Objectives, obstacles and drivers of ICT adoption. What do IT managers perceive?

We study the determinants of innovation adoption decision. We consider a sample of IT managers of SMEs operating in Italy and investigate what influences their evaluation of objectives, obstacles and drivers of adoption. Our results show that adoption decisions are highly path-dependent, as perceptions significantly depend on previous adopted technologies and equipment. Firm specific characteristics such as firm size and the cost structure also matter, tough to a lesser extent.
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1. Introduction

A large number of theoretical and empirical contributions are concerned with the issue of technology adoption. Theoretical models offer predictions on the determinants of early or late adoption. Empirical studies test these predictions. These studies identify different objectives obstacles and drivers of adoption on the basis of different conceptualisations of the diffusion process. Equilibrium models (David, 1969; Davies, 1979) for instance, assume that potential adopters are well informed about the existence of the innovation and evaluate the opportunity of adopting by comparing gross benefits (drivers) and costs (obstacles) from the acquisition. Disequilibrium models (Griliches, 1967; Mansfield, 1968) focus instead on the role (and lack thereof) of information as the major driver of adoption and explain differences between pioneers and laggards on the basis of the awareness of the innovation and of their capability to evaluate its benefits. A number of variants of both types of models exist in the literature.[1] Contributions vary according to the attention placed on specific objectives, obstacles and drivers. In this paper, we look at the role of different objectives, obstacles and drivers as perceived by IT managers in the process of technology adoption.

The data used in this paper come from a survey of 128 small and medium size enterprises operating in Italy that have a Local Area Network (LAN) in place. The survey was carried out in December 2003 and was targeted at IT managers in charge of taking decision concerning the development and updating of firms' network. The cross section provides information on the characteristics of firms (i.e. size, type of activity, location), typology of network, type of equipment (i.e. hubs and/or switches) and standards (i.e. Ethernet, Fast Ethernet, Token ring) in place, as well as on how decisions, eventually leading to adoption, were carried out. Relying on this information, we study the evaluation by respondents of a set of objectives, obstacles and drivers affecting adoption decisions. The final aim is to understand what influenced the perception of these factors by respondents.

The structure of the paper is as follows. Next section reviews the existing contributions on the determinants of technology adoption, in order to highlight how objectives, obstacles and drivers are considered in the literature. Section 3 provides some evidence on the adoption LANs among SMEs in Italy, describing the sample and the structure of our survey. Section 4 illustrates the main findings on objectives, obstacles and drivers in relation to the adoption of LAN technologies, and presents the results of a factor analysis carried out to identify the most important determinants of

[1] For a recent review of these models see Stoneman (2002).

adoption. Section 5 describes the empirical model and the results of the estimates. Section 6 concludes.

2. The determinants of adoption: a literature review

When studying individual choices, the literature on technology adoption generally focuses on three sets of determinants: adopters' characteristics, features of the competitive environment, and attributes of the technology. Among adopters' characteristics, firm size, R&D expenditures, age, and capabilities are usually considered among the main determinants. The competitive environment can be described by the degree of firm concentration, the level of prices, and the existence of informational spillovers among potential users. Attributes of the innovation are usually related to technical features (i.e. compatibility with existing solutions) and may vary depending on the perception of potential adopters. For the scope of this paper, we consider theoretical approaches on technology adoption at the micro level (individual decisions) and examine their perspectives on the determinants of adoption.

There are two contributions that appear to be particularly influential for our analysis. The first one is the so called 'innovation-decision process framework' (Rogers, 1995), which deals with the factors affecting the diffusion of innovations. The second is the so called 'technology acceptance model' (Davis, 1989), which specifically regards the adoption of ICTs. The 'innovation-decision process framework' draws upon different economic, psychological and sociological traditions in an attempt to explain the stylised fact that the distribution of adopters typically follows an S-shaped curve.[2] The 'technology acceptance' model instead stems from the theory of reasoned action and aims at predicting the attitude of potential users towards a new technology by focusing on individual perceptions (Davis, 1989). Both approaches identify different attributes of innovations that drive or hinder the adoption and stress the importance of adopters' characteristics in evaluating costs and benefits.

The diffusion of an innovation is determined by the relative speed at which it is adopted by the members of a social system and is measured by the number of adopters in a given time period. If we consider in particular intra-firm adoption, the decision to adopt is motivated by a series of

[2] The conceptualisation of the process of diffusion underlying the construction of these curves is based on information spreading and learning. It predicts that the rate of adoption slows down after half of the individuals have adopted the innovation. Learning entails decreasing average costs (i.e. dynamic economies of scale) and is a function of the cumulated output. Diffusion is a process which is usually thought to be driven by 'word of mouth' or 'broadcasting' (i.e. the probability of adoption increases as information about the value of adoption spreads) or by some change in what is being adopted (i.e. greater flexibility or lower costs of the innovation). This last factor provides further feedbacks in terms of learning, since cumulative production drives lower costs, which in turn drive accelerated adoption. This process generates S-Shaped adoption curves (Karshenas and Stoneman, 1995).

factors such as the need of increasing operational efficiency, the willing to improve market reach and profitability, and the need to manage risks (Daniel and Grimshaw, 2002). The process of adoption depends upon several specific characteristics of an innovation as perceived by the potential adopters. First and foremost, innovations must possess a *relative advantage* over the existing ideas. According to Rogers (1995), when a new technology, product or service emerges, individuals evaluate both its economic profitability and other variables - degree of risk, decrease in discomfort, savings in time and effort, immediacy of rewards. The concept of relative advantage is very similar to the idea of *perceived usefulness* of the technology, as put forward by the 'technology acceptance' framework. In particular, perceived usefulness identifies the subjective probability that using a specific technology would increase one individual's job performance (Davis, 1989). It has to be noted, however, that the perception of potential users towards the relative advantage of a new technology varies considerably according to firm-specific characteristics. In particular, many authors (see among others Powell, 1995; Oh *et al.*, 2003; Mole *et al.*, 2004; Tung and Rieck, 2005) emphasise the importance of facilitating conditions, which reflect the availability of resources needed to engage in the process of adoption.

Second, even if potential adopters expect an innovation to be useful, they may find it too difficult to use, so that the performance benefits are overcome by the costs of learning. Thus, the extent to which an innovation is perceived as relatively difficult to understand and use - its *complexity* or *perceived difficulty of use* - is also an important variable. Users differ in their knowledge and skills with respect to a specific technology and may perceive different levels of complexity in its use. If some individuals cannot use the technology because it requires a different knowledge base from the one they possess, they are likely to experience a process of 'social exclusion' (Rogers, 1983). Complexity acts as an obstacle to the process of technology adoption and implementing a complex new technology requires learning both at the individual and at the organisational level. Therefore, learning the technical knowledge required to use a complex innovation successfully places a great demand on potential users. In the end, the simplicity of a technology can be related to the capacity of different users to understand and use the technique without a great effort (Davis, 1989; Attewell, 1992; Mole *et al.*, 2004)

Potential users pay great attention also to the *compatibility* of an innovation, which should be understood both in term of technical features and in terms of the existing socio-cultural values, past experiences and needs of potential adopters. Compatibility is especially important in the case of ICT, whose adoption is affected by the existence of network effects (Church and Gandal, 2004). A network effect exists "if the value [of adopting a system component] increases in the number of

other adopters that (ultimately) join the network by purchasing compatible products" (Church and Gandal, 2004: p. 4). In the presence of network effects, the utility from adoption increases in the number of other adopters that purchase the innovation. Two types of networks are generally identified in the literature: direct and indirect networks.[3]

In the case of direct network effect, network size approximates the adopter's desire for horizontal compatibility. When the network effect is indirect, network size can be a proxy for the availability of complementary components of the technical system. In this case network effects are *physical* in the sense that they require compatibility between the hardware and the software components of the system to operate. In presence of technical change, as long as backward compatibility is maintained, the network effect ensures that utility from the consumption increases. Besides being a proxy for desire of horizontal and/or vertical compatibility, network size is also an indicator of the *past behaviour* of existing users and manufacturers. At a specific point in time, network size conveys to potential adopters information about the characteristics of the technology and the payoff from its adoption, which help firms to make inference on the opportunity to adopt it. In this case network effects are *virtual* and can be understood as a particular mechanism for conveying learning spillovers. In the presence of uncertainty on the payoff from adoption, the combination of virtual and physical effects may have ambiguous effects on the decision to adopt a new technology (Choi, 1997). On the one hand, informational spillovers from previous adopters encourage further adoption by those who prefer to imitate to avoid the risk of choosing a relatively worse alternative. On the other hand spillovers may be a source of inertia. If early adopters are aware of being a source of spillovers, they may delay adoption to avoid the risk of being stranded if, by choosing another alternative, followers end up enjoying higher benefits.

The *trialability* of innovations affects adoption since functioning, real world examples are often more important than arguments about advantages and expected functions (Rip, 1995). The opportunity of experimenting with a new technology before deciding whether or not to adopt is an important benefit especially for early adopters, since they can only rely upon available information, while laggards can learn from other users' experience. Finally, an innovation is evaluated according to its *observability*, which identifies the extent to which its performance and related benefits are perceivable to the users and not only to the companies that produce it. Oh *et al.*

[3] Direct networks arise when adopters become part of a network by purchasing a product that provides a (direct) connection between the adopter and other users who bought the same product. In the case of indirect networks, adopters gain utility from the joint consumption of two components that interact to form a system. In this case, vertical (i.e. backward) compatibility (between the system components) matters. The *source* of benefits from the network effect is the same in both types of network and positively depends on the size of the network when adoption occurs. The *mechanisms* of transmission of the benefits instead vary according to the type of network.

(2003) stress that observability includes both visibility and result demonstrability, which are defined as the degree to which the innovation is visible and the degree to which the results of adopting the innovation are observable and can be communicated to others.

It has to be noted that the features of innovations just described and proposed by the different approaches to technology adoption, are not independent from each other. In particular, relative advantage/perceived usefulness and complexity/ease of use of the new technology are strongly affected by compatibility, trialability and observability. Therefore, when carrying out an analysis of the perception of objectives, obstacles and drivers of adoption one has to control for endogeneity. Moreover, these approaches focus on individual adoption decisions by considering only the private incentives of individual agents that must evaluate whether or not to adopt. However, the influence of the external environment is crucial throughout the adoption decision process. On the one hand, several other theoretical and empirical contributions have stressed how indeed competitive pressure on the adoption decisions arises when organisations presume that competitors may gain comparative advantages as a result of adoption (Daniel and Grimshaw, 2002; Tung and Rieck, 2005). On the other hand, in the presence of uncertainty, the value of waiting for others to adopt first increases, because having more information on the new technology makes it easier to evaluate its benefits (Kapur, 1995; Dong and Saha, 1998). Finally, when considering individual attitudes towards new technologies individual beliefs and subjective perceptions become paramount. In particular, potential adopters evaluate the relative advantage and perceived usefulness of an innovation according to their expectations towards the benefits of a new technology. Expectations are a crucial determinant of adoption process especially in contexts characterised by a high degree of uncertainty, rapid improvements and frequent price changes. Expected improvements in the innovation and/or the likelihood that it will experience improvements in the near future contribute to slow down adoption (Rosenberg, 1976; Balcer and Lippman, 1984). Furthermore, waiting for the price to decline can be another important source of delay (Weiss, 1996).

3. The diffusion of LAN technologies among SMEs in Italy

The review carried out in the previous section has highlighted the main variables affecting the adoption decision process. These variables have to be considered when investigating the perception of objectives, obstacles and drivers of adoption. Moreover, it has been argued that when conducting empirical analysis, endogeneity and the influence of external environment should also be taken into account. In this section we proceed further toward the empirical investigation, by describing our sample.

The analysis in this paper focuses on a sample of SMEs operating in Italy. In particular, it relies on a survey of 128 SMEs that have a LAN in place.[4] These firms operate in the computing service industry (NACE 72). The sample was chosen from the AIDA Dataset that contains balance sheet information on firms operating in Italy. We selected firms in the computing service industry, upon conviction that this type of high-tech firms should be more likely to have a LAN in placed and more wiling to consider the adoption of new technologies. In December 2003, telephone interviews were carried out with the purpose of understanding what were the standards and the type of equipment in place, as well as of identifying the factors affecting the process of decision to adopt new ones.

For the survey we followed the 'key informant' methodology described in Weiss (1996) aimed at interviewing those people who have a key role in all decision making related to LAN equipment. In particular, interviews were specifically targeted to the personnel in charge of the firm IT budget such as Chief Information Officers or, being the sample made of SMEs, network and/or IT managers. We collected 98 completed questionnaires, which gave us a fairly high response rate (77%).

The survey is made of 25 questions and structured in four sections. Section A collects general information about firms in terms of sector of activity, location, size and revenues. Section B focuses on the technological endowment of firms – in terms of network type (Internetwork, LAN, WAN), number of nodes, type of equipment (i.e. hubs and switches) as well as applications (i.e. client server, email, intranet etc.) in place – and on the costs of acquiring and upgrading the network in terms of human resources and physical investments. Section C analyses the perception of objectives, obstacles, and drivers of technology adoption, as well as the expectations of firms in terms of price and technological improvements. Section D examines the characteristics of adoption processes, also in relation to the existence of network effects and to the influence of the external environment on the adoption decision process.

[4] A Local Area Network (LAN) is a technical system forming the infrastructure that connects PCs, workstations and peripherals across a single or several company sites within an area of relative small dimensions. A LAN is made up of different hardware pieces (i.e. adapter cards, hubs, switches and routers) each of them carrying out a specific function for the purpose of exchanging data. The rules and the speed at which data are exchanged are defined by communication standards (i.e. Ethernet, Token Ring, and Fast Ethernet). LANs started diffusing in firm environments from mid-1970s and since then several standards have characterised the evolution of LAN technology during different phases in the diffusion of LANsDuring the 1980s Ethernet became the dominant standard winnign the competition against Token Ring (von Burg, 2001). As a high speed upgrade to Ethernet, Fast Ethernet was officially standardised in 1993 and became the dominant high speed LAN standard between 1995 and 1998.

To characterise the technological environment in which adoption decisions are taken, a specific question in the survey asked respondents to report how many months before the survey they first adopted each equipment and standard currently deployed in their network. Four different options were given: a) Less than 12 months before being surveyed, b) Between 12 and 18 months, c) Between 19 and 24 months, d) More than 24 months. Table I reports the number of adopters by standard and timing of first adoption.

{Insert Table I approximately here}

The most common standards are Ethernet and Fast Ethernet adopted by 87% and 76% of firms in our sample while Token Ring (24%) as well as FDDI (12%) and ATM (2%) are less adopted.

Table II instead reports information on firms' characteristics and the related pattern of technology adoption.

{Insert Table II approximately here}

These figures confirm that the majority of firms in our sample are SMEs (73% of respondents have less than 500 employees) with small LANs in place (82% of firms have less than 100 nodes connected). Although all firms are located in Italy, the majority of them (56%) have an international profile (i.e. they are subsidiaries or units of multinational corporations). From Table II we can also gain insights on the relationship between firms' characteristics and the type of technology in use. Irrespectively of firms' characteristics, the majority of Ethernet and Fast Ethernet adoption occurred between 18 and 24 months before the survey took place. It is interesting to investigate whether a particular relationship exists between the technology in place and the perception of objectives, obstacles and drivers of adoption.

4. Objectives, obstacles and drivers of adoption: a descriptive analysis

In this section we provide some preliminary evidence on the perception of objectives, obstacles and drivers of adoption. To understand the evaluation of objectives, we asked respondents to measure on a four points scale the importance of a set of objectives in relation to their decision of investing in networking.[5] Results are reported in Table III (top quadrant). *Planning for growth*, *Providing more bandwidth to the desktop* and *to the backbone*, and *Planning a migration to a new technology* were perceived as the most important objectives, thus suggesting that firms in our

[5] The exact wording of the question was: 'How important are the following objectives when you decide to invest in networking?' In all the questions, the scale ranged from (1) 'not at all important' to (4) 'very important'.

sample seem interested in growing through technology adoption, and are planning their growth strategy.

{Insert Table III approximately here}

Second, we asked firms to evaluate on a four points scale the most important obstacles to technology adoption.[6] The results reported in Table III (middle quadrant) reveal that firms are mostly concerned with *lack of compatibility from currently deployed network*, *lack of sufficient information from vendors* and *absence of proven performance benefits*. This result is quite relevant with reference to the role of physical network effects and information spillovers in stimulating the adoption of new technologies. Indeed, it seems that maintaining compatibility with the existing network and collecting information from vendors are crucial factors, which reflect the relevance of physical and virtual network externalities (in terms of brand effect/advertising). Furthermore, since benefits from adoption are not immediate and information is lacking, firms prefer to adopt a technology which is compatible with their existing one.

Third, we asked firms to evaluate again on a four points scale to what extent different factors influenced the decision to migrate to new technologies.[7] This question aimed at gleaning evidence on the perception of the major drivers of adoption. As shown in Table III (bottom quadrant) most firms are inclined to adopt new products or technologies, especially when these satisfy their immediate needs and ensure that the success of their early investment. This suggests that firms tend to be risk adverse when they face strategic decisions and is consistent with our previous findings indicating that firms in our sample prefer to plan their investment. It is interesting to notice that 45% of firms, which rate *solving future needs* as an important factor, also evaluate *maintaining a strategy of early adoption* as a very important driver. These firms are very innovative and plan their technology-based growth strategies with a medium-long term perspective. Finally, pursuing a strategy of early adoption is also relevant (56.2% of firms) and expectations seem to be an important driver of adoption, since 71.4% of firms consider very important to wait for the technology to mature before adopting.

To investigate more in depth the determinants of objectives, obstacles and drivers of adoption we proceeded in two steps. First, we carried out a factor analysis, in order to identify the most

[6] In this case the exact question was: 'How important are the following factors as obstacles for your decision to buy a new and currently available technology?'
[7] The wording was: 'To what extent are the following factors influencing your decision to migrate to new technologies?'

important factors affecting adoption. Second, we performed a trivariate probit estimation in order to understand how the perception of potential adopters towards objectives, drivers and obstacles vary across a set of firm-specific characteristics and technology features.

In order to identify the variables summarising the evaluation of objectives, obstacles, and drivers, a separate factor analysis for each of the three sets of variables was performed.[8] Factors were extracted by way of principal components analysis and were rotated orthogonally using the VARIMAX rotation method. The number of factors was determined by adopting the Eigenvalue criterion, (i.e. eigenvalues were required to be greater than one). Within each component, we focus in particular on the variables that display a factor loading greater than 0.40. We initially considered the objectives that stimulate firms to adopt LAN technologies, and then we turned to examine the factors that hinder or help firms in the adoption process. Results are reported in Table IV.

{Insert Table IV approximately here}

The top quadrant reports the results for objectives. Three factors summarise the perception of objectives. We label the first factor '*Pursuing technology-based growth*'. This factor is mostly explained by the need to increase bandwidth both at the backbone and at the desktop, to migrate to a new technology and to plan for growth. It reflects the idea that, when facing the decision to adopt new technologies, firms evaluate them in terms of future perspectives of growth. We label the second factor '*Increasing operational efficiency*'. This factor is explained by variables related to cost reduction (i.e. minimising the entire cost of the investment and the capital cost of the upgrades). This factor is particularly important for firms that, besides expanding their market reach, aim at increasing their internal efficiency by adopting network innovation. We label the third factor '*Managing risk*'. This factor is explained by the desire to maximise the life of the current capital investment and the capability of coping with unplanned growth. To summarise, firms' decisions to adopt a new technology concern the relative advantage of an innovation in relation both to the internal efficiency and to the expansion of the market reach.

Results for the obstacles to technology adoption are reported in the middle quadrant. Again we identify three main factors. First, adoption is hindered by '*Costs*', which include not only the total cost of the investment, but also the cost of making the currently deployed network compatible with the new technology and the cost of searching information from vendors. As stressed in

[8] In each factor analysis, we use normalised variables. Furthermore, we control for size, as patterns of technology adoption differ significantly between small and large firms (Davies, 1979).

Section 2, network effects play a significant role in determining the incentives to adopt. In particular, lack of compatibility and lack of informational spillovers slow down adoption. Second, adoption is hindered by '*Technological uncertainty*' surrounding the innovation, which is determined by the lack of observability of proven technology and by the lack of technical standards. This confirms that the extent to which the benefits of a technology are visible to potential users is crucial in determining adoption. Third, adoption is hindered by '*Lack of relative advantage*', which is associated both to the lack of performance benefits and to the expectations of future technical improvements.

Finally, results for the drivers of adoption are reported in the bottom quadrant. In this case we identified the following three factors. The first factor has been labelled '*Path dependence and learning*', and is associated with the need to support past network plans and future needs, and with the desire of waiting for the technology to mature. Firms are strongly driven by their past strategies and learning processes, as well as by expectations on future technological developments in relation to their needs. The second factor has been labelled '*Compatibility*', which is explained by the willing of addressing current needs together with the need of ensuring a protection to legacy investment. As underlined by the literature, if the new technology is compatible with the existing one, firms find it more convenient to adopt. The third factor has been labelled '*Competitive pressure*' and identifies the role of the external environment for firms that have to decide whether or not to adopt. This factor is almost entirely explained by the desire of maintaining a strategy of early adoption with respect to the competitors in the market. This supports the view that firms are stimulated to adopt in order to prevent competitors to gain a competitive advantage.

5. Econometric analysis of the perception of objectives, obstacles and drivers of adoption

As argued in the previous sections, conceptualising innovation adoption involves the definition, identification and analysis of three components: objectives of the adoption, obstacles to adoption and drivers of adoption. In principle, a variety of objectives, obstacles and drivers exists. For the purpose of empirical investigation our survey has defined, for each component, a set of possible indicators. Our factor analysis has revealed that the chosen indicators can be actually grouped into three main 'factors' on the basis of the percentage variance explained. In this section, we build upon these preliminary findings and use the information contained in our survey and in the factor analysis to study the attitude of the surveyed firms toward the three main components of adoption. As stated by the literature, the idea is that different objectives, obstacles and drivers can be perceived very differently across firms, depending upon adopters' characteristics and resources. The final goal is to understand for each component whether perception depends on economic

characteristics of the firm (i.e. firm size, cost structure, status), past investments made in the technology infrastructure or again on specific network applications that the firm is currently deploying.

5.1 The variables

In order to achieve our goal, we carry out an econometric analysis of the determinants of the perception of objectives, obstacles and drivers. Our dependent variable is firms' evaluation of the importance of a set of objectives, obstacles and drivers when deciding to adopt an innovation. We construct the variable in two steps. First, from the factor analysis, we select for each component (i.e. objectives, obstacles, and drivers) the three variables with the highest factor loading. These variables are highlighted in bold in Table IV. Second, for each selected variable we construct a dummy that takes the value (1) if the respondent firm evaluates it as 'important' or 'very important' and (0) if it evaluates it as 'not important' or 'not at all important'. At the end of this process we are left with the following nine dependent variables: Increase bandwidth, Minimise the capital costs of upgrades, Maximise the life of previous capital investment for objectives; Lack of compatibility, Lack of standards and Lack of performance for barriers; Addressing future needs, Addressing current needs, and Maintain a strategy of early adoption with respect to competitors for drivers.

We identify three sets of independent variables: firm-specific characteristics, past investments in specific network technology, type of network applications in use.

<u>Firm specific characteristics</u>

This set of covariates includes firms size (SIZE), cost structure (SW_COST), and firm status (NATIONAL). Firm size is expected to play an important role in the process of adoption and to influence the perception of objectives, obstacles and drivers to adoption. For instance, larger firms usually have a larger network in place and are more likely to experience congestion if proper investments are not carried out. This may influence their perception of objectives. Moreover, larger firms generally have more resources to invest and are more prone to risk, an attitude that may impact on their perception of obstacles to adoption. Finally, as we have pointed out in the previous section, size explains a large share of the total variance in the factor analysis. This is likely to influence firms' perception of the drivers of adoption. Our measure of size is the firm annual revenues in the latest year preceding the survey. In particular, we identified six possible intervals and asked firms to select one of them. Our variable SIZE varies between 1 ('annual revenue $\leq$ 50K euros') and 6 ('annual revenue > 10milion euros').

The cost structure is also expected to influence the perception of objectives, obstacles and drivers of adoption. The presence of switching costs in particular is likely to impact on the perception of obstacles particularly when maintaining compatibility is an important issue to consider when planning future investments. Moreover, being the legacy of past investments, switching costs impact on the perception of firm objectives, particularly when firms must evaluate whether to upgrade their equipment or to maximise the life of the existing capital. Finally, to the extent to what high switching costs generally represent a constraint for firms they tend to bias firms' investment decisions that become progressively driven by short term concerns such as addressing current needs as opposed to future or planning a migration to new technologies. We have identified three cost components of running a network: Capital Equipment costs deriving from the purchase of hardware equipment (i.e. hubs, switches); Facilities costs (i.e. costs for wiring/cabling, equipment and software maintenance); Personnel/ Human capital costs (i.e. costs for network design and management support and training). We asked firms to give an estimate of the share of each component over the total cost. SW_COST is a variable that considers the sum of the share of capital and personnel costs.

Finally, we control for firm status. NATIONAL is a dummy that is equal to (1) if the firm is Italian and independent and (0) if it is a subsidiary or a unit of a foreign multinational corporation. We expect perceptions to be associated to firm status particularly concerning the evaluation of relevant objectives.

Past investments in specific network technology

Local networks are technological system made of various components whose interfaces have to adhere to precise specifications set by standards. This characteristic makes adoption decisions on the single components highly dependable on previous investments. This raises important issues of compatibility and more in general generates learning economies which are likely to influence the perception of objectives, obstacles and drivers when new investments are needed. For instance, when a particular set of standards (i.e. Ethernet, Fast Ethernet and Token Ring) is already in place, maintaining backward compatibility with them becomes an issue and a constraint when considering new investments. To the extent to what the current installed base is seen as a constraint, the perception of obstacles such as lack of compatibility, lack of standards and/or performance may increases or decrease depending on the performance of the equipment currently in use. Perception of objectives as well as drivers of adoption may also be affected by previous investment in a specific type of hardware component. For instance, firms that have a specific

component in place (i.e. hubs) may decide to go for updating the same type of equipment or to opt instead for changing the type of hardware equipment (i.e. moving to switches). In this case a trade-off arises between maintaining compatibility and achieving higher overall network performance which is likely to influence the perception of objectives such as 'minimising the cost of capital upgrades' as opposed to a strategy aimed at 'maximising the maximum life of previous investments' in hardware.

To capture the influence of past investments in specific technologies on the perception of objectives, obstacles and drivers we have constructed the following variables to reflect the standards and the type of hardware equipment that formed the infrastructure of the firms at the time the survey was carried out. ETH_ H and ETH_SW are dummies that take the value (1) or (0) when Ethernet is in place in hub equipment or switch equipment respectively. FETH_ H and FETH_SW are dummies that take the value (1) or (0) when Fast Ethernet is in place in hub equipment or switch equipment respectively. Finally, TR_ H and TR_SW are dummies that take the value (1) or (0) when Token ring is in place.

Type of network applications in use

The third set of independent variables accounts for the impact on perceptions of different types of network applications in use. The use of a specific type of network application is a direct indicator of firm needs. To the extent to what needs satisfaction depends on the existing network equipment and standards, the type of application in use is also indirectly associated to a specific demand for innovation. In particular, using emails, implementing client server architectures and having an intranet in place can increase network congestion and modify the perception of objectives, obstacles and drivers of adoption. EMAIL, CLIENT and INTRANET are dummy variables used to account for this influence. They take the value (1) if the specific application is in use and (0) if not. Descriptive statistics and the correlation matrix for all the variables are reported in the Appendix.

5.2 Results

In this section we carry out the estimates and look at the determinants of the perception of objectives, obstacles and drivers of innovation adoption. Previous studies of the determinants of respondents' perceptions in surveys have stressed that complementarities may exist among certain questions. The presence of complementarities is a major source of correlation in answers and to account for them, a regrouping of questions should be carried out (Galia and Legros, 2004). Furthermore, we have underlined that the relative advantage of innovations may be affected by

other attributes such as complexity, compatibility and observability. Regrouping the variables in 'factors', as we have done in Section 4, is a good way of reducing the correlation. However, other contributions have recently argued that this procedure may not completely eliminate the source of bias, since respondents may be inclined to give similar answers simply because the questions belong to the same set (Iammarino *et al.*, 2005). When several answers (in our case three) may be interdependent, estimating separate equations for each of them is likely to generate correlated disturbances. In order to control for this, the equations should be estimated jointly. Given that our dependent variables are dichotomous and that we have a set of three equations for each component, we have chosen to estimate the following trivariate probit model:

$$v_{ij}^{*} = \beta_j x_{ij} + u_{ij}, \qquad (1)$$

where:

$$v_{ij} = 1 \quad if \quad v^{*} = \{3,4\}$$
$$v_{ij} = 0 \quad otherwise$$

with $i = 1,\ldots, n$ observations, and $j = 1,\ldots, 3$ equations for each set of objectives, obstacles, and drivers.[9]

The covariates are those described in the previous section grouped according to firm specific characteristics, past investments in specific network technology, and type of applications in use. Table V below reports the estimates of the trivariate probit for objectives, barriers and drivers separately.[10]

{Insert Table V approximately here}

[9] The error terms u_{ij} follow a normal distribution with mean 0 and a variance-covariance matrix with diagonal elements equal to 1 and off-diagonal elements $\rho_{jk} = \rho_{kj} \quad \forall j,k \quad \in [1;3]$ where ρ is the vector of correlation parameters denoting the extent to which error terms co-vary. If statistically significantly different from zero, these parameters evaluate the extent to what pairs of equations within each set are interdependent. The estimation is carried out using the recursive conditioning simulator implemented for STATA by Terracol (2002) and subsequently improved by Cappellari and Jenkins (2003). The number of recursive draws is equal to 500.

[10] To check for robustness, we tried two other specifications. Separate probit regressions not controlling for correlation have been run. Moreover, multinomial ordered multivariate probits have also been tried. In all these cases results have been confirmed.

Results for the perception of objectives

Columns 1-3 report the estimates for the perception of the selected set of objectives: increase the bandwidth, minimise the cost of capital upgrades and maximise the life of existing capital stock. While the model seems quite explanatory overall, covariates tend to be more significantly associated to one objective: minimise the cost of capital upgrades (see column 2). For this objective, results indicate that past investments in network technology exert a significant influence. More specifically, firms with hub equipment in place (both Ethernet and Fast Ethernet) are those that evaluate less 'minimising the cost of capital upgrades' as an objective. This is not surprising. Hubs are cheap, relatively old, and technologically unsophisticated equipment. It is understandable that firms want to substitute for them. Coefficients indicate that substitution would occur independently from the cost of the upgrades. The same type of explanation applies for the negative and significant coefficient for EMAIL which is the most inexpensive and simple application among those considered. Finally, among firms specific characteristics, only NATIONAL has a positive and significant coefficient indicating that national firms generally tend to evaluate minimise capital cost significantly more than those firms that are part of a multinational. This may be the consequence of a conservative approach to innovation adoption which leads national SMEs to search for inexpensive upgrades.

Concerning the other two objectives - increase bandwidth and maximise the life of existing capital (column 1 and 3 respectively) - it is interesting to notice that their perception significantly depends only on the technology previously adopted. On the one hand, firms with Ethernet hubs in place tend to evaluate significantly less an increase in the bandwidth as an important objective and seem keener in maximising the life of existing capital when investing in new technologies as suggested by the negative coefficient of ETH_H in column 1 and by the positive sign in column 3 respectively. Both results are consistent with a picture of slow growing SMEs or with firms that are not planning to grow and consequently are not likely to face decisions of network expansion in the near future. On the other hand, the coefficient for ETH_SW is positive and significant thus indicating that firms with Ethernet switches in place tend to evaluate significantly more maximising the life of existing capital. This is typical of firms that have already updated their network infrastructure and are waiting for their investment to pay back.

Results for the perception of obstacles

Estimates for the perception of the set of obstacles are summarised in columns 4-6. In this case three types of obstacles have been considered: lack of compatibility with the existing network, lack of standard technology and lack of performance. Results in column 4 indicate that lack of

compatibility is positively and significantly associated to the presence of switching costs, and negatively and significantly associated to the current use of Fast Ethernet hubs. These results are expected. On the one hand, as argued above, maintaining backward compatibility is a major concern for firms' willing to undertake new investments in networking. It is understandable that firms with high switching costs pay particular attention to it and tend to perceive lack of compatibility as an important barrier to adoption. On the other hand, having Fast Ethernet hubs in place reduces firms' perception of compatibility as an obstacle. This can be explained as follows. Being a high speed upgrade to Ethernet, Fast Ethernet should provide firms, with an adequate boost of bandwidth. Thus firms who have adopted Fast Ethernet are, so to speak, on the 'technological frontier'.[11] Should they wish to upgrade further they could adopt Fast Ethernet switches. However this decision would be driven by performance and not so much by compatibility. Thus, it is reasonable that for these firms, lack of compatibility is less of a concern as a barrier.

Concerning the other two types of barriers, the perception of lack of standards (column 5) seems to be entirely and negatively dependant on the technology in use. This is true both across standards (i.e. Ethernet, Fast Ethernet and Token ring) and across type of hardware (i.e. hubs and switches). Both the standards and the technologies considered are well established and have been available on the market for quite a while. These results suggest that firms are satisfied with them and do not perceive the lack of new standards as an important obstacle to their investments. Finally, it is noticeable that just one of our covariates is significantly associated to the perception of lack of performance as an obstacle (see column 6). This may reflect an overall lack of concern with performance by the firms in our sample.

Results for the perception of drivers

The last three columns report the estimates for the perception of our set of drivers of innovation adoption: addressing current needs, addressing future needs and maintaining an early lead with respect to competitors. The following results emerge. First, addressing future needs (column 7) does not seems to be a major concern for the firms in our sample as can be seen from the lack of significance of any of the covariates. Second, contrary to the case of objectives and obstacles, firm

[11] Indeed, the choice of standards available to firms is not restricted to the ones included among our independent variables. Firms wishing to update their network may also decide to purchase other technologies such as Fiber Distributed Data Interface (FDDI), Asynchronous Transfer Mode (ATM) or Gigabit Ethernet. These standards are faster than Fast Ethernet which cannot be technically defined as the 'technological frontier'. However, these alternatives are very expensive and they usually tend to be implemented in big firms with very large 'global' networks. The majority of our sample is constituted by SMEs with small or very small and local networks (see Table II). For these firms Fast Ethernet can be reasonably considered as the 'frontier'.

size seems to play a role albeit weak. In particular, SIZE is positively and significantly associated to the pursuing of an early adoption strategy (column 9), thus indicating that for large firms taking an early lead is an important way to gain advantages with respect to competitors. Finally, the technology in use is also associated to the perception of the drivers of adoption to the extent to what firms with Fast Ethernet hubs and Ethernet switches in place tend to evaluate addressing current needs significantly more, while adoption decision by firms with previous investment in switches, both in Ethernet and Token ring, are more likely to be driven by the desire to keep an early lead with respect to competitors.

Finally a comment on the sign, significance, and size of the correlation coefficients ρ is needed. Recall that these coefficients reflect whether, within each set, objectives, obstacles and drivers are interrelated and have therefore to be studied under a simultaneous framework. In the case of objectives, coefficients are generally positive although significant only for some of them. In particular, maximising the life of existing capital is correlated with both increasing bandwidth and minimising the cost of upgrades meaning that, in the perception of the firms in our sample, gains in performance should be achieved in combination with a strategy of gradual investment. In the case of obstacles ρ is positive and significant only for lack of standards and lack of backward compatibility basically confirming the relationship between these two types of barriers and indicating that performance tends to be perceived as independent from compatibility. Finally in the case of drivers, ρ is always negative. This suggests that, when considering adoption, there is negative correlation between the perception of drivers and trade-offs exist. In particular, current needs seem to be important. Indeed, when 'addressing current needs' is a major concern, firms tend to overlook both future needs and the pursuit of an early adoption strategy.

6. Conclusions

The paper has analysed the decisions to adopt LAN technologies by SMEs in Italy. By surveying a sample of IT managers, it identified the major objectives underlying the decisions to adopt, and provided empirical evidence on the main obstacles and drivers to adoption. In doing so, it highlighted a series of variables that explain individual decision behaviour and investigated how the perception of the relevance of different factors varies according to the structural characteristics of the firms and the availability of resources. Our empirical analysis has shown that IT managers seem to adopt with the objectives of increasing operational efficiency, implementing a technology-based growth and managing risk. Three main factors drive their decisions: path dependence and learning, compatibility and competitive pressure. These drivers account for the influence of both firms' technological and organisational resources, and of the features of the competitive

environment. Costs, technological uncertainty and lack of relative advantage represent instead the most important obstacles to adoption. Costs refer not only to the total investment, but also to the collection of information on the new technology and to the adaptation of the existing networks to the new standards. Our econometric analysis has shown that the perception of the importance of objectives, obstacles and drivers of adoption by IT managers is highly dependent on past investments and to a lesser extent on firms' specific characteristics such as size, switching costs and status. While previous investments in networking technology are crucial to explain IT managers' perception of objective, obstacles, and drivers, switching costs seem to matter only for the perception of obstacles and size only for drivers. So, what do IT managers perceive when deciding about adoption? Our results indicate that perception is characterised by a high degree of hysteresys and path dependence. However, one result seems to emerge: technology seems to matter more than size.

REFERENCES

Attewell, P. (1992) Technology Diffusion and Organizational Learning: The Case of Business Computing. Organization Science, 3(1): 1-19.

Balcer, Y. and S. A. Lippman (1984), Technological Expectations and Adoption of Improved Technology: Journal of Economic Theory, 34, 292-318

Cappellari, L. and S.P. Jenkins (2003) Multivariate probit regressions using simulated maximum likelihood. The STATA Journal, 3: 278-294.

Choi, J. P. (1997), Herd Behavior, the "Penguin Effect", and the Suppression of Informational Diffusion: an Analysis of Informational Externalities and Payoff Interdependency. *RAND Journal of Economics*, 28(3): 407-425

Church, J. and N. Gandal (2004), Platform Competitions in Telecommunications: CEPR Discussion Paper No 4659 forthcoming in *The Handbook of Telecommunications, Volume 2*, M. Cave, S. Majumdar and I. Vogelsgang (eds.)

Daniel, E.M. and D.J. Grimshaw (2002) An exploratory comparison of electronic commerce adoption in large and small enterprises. Journal of Information Technology, 17: 133-147.

David, P.A. (1969) A Contribution to the Theory of Diffusion: memorandum No 71, Stanford Centre for Research in Economic Growth.

Davis, F.D. (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly, 13(3): 319-340.

Davies, S. (1979), *The Diffusion Of Process Innovations*. Cambridge, UK, Cambridge University Press.

Dong, D. and A. Saha (1998) He came, he saw, (and) he waited: an empirical analysis of inertia in technology adoption. Applied Economics, 30: 893-905.

Galia, F. and D. Legros (2004) Comlementarities between obstacles to innovation; evidence from France. *Research Policy*, 33: 1185-1199.

Griliches, Z. (1967), Hybrid Corn: an Exploration in the Economics of Technological Change, *Econometrica*, 25(4): 501-522.

Iammarino, S., Sanna-Randaccio, F. and M. Savona (2005) Multinational firms and obstacles to innovation in Italy. Evidence from the Third Community Innovation Survey. Mimeo.

Karshenas, M. and Stoneman, P. (1995) Technological Diffusion, in the *Handbook of the economics of innovation and technological change*, Stoneman P.(ed.). Oxford, Blackwell.

Kapur, S. (1995) Technological Diffusion With Social Learning, *Journal of Industrial Economics* 43(2): 173-196.

Mansfield, E. (1968) *Industrial Research and Technological Innovation*. New York, W.W. Norton.

Mole, K.F., Ghobadian, A., O'Reagan, N. and J. Liu (2004) The Use and Deployment of Soft Process Technologies within UK Manufacturing SMEs: An empirical Assessment Using Logit Models. *Journal of Small Business Management*, 42(3): 303-324.

Oh, S., Ahn, J., and B. Kim (2003) Adoption of broadband Internet in Korea: the role of experience in building attitudes. *Journal of Information Technology*, 18: 267-280.

Powell, T.C. (1995) Total Quality Management as Competitive Advantage: A Review and Empirical Study. *Strategic Management Journal*, 16(1): 15-37.

Rip, A. (1995) Introduction of New Technology: Making Use of Recent Insights from Sociology and Economics of Technology, *Technology Analysis & Strategic Management*, 7(4), pp.417-431.

Rogers, E.M. (1995), Diffusion of Innovation. New York, The Free Press.

Rogers, E.M. and Shoemaker, F.F. (1971), Communication of Innovations: A Cross-Cultural Approach. New York, The Free Press.

Rosenberg, N. (1976), On Technological Expectations: The Economic Journal, 86, (343): 523-535.

Stoneman, P. (2002), The Economics of Technological Diffusion. Oxford, Blackwell

Terracol, A. (2002) Triprobit: STATA module to estimate trivariate probit model using the GHK simulator, *Statistical software components No S424302*, Boston College Department of Economics.

Tung, L.L. and O. Rieck (2005) Adoption of electronic government services among business organizations in Singapore. *Journal of Strategic Information Systems*, 14: 417-440.

von Burg, U. (2001), The triumph of Ethernet. Stanford, Stanford University Press

Weiss, A. M. (1994), The Effects of Expectations on Technological Adoption: Some Empirical Evidence: The Journal of Industrial Economics, XLII (4): 341-60.

LIST OF TABLES

TABLE I - PATTERN OF LAN STANDARD ADOPTION (NO OF FIRMS)

	<12	12-18	18-24	>24	% OF ADOPTERS
ETHERNET	4	21	35	25	87
FAST ETHERNET	7	12	32	24	76
TOKEN RING	3	7	12	2	24
FDDI	1	2	7	2	12
ATM	0	0	2	0	0.2

TABLE II - PATTERN OF ETHERNET AND FAST ETHERNET ADOPTION BY FIRM CHARACTERISTICS

	SAMPLE	ETHERNET				FAST ETHERNET			
		<12	12-18	18-24	>24	<12	12-18	18-24	>24
FIRM TYPE									
National	41%	2%	7%	14%	15%	3%	2%	10%	12%
International	56%	2%	14%	20%	10%	3%	10%	20%	12%
Local	1%	-	-	-	-	-	-	1%	-
Regional	2%	-	-	1%	-	1%	-	1%	-
NO OF EMPLOYEES									
<500	73%	3%	15%	24%	21%	6%	7%	24%	17%
500-999	20%	1%	6%	7%	1%	1%	5%	5%	3%
1000-5000	7%	-	-	4%	3%	-	-	3%	4%
REVENUES (EUROS)									
100K-499K	9%	-	1%	3%	2%	1%	-	4%	3%
500K-999K	33%	2%	6%	13%	9%	2%	3%	5%	7%
1M-10M	41%	2%	11%	10%	10%	2%	5%	18%	10%
>10M	17%	-	3%	9%	4%	2%	4%	5%	4%
TYPE OF NETWORK									
Internetwork	26%	1%	3%	12%	7%	-	2%	8%	6%
LAN	58%	3%	17%	15%	12%	6%	9%	18%	14%
WAN	16%	-	1%	8%	6%	1%	1%	6%	4%
NO OF NODES									
<50	50%	3%	9%	18%	18%	4%	5%	18%	14%
50-100	27%	1%	9%	11%	3%	2%	3%	9%	5%
101-250	10%	-	3%	3%	3%	1%	3%	1%	3%
251-500	5%	-	-	3%	-	-	1%	2%	1%
>500	3%	-	-	-	1%	-	-	2%	1%

TABLE III – EVALUATING OBJECTIVES, OBSTACLES AND DRIVERS OF ADOPTION (FREQUENCY TABLE)

	NOT AT ALL IMPORTANT	NOT IMPORTANT	IMPORTANT	VERY IMPORTANT
OBJECTIVES				
PROVIDING MORE BANDWIDTH AT THE BACKBONE (OBJBANDB)	1%	22.6%	52%	24.4%
MINIMISING THE CAPITAL COST OF THE UPGRADES (OBJMINCA)	6.1%	35.8%	44.9%	13.2%
MINIMISING THE ENTIRE COST OF THE INVESTMENT (OBJMINTO)	9.1%	30.6%	42%	18.3%
MAXIMISING THE LIFE OF THE CAPITAL INVESTMENT (OBJMAXLI)	5.1%	21.4%	49%	24.5%
KEEPING UP WITH UNPLANNED GROWTH (OBJUNPLG)	12.3%	28.7%	39%	20%
PLANNING FOR GROWTH (OBJLPLAG)	2%	19.3%	55.3%	23.4%
PROVIDING MORE BANDWIDTH TO THE DESKTOP (OBJBANDD)	6.1%	28.5%	52.2%	13.2%
PLANNING A MIGRATION TO A NEW TECHNOLOGY (OBJPLMIG)	3%	23.5%	63.3%	10.2%
OBSTACLES				
LACK OF STANDARDS (BARNOSTAND)	1%	24.4%	57.2%	17.4%
LACK OF PROVEN TECHNOLOGY (BARNOPROVTECH)	0%	36.8%	51%	12.2%
VERY FAST EXPECTED PACE OF TECHNOLOGICAL IMPROVEMENT (BARTECHEXP)	0%	39.8%	48%	12.2%
NO PROVEN PERFORMANCE BENEFIT (BARNOPER)	2%	16.4%	60.2%	21.4%
HIGH COSTS OF ADOPTION (BARHIGHCOST)	5.1%	18.4%	51%	25.5%
LACK OF COMPATIBILITY FROM CURRENTLY DEPLOYED NETWORK (BARPHYSNE)	5.2%	11.2%	53%	30.6%
LACK OF SUFFICIENT INFORMATION FROM VENDORS (BARVIRTNE)	3%	15.4%	48%	33.6%
DRIVERS				
ADDRESSING CURRENT NEEDS (DRCURR)	1%	20.4%	39.8%	38.8%
SUPPORTING PAST NETWORK PLANS/STRATEGIES (DRPAST)	15.3%	55.2%	27.5%	2%
SOLVING FUTURE NEEDS (DRFUT)	5.2%	29.5%	51.1%	14.2%
WAITING FOR THE TECHNOLOGY TO MATURE (DRTECHEXP)	5.2%	23.4%	60.2%	11.2%
ENSURING A PROTECTION TO LEGACY INVESTMENT (DRPHYSNE)	4%	22.5%	57.1%	16.4%
MAINTAINING A STRATEGY OF EARLY ADOPTION (DREARLY)	5.1%	38.7%	43%	13.2%
WAITING FOR THE PRICES TO DECLINE (DRPRICEEXP)	7.2%	31.6%	49%	12.2%

TABLE IV – IDENTIFYING THE FACTORS UNDERLYING OBJECTIVES, OBSTACLES AND DRIVERS OF ADOPTION (FACTOR ANALYSIS)

	PURSUING TECHNOLOGY-BASED GROWTH	INCREASING OPERATIONAL EFFICIENCY	MANAGING RISK
OBJECTIVES			
EMPLOYEES	0.1032	-0.1114	0.1339
REVENUES	0.1217	0.0521	-0.0240
NODES	-0.1921	-0.0231	-0.1494
OBJBANDD	**0.7957**	0.1945	0.0350
OBJLPLAG	0.7640	-0.1933	0.1214
OBJPLMIG	0.5732	0.1643	0.3165
OBJMINTO	0.0265	**0.8481**	0.2289
OBJMINCA	0.0608	0.8389	-0.1208
OBJMAXLI	0.1113	0.2804	**0.7025**
OBJUNPLG	0.2768	-0.2062	0.6663
OBJBANDB	0.4903	-0.0295	-0.4904
EIGENVALUES	1.99	1.58	1.19
% OF VARIANCE EXPLAINED	18.11%	14.32%	10.82%
	COSTS	TECHNOLOGICAL UNCERTAINTY	LACK OF RELATIVE ADVANTAGE
OBSTACLES			
BARPHYSNE	**0.9201**	0.0400	0.0083
BARVIRTNE	0.7998	0.1749	0.1682
BARHIGHCOST	0.7486	0.1388	-0.0115
NODES	0.0622	0.0363	-0.0953
EMPLOYEES	-0.2154	-0.1063	0.1372
REVENUES	-0.1257	0.0653	0.0380
BARNOSTAND	0.0779	**0.8538**	-0.1130
BARNOPROVTECH	0.2791	0.7130	0.2125
BARNOPERF	0.0692	-0.1860	**0.8426**
BARTECHEXP	0.0615	0.3787	0.7318
EIGENVALUES	2.77	1.24	1.10
% OF VARIANCE EXPLAINED	27.69%	12.43%	11.02%
	PATH DEPENDENCE AND LEARNING	COMPATIBILITY	COMPETITIVE PRESSURE
DRIVERS			
EMPLOYEES	0.1031	-0.0602	0.1062
REVENUES	0.0364	0.1557	0.3243
NODES	-0.0840	-0.2209	-0.1113
DRFUT	**0.8070**	0.1620	0.0977
DRTECHEXP	0.6927	0.0979	-0.2135
DRPAST	0.6092	-0.3256	0.1844
DPRICEEXP	0.0651	-0.6854	-0.3318
DRCURR	-0.0069	**0.6417**	-0.3281
DRPHYSNET	0.2762	0.5819	-0.1681
DREARLY	0.0338	-0.1041	**0.8331**
EIGENVALUES	1.67	1.35	1.05
% OF VARIANCE EXPLAINED	16.74%	13.49%	10.52%

TABLE V - DETERMINANTS OF ADOPTION DECISION: TRIVARIATE PROBIT ESTIMATION
DEPENDENT VARIABLE: PERCEPTION OF OBJECTIVES / OBSTACLES / DRIVERS AS IMPORTANT OR VERY IMPORTANT

	OBJECTIVES			OBSTACLES			DRIVERS		
INDEPENDENT VARIABLE	INCREASE BANDWIDTH	MINIMISE COST	MAXIMISE LIFE	COMPATIBILITY LACK	STANDARDS LACK	PERFORMANCE LACK	FUTURE NEEDS	CURRENT NEEDS	EARLY STRATEGY
	1	2	3	4	5	6	7	8	9
SIZE	0.322	0.244	0.105	-0.114	0.383	-0.069	0.041	-0.270	0.323
	[0.213]	[0.221]	[0.190]	[0.313]	[0.253]	[0.202]	[0.215]	[0.222]	[0.199]*
SW_COST	0.532	1.281	1.114	3.566	-0.767	1.126	0.008	-1.035	0.84
	[0.985]	[0.971]	[1.019]	[1.397]**	[1.192]	[1.119]	[1.001]	[1.070]	[1.004]
NATIONAL	-0.047	0.739	0.318	0.430	0.457	-0.534	-0.02	-0.183	-0.077
	[0.333]	[0.358]**	[0.342]	[0.505]	[0.426]	[0.369]	[0.329]	[0.356]	[0.329]
ETH_H	-0.532	-1.023	0.647	-0.045	-1.315	0.014	0.131	-0.133	-0.410
	[0.303]*	[0.332]***	[0.316]**	[0.369]	[0.342]***	[0.350]	[0.309]	[0.300]	[0.310]
FETH_H	0.356	-0.769	0.125	-0.93	-0.701	-0.244	0.09	0.513	-0.423
	[0.316]	[0.326]**	[0.322]	[0.418]**	[0.357]**	[0.322]	[0.313]	[0.311]*	[0.302]
TR_H	0.949	0.277	-0.722	-0.118	-0.265	-0.447	-0.609	-0.650	0.719
	[0.607]	[0.509]	[0.500]	[0.541]	[0.531]	[0.539]	[0.503]	[0.550]	[0.502]
ETH_SW	-0.148	0.371	-0.628	-0.105	0.042	0.184	-0.186	0.633	0.557
	[0.318]	[0.313]	[0.351]*	[0.433]	[0.360]	[0.361]	[0.329]	[0.343]*	[0.318]*
FETH_SW	-0.354	-0.181	0.125	0.441	-0.871	-0.290	0.295	0.012	-0.281
	[0.314]	[0.333]	[0.333]	[0.375]	[0.314]***	[0.367]	[0.301]	[0.357]	[0.318]
TR_SW	-0.246	-0.362	-0.592	-0.116	-1.275	0.999	0.642	-0.592	1.210
	[0.418]	[0.456]	[0.405]	[0.484]	[0.438]***	[0.586]*	[0.430]	[0.445]	[0.531]**
EMAIL	0.106	-0.909	0.410	0.020	0.093	-0.472	0.012	-0.500	0.360
	[0.299]	[0.339]***	[0.328]	[0.361]	[0.335]	[0.345]	[0.289]	[0.289]*	[0.308]
CLIENT	-0.092	0.276	0.325	0.420	-0.188	0.201	0.079	-0.049	0.194
	[0.300]	[0.316]	[0.303]	[0.436]	[0.308]	[0.296]	[0.284]	[0.298]	[0.310]
INTRANET	-0.227	-0.304	-0.099	0.512	-0.843	0.143	-0.304	-0.270	0.430
	[0.314]	[0.349]	[0.336]	[0.463]	[0.363]**	[0.360]	[0.318]	[0.337]	[0.320]
CONSTANT	-0.658	-0.442	-0.328	0.652	1.183	1.266	0.081	2.312	-1.935
	[1.152]	[1.106]	[1.092]	[1.656]	[1.290]	[1.068]	[1.125]	[1.189]*	[1.060]*
OBSERVATIONS		98			98			98	
LOG PSEUDO LL		-154.5604			-115.8743			-156.2095	
WALD CHISQ		117.19***			105.70***			50.81**	
		rho12: 0.218			rho45: 0.706***			rho78: -0.333**	
		rho13: 0.489***			rho46: 0.238			rho79: -0.156	
		rho23: 0.375**			rho56: 0.035			rho89: -0.302*	

* denotes 10% significance level, ** denotes 5% significance level, *** denotes 1% significance level.
Robust standard errors in brackets

APPENDIX

TABLE A1
SUMMARY STATISTICS

	VARIABLE NAME	MEAN	S.D.	MIN	MAX
1	INCREASE BANDWIDTH	0.653	0.478	0:34	1:64
2	MINIMISE COST	0.602	0.492	0:39	1:59
3	MAXIMISE LIFE	0.735	0.444	0:26	1:72
4	COMPATIBILITY LACK	0.837	0.372	0:16	1:82
5	STANDARDS LACK	0.745	0.438	0:25	1:73
6	PERFORMANCE LACK	0.806	0.397	0:19	1:79
7	FUTURE NEEDS	0.653	0.478	0:34	1:64
8	CURRENT NEEDS	0.786	0.412	0:21	1:77
9	EARLY STRATEGY	0.561	0.499	0:43	1:55
10	SIZE	4.663	0.873	3	6
11	SW_COST	0.261	0.142	0	0.6
12	NATIONAL	0.439	0.499	0:55	1:43
13	ETH_H	0.582	0.496	0:41	1:57
14	FETH_H	0.449	0.5	0:54	1:44
15	TR_H	0.092	0.29	0:89	1:9
16	ETH_SW	0.735	0.444	0:26	1:72
17	FETH_SW	0.551	0.5	0:44	1:54
18	TR_SW	0.163	0.372	0:82	1:16
19	EMAIL	0.327	0.471	0:66	1:32
20	CLIENT	0.551	0.5	0:44	1:54
21	INTRANET	0.296	0.459	0:69	1:29

TABLE A2

CORRELATION MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1																				
2	0.152	1																			
3	0.096	0.031	1																		
4	0.026	0.036	0.047	1																	
5	0.065	0.194	-0.087	0.121	1																
6	0.131	0.076	-0.002	0.063	0.009	1															
7	0.009	-0.023	0.193	0.026	0.114	0.076	1														
8	0.037	0.033	-0.089	-0.029	0.094	0.121	-0.172	1													
9	0.220	0.247	-0.112	-0.057	-0.093	-0.07	-0.083	-0.161	1												
10	0.211	-0.003	-0.073	-0.267	0.016	0.077	0.038	-0.031	0.225	1											
11	-0.018	0.087	0.130	0.309	-0.078	0.03	-0.018	-0.055	-0.024	-0.315	1										
12	-0.133	0.089	0.066	0.168	0.046	-0.139	-0.004	0.011	-0.130	-0.557	0.112	1									
13	-0.227	-0.182	0.146	0.017	-0.307	0.055	0.034	-0.04	-0.083	0.028	-0.072	0	1								
14	0.184	-0.104	0.031	-0.212	-0.036	-0.076	0.055	0.171	-0.029	0.208	-0.014	-0.013	-0.316	1							
15	0.158	0.114	-0.209	-0.051	0.024	-0.023	-0.139	-0.092	0.139	0.164	-0.088	-0.21	-0.017	-0.145	1						
16	-0.001	0.125	-0.152	-0.078	0.019	0.115	-0.050	0.193	0.214	0.166	-0.067	0.019	0.099	0.031	0.031	1					
17	-0.098	-0.063	0.155	0.156	-0.152	-0.131	0.075	-0.021	-0.219	-0.019	0.13	-0.070	0.066	-0.051	0.003	-0.217	1				
18	0.032	-0.036	-0.172	-0.178	-0.058	0.147	0.148	-0.106	0.279	0.14	-0.152	0.054	-0.017	0.045	-0.045	0.140	-0.378	1			
19	0.005	-0.234	0.123	0.013	0.108	-0.154	0.050	-0.114	0.046	-0.131	0.068	0.130	-0.159	0.028	-0.221	-0.074	0.060	0.046	1		
20	0.032	0.021	0.108	-0.010	-0.105	0.076	0.032	0.029	0.029	0.241	-0.015	-0.277	0.108	0.155	0.003	0.015	0.093	-0.156	-0.071	1	
21	-0.091	-0.067	0.035	0.105	-0.133	0.035	-0.138	-0.043	0.033	-0.006	0.067	0.012	0.051	-0.001	-0.129	-0.016	-0.089	-0.226	-0.070	-0.044	1

1 INCREASE BANDWIDTH, 2 MINIMISE COST, 3 MAXIMISE LIFE, 4 COMPATIBILITY LACK, 5 STANDARDS LACK, 6 PERFORMANCE LACK, 7 FUTURE NEEDS, 8 CURRENT NEEDS, 9 EARLY STRATEGY, 10 SIZE, 11 SW_COST, 12 NATIONAL, 13 ETH_H, 14 FETH_H, 15 TR_H, 16 ETH_SW, 17 FETH_SW, 18 TR_SW, 19 EMAIL, 20 CLIENT, 21 INTRANET