effect: we find evidence of more intensive ICT use in the HSE South and, to a lesser extent, in the HSE West region. Practices located in the HSE South region are 11 and 9% more likely to be enhanced ICT users for administrative and patient care purposes respectively than practices in the HSE Mid-Leinster region. Likewise, practices located in the HSE West region are 9% more likely to be enhanced users for administrative purposes than practices in the HSE Mid-Leinster region.

Within the equilibrium framework, we find little evidence of size effects in relation to intensity of ICT use. Although the more GPs there are in a practice the more probable the practice is an enhanced ICT user for administrative purposes; the size of the marginal effect is relatively small. Interestingly, the higher the proportion of public patients a practice has, the more likely they are to be basic or intermediate users of ICT for administrative purposes. As is evident from the marginal effects, the size of this effect is relatively large. We also find that GP characteristics influence intensity of ICT use, in that practices where all GPs are older than 40 years of age and practices that are predominately male are 13 and 9% respectively less likely to be enhanced users of ICT for patient care purposes.

With respect to learning-by-using effects and their influence on intensity of ICT use, the size of the marginal effects are quite large, indicating a significant economic effect (Table 5). A

practice which uses ICT for three or more administrative functions is 51% more likely to be an enhanced ICT user for patient care purposes. Likewise, a practice which uses ICT for three or more patient care functions is 53% more likely to be an enhanced ICT user for administrative purposes. A similar pattern is evident in relation to learning by using a portfolio of medical equipment and intensity of ICT use for administrative purposes, although to a lesser extent. Practices which use at least three types of medical equipment are 12% more likely to be enhanced ICT users for administrative purposes.

6: Discussion

Previous studies of health technology adoption also report learning and educational factors influencing use and uptake. For instance, Meade *et al.* (2009) report that Irish GPs involved in vocational training are more likely to use Electronic Patient Records (EPR). Similarly, Baker and Thompson (1995) report UK training practices are more likely to develop than non-training practices in relation to equipment provision. However, previous empirical studies, also drawing on a complementary equilibrium and disequilibrium framework, report conflicting evidence of epidemic effects in relation to ICT adoption by businesses (Battisti *et al.*, 2007; Hollenstein, 2004). It is worth noting that these studies use different variables to measure epidemic effects which may impact on findings (Battisti *et al.*, 2007), and there is evidence that the importance of explanatory variables is technology-specific (Hollenstein, 2004).

Our results in relation to practice location are interesting. As there are higher proportions of smaller rural practices in the HSE South and West, we would expect such practices to be less intensive users of ICT. Interestingly, previous studies of health technology adoption report a higher availability of medical equipment (Nic Gabhainn *et al.*, 2001; Boerma *et al.*, 1998) and a more comprehensive service mix in rural practices (Boerma *et al.*, 1998). Smaller, more rural practices may be acquiring this equipment to recompense for less access to secondary care services (Ni Shuilleabhain *et al.*, 2007). Indeed, there is evidence that practices in the HSE South and West regions are better equipped with respect to their portfolio of medical equipment than practices in the HSE Dublin Mid-Leinster and Dublin North East regions (Bourke and Bradley, 2010). Although this 'locational' effect is in contrast to the theoretical presuppositions of the disequilibrium model of adoption, it may not be particularly surprising

as such practices compensate for the locational disadvantage of their patients to secondary care hospitals.

This 'locational' finding is also interesting in light of the ICT Strategy previously developed in 2001 by the Southern Health Board (which was subsumed into the HSE South region in 2005) to improve service delivery. The European Commission acknowledged the HSE South's ICT Strategy with a "Best Practices in eService Delivery" award – the first time it was awarded to a health care organisation. An evaluation of the HSE South's ICT strategy demonstrates how a system-level approach to eHealth maximises the use of technology (Podsakoff *et al.*, 2003). It is likely that this system-level strategy results in knowledge spillovers and, in turn, influences how GPs use ICT in their practices. The implementation of this strategy centres on information and education; which is in line with our findings that learning-by-using and epidemic learning effects positively influence the extent to which practices use ICT. Therefore, there may be merit in extending this strategy nationwide ensuring that practices have the necessary information and know-how to gain proficiency in ICT use and to solve the complex problems that result from using numerous ICT applications. In a broader sense, IT strategies such as this one may have far-reaching benefits in terms of providing physicians with knowledge and expertise which may increase ICT use and efficiencies in health care organisations.

Our research also demonstrates the beneficial influence of research and academic involvement on intensity of ICT use, particularly in relation to patient care applications. Therefore, academic-practitioner networks, which are primarily developed to engage in research and implement research evidence, may also positively influence adoption of technologies by practitioners. The Western Research and Education Network (WestREN) is a collaborative network consisting of the Discipline of General Practice at the National University of Ireland (NUI) Galway and 71 West of Ireland general practices (Malhotra *et al.*, 2006). Therefore, consideration should be given to the possibility of positive externalities, in the form of adoption decision-making, resulting from such university-affiliated general practice research networks.

Within the equilibrium framework, in line with Battisti *et al.* (2007) and Hollenstein (2004), we find little evidence of size effects in relation to intensity of ICT use. It is possible that

once a practice adopts ICT, small and large practices use it to the same extent (Hollenstein, 2004). Interestingly, the higher the proportion of public patients a practice has, the more likely they are to be basic or intermediate users of ICT for administrative purposes. Previously, McCullough (2008) reported that increasing admissions positively affects IS adoption. Therefore, our findings may indicate that that being an early ICT adopter does not necessarily translate into being an extensive ICT user (Hollenstein, 2004; Battisti *et al.*, 2007). An interesting aspect of the Irish health care system is that public patients must register with a GP, whereas private patients are not required to do so (although, this is likely to change if the Government's health care reforms are implemented and all citizens will be obliged to register with a GP). Our results may indicate that practices with a high proportion of public patients must fulfil certain requirements in terms of registering patients, etc..., but are not obliged to be extensive users of ICT for administrative purposes. It is likely that intensity of adoption determinants and patterns differ from adoption as initial use of a technology by a firm is limited because risks of use are high. However, this risk reduces with ownership and use, and as it does extent of use increases and intra-firm diffusion proceeds (Mansfield, 1963; Hollenstein, 2004).

We also find that the age and gender profile of GPs in the practice influence intensity of ICT use for patient care purposes. The finding in relation to age, that practices with older GPs are less likely to be enhanced users of ICT, is intuitive and in line with previous research in relation to ICT use (Masters, 2008; Meade *et al.*, 2009). However, it is somewhat surprising that male dominated practices are less likely to be extensive users of ICT. Previous research indicated that male GPs were more likely to use ICT than female GPs (Masters, 2008; Meade *et al.*, 2009). This finding, that male (GP) dominated practices are less likely to be extensive users of ICT, may be further evidence that drivers of use are not necessarily drivers of extent of use.

Within the adoption literature, there is limited empirical evidence of the influence of learning-by-using effects on such decision-making. In fact, we are not aware of previous research examining the influence of learning-by-using effects on intensity of ICT use. To our knowledge, Battisti and Stoneman's (2005) study of intra-firm diffusion of CNC machines is the first to examine the influence of learning-by-using effects on intensity of adoption. Therefore, it is possible that our analysis of intensity of ICT use in general practices is the first application of learning-by-using effects in relation to intensity of ICT adoption. We find

experience with ICT applications for one purpose (e.g. administrative) positively influences intensity of ICT use for a different purpose (e.g. patient care). The marginal effects presented in Table 5 demonstrate the magnitude of these effects on intensity of ICT use. Therefore, our empirical results clearly support the extension of learning-by-using effects to analyses of intensity of adoption in a health care setting, as well as the broader small business environment.

7: Conclusion

This study explores the mechanisms influencing intra-practice ICT adoption. Given the importance of ICT to the delivery of consistent and high quality health care, it is important to understand health care providers' motivations in the adoption of ICT. As with many health care systems, primary care is the central focus of the Irish health care system, with GPs central to its provision (Department of Health and Children, 2001). More than two-thirds of the Irish population attend their GP each year (Central Statistics Office, 2001). Given the commercial and autonomous nature of General Practice in Ireland, decision-making regarding ICT use is devolved to individual general practices. Our findings provide us with many insights into how practice profile and informational and experiential stimuli influence intra-practice ICT diffusion in Irish general practices.

Our findings, in line with Bourke and Roper (2012) and McCullough (2008), provide further support for taking an economic approach to examinations of innovative decision-making in health care organisations. Furthermore, our empirical findings support the taking of an intra-practice approach to examinations of ICT use in small health care organisations. As well as highlighting the influence of equilibrium and disequilibrium mechanisms on intensity of adoption decision-making, our findings in relation to the influence of learning-by-using effects are particularly noteworthy. However, in this paper, we extend earlier conceptualisations of learning-by-using effects with a broader definition of experiential learning (Colombo and Mosconi, 1995; Arvantis and Hollenstein, 2001). Therefore, our variable measurements of learning-by-using effects include learning from a general practice's portfolio of medical equipment and learning from ICT use for contrasting purposes. Our findings demonstrate that learning which takes place within a health care organisation from experience with a technology not only influences adoption and intensity of adoption of related technologies, but also has a positive influence on the adoption of seemingly unrelated

technologies. These results indicate that future studies should consider a broad spectrum of experiential stimuli when investigating adoption and intensity of adoption decision-making.

This research highlights that adoption is a complex process, with commercial, informational and experiential effects influencing intra-practice ICT diffusion. Our findings support the extension of an encompassing equilibrium, disequilibrium and learning-by-using effects model of adoption to intensity of ICT use. More importantly, however, this research provides further support for the application of this model to adoption decision-making in a health care setting as per Bourke and Roper (2012) and McCullough (2008). Our findings demonstrate the potential value of economic approaches to examining adoption decision-making in health care, particularly in markets with features similar to those which characterise the Irish general practice environment. While acknowledging that this work is not definitive, it provides a context for future studies examining the motivations of intensity of ICT use by health care organisations.

References

- Arvantis, S. & Hollenstein, H. (2001). The Determinants of the Adoption of Advanced Manufacturing Technology. *Economics of Innovation and New Technology*, 10, 377-414.
- Baker, R. & Thompson, J. (1995). Innovation in general practice: is the gap between training and non-training practices getting wider? *British Journal of General Practice*, 45, 297-300.
- Baptista, R. (1999). The Diffusion of Process Innovations: A Selective Review. *International Journal of the Economics of Business*, 6, 107-129.
- Battisti, G. (2000). *The intra-firm diffusion of new technologies*. PhD thesis, Warwick University.
- Battisti, G., Hollenstein, H., Stoneman, P. & Woerter, M. (2007). Inter and Intra Firm Diffusion of ICT in the United Kingdom (UK) and Switzerland (CH): An Internationally Comparative Study base on Firm-Level Data. *Economics of Innovation and New Technology*, 16, 669-687
- Battisti, G. & Stoneman, P. (1997). Intra Firm Diffusion of New Technologies: the Neglected Part of Technology Transfer. *International Journal of Industrial Engineering*, 4, 270-282.
- Battisti, G. & Stoneman, P. (2003). Inter- and intra-firm effects in the diffusion of new process technology. *Research Policy*, 32, 1641-1655.
- Battisti, G. & Stoneman, P. (2005). The intra-firm diffusion of new process technologies. *International Journal of Industrial Organization*, 23, 1-22.
- Boerma, W. G. W., Groenewegen, P. P. & Van Der Zee, J. (1998). General Practice in Urban and Rural Europe: The Range of Curative Services. *Social Science and Medicine*, 47, 445-453.
- Bonneville, L. & Pare, D. J. (2006). Socioeconomic Stakes in the Development of Telemedicine *Journal of Telemedicine and Telecare*, 12, 217-219.
- Bourke, J. & Bradley, C. P. (2010). General Practice in Ireland in 2010: A Survey of Staff and Equipment Investment *Department of Economics, University College Cork, Working Paper Series*,, 10-07.
- Bourke, J. & Bradley, C. P. (2012). Factors associated with staffing provision and medical equipment acquisition in Irish general practice. *Irish Medical Journal*, forthcoming.
- Bourke, J. & Roper, S. (2012). In with the new: the determinants of prescribing innovation by Irish general practitioners. *European Journal of Health Economics*, 13, 393-407.
- Cameron, A. C. & Trivedi, P. K. (2009). *Microeconometrics: Using Stata*, Cambridge University Press.
- Central Statistics Office (2001). Quarterly National Household Survey: Module on Health. Cork: Central Statistics Office.
- Coleman, J., Katz, E. & Menzel, H. (1966). *Medical Innovation: A Diffusion Study*, New York, Bobbs Merrill.
- Colombo, M. G. & Mosconi, R. (1995). Complementarity and Cumulative Learning Effects in the Early Diffusion of Multiple Technologies. *The Journal of Industrial Economics*, 43, 13-48.
- Competition Authority (2010). Competition in Professional Services. General Medical Practitioners. Dublin: Competition Authority.
- Department of Health and Children (2001). Primary Care: A New Direction. Dublin: Government of Ireland.

- Department of Health and Children (2004). Health Information: A National Strategy. Dublin: Government of Ireland.
- Djellal, F. & Gallouj, F. (2007). Innovation in hospitals: a survey of the literature. *European Journal of Health Economics*, 8, 181-193.
- Dobrev, A., Haesner, M., Husing, T., Korte, W. B. & Meywer, I. (2008). Benchmarking ICT use among General Practitioners in Europe. Bonn: European Commission - Information Society and Media Directorate General.
- Government of Ireland (1978). Medical Practitioners Act. Ireland: Office of the Attorney General.
- 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*, 15, 315-342.
- Hollenstein, H. & Woerter, M. (2004). The Decision to Adopt Internet-based E-Commerce. An Empirical Analysis based on Swiss Firm-Level Data. *KOF Working Paper Zurich*.
- Jones, A. M., Rice, N., Bago D'uva, T. & Balia, S. (2007). *Applied Health Economics*, New York, Routledge.
- Kann, I. C., Biorn, E. & Luras, H. (2010). Competition in General Practice: Prescriptions to the elderly in a list patient system. *Journal of Health Economics*, 29, 751-764.
- Karshenas, M. & Stoneman, P. L. (1993). Rank, Stock, Order, and Epidemic Effects in the Diffusion of New Process Technologies: An Empirical Model. *The RAND Journal of Economics*, 24, 503-528.
- Kvist, M. & Kidd, M. (1998). The role of new information and communication technologies in primary care. In: SALTMAN, R. B., RICO, A. & BOERMA, W. G. W. (eds.) *Primary care in the driver's seat? Organisational reform in European primary care*. Berkshires: Open University Press.
- Layte, R., Barry, M., Bennett, K., Brick, A., Morgenroth, E., Normand, C., O'reilly, J., Thomas, S., Tilson, L., Wiley, M. & Wren, M.-A. (2009). *Projecting the Impact of Demographic Change on the Demand for and Delivery of Health Care in Ireland*, Dublin, ESRI.
- Lievens, F. & Jordanova, M. (2004). Is there a Contradiction between Telemedicine and Business? *Journal of Telemedicine and Telecare*, 10, 71-74.
- Lindell, M. K. & Whitney, D. J. (2001). Accounting for Common Method Variance in Cross-sectional Research Designs. *Journal of Applied Psychology*, 86, 114-121.
- Macgregor, R. C., Hyland, P. N. & Harvie, C. (2009). Do organisational characteristics explain the differences between drivers of ICT adoption in rural and urban general practices in Australia. *Australasian Journal of Information Systems*, 16, 77-97.
- Malhotra, N. K., Kim, S. S. & Patil, A. (2006). Common method variance in IS research: A comparison of alternative approaches and a reanalysis of past research. *Management Science*, 52, 1865-1883.
- Mansfield, E. (1963). Intrafirm rates of diffusion of an innovation. *The Review of Economics and Statistics XLV*, 348-359.
- Masters, K. (2008). For what purpose and reasons do doctors use the Internet: A systematic review. *International Journal of Medical Informatics*, 77, 4-16.
- Mccullough, J. S. (2008). The adoption of hospital information systems. *Health Economics*, 17, 649-664.
- Mcwilliams, B. & Zilbermanfr, D. (1996). Time of Technology Adoption and Learning By Using. *Economics of Innovation and New Technology*, 4, 139-154.
- Meade, B., Buckley, D. & Boland, M. (2009). What factors affect the use of electronic patient records by Irish GPs? *International Journal of Medical Informatics*, 78, 551-558.

- Misan, G. (2003). Why Computerise General Practice? *10th RACGP Computer Conference*. Sydney, Australia.
- Ni Shuilleabhain, A., O'Kelly, M., O'Kelly, F. & O'dowd, T. (2007). Limited options: a report on GP access to services. *Irish Journal of Medical Science*, 176, 27-32.
- Nic Gabhainn, S., Murphy, A. W. & Kelleher, C. (2001). A national general practice census: characteristics of rural general practices. *Family Practice*, 18, 622-626.
- O'dowd, T., O'Kelly, M. & O'Kelly, F. (2006). Structure of General Practice in Ireland, 1982-2005. Dublin: Irish College of General Practitioners & Trinity College Dublin.
- Podsakoff, P. M., Mackenzie, S. B., Lee, J. Y. & Podsakoff, N. P. (2003). Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. *Journal of Applied Psychology*, 88, 879-903.
- Podsakoff, P. M. & Organ, D. W. (1986). Self-reports in organizational research: Problems and prospects. *Journal of Management*, 12, 531-544.
- Rahimi, B. & Vimarlund, V. (2007). Methods to evaluate health information systems in health care settings: a literature review. *Journal of Medical Systems*, 31, 411-422.
- Rogers, E. M. (2003). *Diffusion of Innovations*, New York, Free Press.
- Scott, A. (2000). Economics of General Practice. In: ANTHONY, J. C. J. (ed.) *Handbook of Health Economic*. Elsevier.
- Sharma, R., Yetton, P. & Crawford, J. (2010). A critique of the marker variable technique: the effect of alternative marker variable criteria. *18th European Conference on Information Systems*.
- Stoneman, P. & Kwon, M.-J. (1994). The Diffusion of Multiple Process Technologies. *The Economic Journal*, 104, 420-431.
- Stoneman, P. & Toivanen, O. (1997). The Diffusion of Multiple Technologies: An Empirical Study. *Economics of Innovation and New Technology*, 5, 1-17.
- Tamblyn, R., Mcleod, P., Hanley, J. A., Girard, N. & Hurley, J. (2003). Physician and Practice Characteristics Associated with the Early Utilisation of New Prescription Drugs. *Medical Care*, 41, 895-908.
- Walley, T., Murphy, M., Codd, M., Johnston, Z. & Quirke, T. (2001). Effects of a monetary incentive on primary care prescribing in Ireland. *European Journal of General Practice*, 7, 92-98.
- Wren, M.-A. (2003). *Unhealthy State: Anatomy of a Sick Society*, Dublin, New Island.

Table 1: General Practice's ICT Use for patient care and administrative purposes

	Percentage of Users
<hr/> <i>Patient Care Applications</i> <hr/>	
Repeat Prescriptions	88.9%
Consultation Records	84.4%
Download Lab Reports	80.2%
Internet Research	75.7%
Scan Correspondence	74.4%
Recall of Items	73.4%
Audit/Quality Assurance	41.8%
Coding of Diseases	40.1%
<hr/> <i>Administrative Applications</i> <hr/>	
Patient Registration	90.4%
Referral Letters	88.5%
Word Processing	87.7%
Email	79.5%
Appointment	77.5%
Accounts	63.9%
Billing	59.4%
Calendar	39.8%
Practice Website	28.1%

Note 1: n = 601 general practices

Table 2: Intensity of ICT Use for Administrative and Patient Care Purposes

	Number of ICT Applications	Percentage of Users
<i>Intensity of ICT Use for Administrative Purposes</i>		
Basic Users	0-4	21.0%
Intermediate Users	5-7	45.4%
Enhanced Users	8-9	33.6%
		100.0%
<i>Intensity of ICT Use for Patient Care Purposes</i>		
Basic Users	0-4	24.3%
Intermediate Users	5-6	32.7%
Enhanced Users	7-8	43.0%
		100.0%

Table 3: Descriptive Statistics of Explanatory Variables

Variable Name	Variable Description	Mean	S.D.
<i>Rank Effects</i>			
Number of GPs	Number of GPs	2.70	1.7
Log of Patients	Log of total number of patients	8.07	0.7
Public / Total Patients	Proportion of Public patients to total patients	0.38	0.2
Nursing Support (d)	Nursing Support	0.81	0.4
Administrative Support (d)	Administrative Support	0.91	0.3
Age ≥ 40 (d)	All GPs are 40 years or older	0.25	0.4
Male Dominated (d)	All GPs are male	0.51	0.5
<i>Learning-by-using Effects</i>			
LBU Patient Care ICT (d)	3 or more patient care ICT applications	0.88	0.3
LBU Administrative ICT (d)	3 or more administrative ICT applications	0.91	0.3
LBU Medical Equipment (d)	3 or more items of medical equipment	0.90	0.3
<i>Epidemic Effects</i>			
Rural	Rural Location	0.19	0.4
Town	Town Location	0.50	0.5
City	City Location	0.32	0.5
HSE Dublin Mid-Leinster	HSE Dublin Mid-Leinster ¹	0.24	0.4
HSE Dublin North East	HSE Dublin North East	0.15	0.4
HSE South	HSE South	0.35	0.5
HSE West	HSE West	0.26	0.4
Training Practice (d)	Postgraduate GP training practice	0.29	0.5
Clinic (d)	Practice holds a clinic(s)	0.49	0.5
Supplier Visits = 0	Frequency of IT supplier visits each year ²	0.41	0.5
Supplier Visits = 1.5	Frequency of IT supplier visits each year ²	0.37	0.5
Supplier Visits = 4	Frequency of IT supplier visits each year ²	0.16	0.4
Supplier Visits = 7	Frequency of IT supplier visits each year ²	0.04	0.2
Supplier Visits = 10	Frequency of IT supplier visits each year ²	0.03	0.2
Committee Member (d)	Committee member of medical organisation.	0.41	0.5
Academic Department (d)	Affiliated with an academic department	0.38	0.5
Research Project (d)	Actively involved in research projects	0.24	0.4
ICGP Course (d)	Completing/completed ICGP course or equivalent ³	0.31	0.5
CME Meetings = 0	Average annual CME meeting attendance ⁴	0.09	0.3
CME Meetings = 1.5	Average annual CME meeting attendance	0.07	0.3
CME Meetings = 4	Average annual CME meeting attendance	0.31	0.5
CME Meetings =7	Average annual CME meeting attendance	0.54	0.5

Note 1: The Health Service Executive (HSE) is responsible for delivering health care for the population of Ireland, and has four administrative divisions: HSE Dublin Mi-Leinster, HSE Dublin North East, HSE South and HSE West. **Note 2:** The Supplier Visits variable consists of 5 numeric mid-point categories: 0, 1.5, 4, 7 and 10. **Note 3:** The Irish College of General Practitioners (ICGP) is the professional body for general practice in Ireland. It is the recognised body for the accreditation of specialist training in general practice in Ireland and is recognised by the Medical Council as the representative academic body for the speciality of general practice. **Note 4:** The CME Meetings variable consists of 4 midpoint numeric categories: 0, 1.5, 4, and 7.

Table 4a: Intensity of ICT Use for Administrative Functions – Ordered Probits

	Saturated Model	Model (ii)	Model (iii)	Preferred Model
	b/se	b/se	b/se	b/se
<i>Rank Effects</i>				
Nursing Support	0.17 (0.17)	0.17 (0.17)	0.18 (0.17)	0.18 (0.17)
Number of GPs	0.12** (0.05)	0.12** (0.05)	0.13*** (0.04)	0.13*** (0.04)
Proportion of Public Patients	-1.04*** (0.32)	-1.04*** (0.32)	-1.08*** (0.29)	-1.08*** (0.29)
Log of Number of Patients	0.04 (0.13)	0.04 (0.12)		
Administration Support	0.32 (0.24)	0.32 (0.24)	0.34 (0.24)	0.34 (0.24)
All GPs >40 years	-0.18 (0.14)	-0.18 (0.13)	-0.18 (0.13)	-0.18 (0.13)
Male (GP) Dominated	-0.06 (0.11)	-0.06 (0.11)	-0.06 (0.11)	-0.06 (0.11)
<i>Learning-by-using Effects</i>				
LBU Patient Care ICT	1.84*** (0.25)	1.84*** (0.25)	1.84*** (0.25)	1.84*** (0.25)
LBU Medical Equipment	0.38* (0.22)	0.38* (0.22)	0.39* (0.22)	0.40* (0.22)
<i>Epidemic Effects</i>				
HSE Dublin Northeast	0.18 (0.19)	0.18 (0.19)	0.18 (0.19)	0.19 (0.18)
HSE South	0.38** (0.15)	0.38** (0.15)	0.37** (0.15)	0.37** (0.15)
HSE West	0.31* (0.17)	0.31* (0.17)	0.31* (0.17)	0.30* (0.16)
Town Practice	-0.22 (0.13)	-0.22 (0.13)	-0.21 (0.13)	-0.21 (0.13)
Rural Practice	-0.28 (0.18)	-0.28 (0.18)	-0.28 (0.18)	-0.26 (0.17)

Table 4a (continued): Intensity of ICT Use for Administrative Functions – Ordered Probits

Training Practice	0.29**	0.29**	0.29**	0.29**
	(0.14)	(0.14)	(0.14)	(0.14)
Visits from It Suppliers	0.07***	0.07***	0.08***	0.08***
	(0.03)	(0.03)	(0.02)	(0.03)
Practice Holds a Clinic	0.06	0.06	0.05	
	(0.11)	(0.11)	(0.11)	
Committee Member	0.01			
	(0.11)			
Academic Department	0.26**	0.26**	0.25**	0.25**
	(0.13)	(0.12)	(0.12)	(0.12)
Research Projects	0.22	0.22	0.22	0.22
	(0.14)	(0.14)	(0.13)	(0.14)
ICGP Course	0.15	0.16	0.15	0.16
	(0.12)	(0.12)	(0.12)	(0.12)
CME Meetings	-0.02	-0.02	-0.02	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Summary Statistics				
Threshold Parameter 1	1.86*	1.85*	1.60***	1.59***
	(0.96)	(0.96)	(0.41)	(0.40)
Threshold Parameter 2	3.62***	3.61***	3.36***	3.36***
	(0.97)	(0.96)	(0.42)	(0.42)
N	523	523	523	523
Chi-Square	270.23	270.22	270.13	269.91
P - value	0	0	0	0
Bayesian Information Criterion	973.11	966.86	960.64	954.65

Table 4b: Intensity of ICT Use for Patient Care Functions - Ordered Probits

	Saturated Model b/se	Model (ii) b/se	Model (iii) b/se	Preferred Model b/se
<i>Rank Effects</i>				
Nursing Support	0.39** (0.17)	0.39** (0.17)	0.38** (0.16)	0.39** (0.16)
Number of GPs	0.60 (0.06)	0.06 (0.06)	0.06 (0.05)	0.05 (0.05)
Prop. of Public Patients	-0.12 (0.32)	-0.11 (0.32)		
(Log) Number of Patients	0.08 (0.13)	0.09 (0.13)	0.10 (0.12)	0.11 (0.11)
Administration Support	0.18 (0.25)	0.18 (0.25)	0.17 (0.24)	0.18 (0.24)
All GPs >40 years	-0.42*** (0.13)	-0.42*** (0.13)	-0.42*** (0.13)	-0.42*** (0.13)
Male (GP) Dominated	-0.28** (0.11)	-0.28** (0.11)	-0.29** (0.11)	-0.29** (0.11)
<i>Learning-by-using Effects</i>				
LBU Administration ICT	1.71*** (0.28)	1.71*** (0.28)	1.72*** (0.28)	1.73*** (0.28)
LBU Medical Equipment	0.11 (0.22)	0.11 (0.22)	0.11 (0.22)	
<i>Epidemic Effects</i>				
HSE Dublin Northeast	0.05 (0.19)			
HSE South	0.31** (0.15)	0.29** (0.13)	0.29** (0.13)	0.29** (0.13)
HSE West	0.2 (0.17)	0.18 (0.15)	0.17 (0.15)	0.18 (0.15)
Town Practice	-0.13 (0.13)	-0.13 (0.13)	-0.14 (0.13)	-0.13 (0.13)
Rural Practice	-0.27 (0.18)	-0.27 (0.18)	-0.27 (0.18)	-0.26 (0.18)

Table 4b (continued): Intensity of ICT Use for Patient Care Functions – Ordered Probits

Training Practice	0.37**	0.37**	0.36**	0.36**
	(0.15)	(0.15)	(0.15)	(0.15)
Visits from It Suppliers	0.05**	0.05**	0.05**	0.05**
	(0.03)	(0.03)	(0.03)	(0.03)
Practice Holds a Clinic	0.09	0.09	0.09	0.10
	(0.12)	(0.12)	(0.12)	(0.12)
Committee Member	0.20*	0.20*	0.20*	0.21*
	(0.12)	(0.12)	(0.17)	(0.12)
Academic Department	0.12	0.12	0.12	0.13
	(0.13)	(0.13)	(0.13)	(0.13)
Research Projects	0.35**	0.35**	0.35**	0.36**
	(0.14)	(0.14)	(0.14)	(0.14)
ICGP Course	0.23*	0.24*	0.24*	0.24*
	(0.13)	(0.12)	(0.12)	(0.12)
CME Meetings	0.04*	0.04*	0.04*	0.04*
	(0.02)	(0.02)	(0.03)	(0.02)
Summary Statistics				
Threshold Parameter 1	2.40**	2.39**	2.54***	2.54***
	(0.99)	(0.99)	(0.89)	(0.89)
Threshold Parameter 2	3.69***	3.68***	3.83***	3.81***
	(0.99)	(0.99)	(0.89)	(0.89)
N	523	523	523	523
Chi-Square	253.22	253.16	253.05	252.81
P - value	0	0	0	0
Bayesian Information Criterion	1006.45	1000.25	994.1	988.077

Table 5a: Intensity of ICT use for Administrative Purposes – Marginal Effects

	Basic User	Intermediate User	Enhanced User
	dy/dx	dy/dx	dy/dx
<i>Rank Effects</i>			
Nursing Support	-0.03	-0.02	0.05
Number of GPs	-0.02***	-0.02***	0.04***
Prop. of Public Patients	0.18***	0.13***	-0.31***
Administration Support	-0.06	-0.04	0.10
All GPs >40 yrs	0.03	0.02	-0.05
Male Dominated	0.01	0.01	-0.02
<i>Learning-by-using Effects</i>			
LBU Patient Care ICT	-0.31***	-0.22***	0.53***
LBU Medical Equipment	-0.07*	-0.05*	0.12*
<i>Epidemic Effects</i>			
HSE Dublin Northeast	-0.03	-0.02	0.05
HSE South	-0.06**	-0.04**	0.11**
HSE West	-0.05*	-0.04*	0.09*
Town Practice	0.04	0.02	-0.06
Rural Practice	0.04	0.03	-0.08
Training Practice	-0.05**	-0.04**	0.08**
Visits from It Suppliers	-0.01***	-0.01***	0.02***
Academic Department	-0.04**	-0.03**	0.07**
Research Projects	0.04	-0.03	0.06
ICGP Course	-0.03	-0.02	0.05
CME Meetings	0.00	0.00	-0.01

Notes: *** denotes significance at the 1% level; ** at the 5% level and * at the 10% level.

Table 5b: Intensity of ICT use for Patient Care Purposes – Marginal Effects

	Basic User	Intermediate User	Enhanced User
	dy/dx	dy/dx	dy/dx
<i>Rank Effects</i>			
Nursing Support	-0.08***	-0.04***	0.12***
Number of GPs	-0.01	-0.01	0.02
(Log) Number of Patients	-0.02	-0.01	0.03
Administration Support	-0.04	-0.02	0.05
All GPs >40 yrs	0.08***	0.04***	-0.13***
Male Dominated	0.06**	0.03**	-0.09**
<i>Learning-by-using Effects</i>			
LBU Administration ICT	-0.34***	-0.17***	0.51***
<i>Epidemic Effects</i>			
HSE Dublin Northeast	-0.06	-0.03	0.09
HSE South	-0.04**	-0.02**	0.05**
HSE West	0.03	0.01	-0.04
Rural Practice	0.05	0.03	-0.08
Training Practice	-0.07**	-0.04**	0.11**
Visits from It Suppliers	-0.01**	-0.05**	0.15**
Practice holds Clinics	-0.02	-0.01	0.03
Committee Member	-0.04*	-0.02*	0.06*
Academic Department	-0.03	-0.01	0.04
Research Projects	-0.07**	-0.04**	0.11**
ICGP Course	-0.05*	0.02*	0.07*
CME Meetings	-0.01*	0.00*	0.02*

Notes: *** denotes significance at the 1% level; ** at the 5% level and * at the 10% level.