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REGULAR ARTICLE

Innovation and ICT in service firms: towards a multidimensional approach for impact assessment

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Abstract This article focuses on the multimodal character of innovation in services firms as the analytical framework by which to assess the role of different sources and agents, ICT in particular, in enabling various impacts of innovation. The peculiarities of service innovation require a wider approach than that observed for goods innovation, which is less focused on non-technological aspects. An ad hoc survey was carried out in the region of Madrid to test a microeconometric and multidimensional approach at the firm level. Specific impacts of innovation are examined by carrying out an ordered probit model with sample selection. Results indicate a certain correspondence between the multidimensional nature of service innovation and a preliminary impact assessment. The paper notes that ICT and clients–providers interactions are both important, acting to facilitate different types of service innovation.

Keywords Innovation · Services · Ordered probit model · Information and Communications Technology (ICT) · Impact assessment

JEL Classification O33 · C35 · L8 · L25

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1 Introduction

Despite the continuous growth of the service sector in the advanced economies, services have long been perceived as non-innovative or technologically backward activities. It was only during the 1990s that the traditional conception of services as innovation laggards gradually changed. The earlier studies that paved the way for this shift were mainly focused on the use of technologies by services activities, notably ICT (Information and Communication Technologies) in creative rather than standard ways (Miles and Ducatel 1994; OECD 1996; Antonelli 1998). In this scenario, service innovations were implicit in the hardware components and transferred when implemented by service industry users. This pattern of innovation depicted service innovative trajectories as supplier-dominated.

ICT somehow helped transform the passive image of services in relation to innovation so that they have become an important locus for innovative activity within the emerging 'knowledge economy' (Metcalfe and Miles 2000). The actual innovation and implementation is thus initiated by and implemented throughout the organization, possibly with 'innovation support' from outside. Moreover, the service firm may also influence the innovation process that takes place within a client firm by providing knowledge resources that support the innovation process. In this way, the service firm may constitute a source of innovation if it plays a major role in initiating and developing innovation in client firms, usually in close interaction with the client firm. In this context, the role of Knowledge Intensive Business Services (KIBS) must be highlighted (Miles et al. 1995; Rubalcaba 1999; Wood 2001) and considered as part of innovation systems (Antonelli 1999; Hipp 2000). Despite the relatively minor role of ICT as sources of services innovation in analysis based on European CIS data (Tether 2003), ICT act as innovative drivers of services when services innovation is based on new ways of client–provider co-production or on the more advanced use of business services, both KIBS and traditional professional services.

The increasing importance of services in relation to innovation has greatly benefited from the still on-going debate as to whether service innovation should be analyzed using the same concepts and tools as innovation in manufacturing. The assimilation approach, which treats services as similar to manufacturing (Coombs and Miles 2000) and epitomises the passive role of services as mere technology adopters, seems to have been definitely left behind. In an attempt to move away from what might be seen as manufacturing based models of innovation, the more recent approaches have either sought to highlight the distinctiveness of service innovation in terms of the innovation in manufacturing (the demarcation approach) or brought to the forefront hitherto overlooked elements of innovation, basically of non-technological content, such as human and organizational capabilities, which are of relevance for manufacturing as well as for services. Specific service innovation may be identified in all economic sectors, whether these are goods or service sectors, through the presence of innovative intangibles or, when appropriate, through the "encapsulation" described by Howells (2004).

Survey based studies have also followed the evidence gained at the theoretical level to put forward a broader conception of innovation in which often neglected dimensions are considered. The shift of focus has been decisive in shedding some

light on the so called *productivity paradox* (i.e. the fact that productivity measures do not seem to show any impact derived from the massive deployment of ICT), which is of special relevance in services. In fact, one of their explanatory factors may be that, unlike manufacturing, innovation in services is often neither represented by new services nor by process improvements which increase outputs or decrease inputs. As Licht and Moch (1999) put it, *innovation in services is often more closely connected to the way products are delivered*, such as the loosening of time-and-space restrictions or the increasingly *just in time* nature of services. This reinforces the hierarchy of services as innovative activities.

Figure 1 presents the main possible interrelations between ICT and service innovation based on a multidimensional view of innovation in services and the prominent role of co-productions between providers and users, and the complementarities between technological and non-technological components of services innovation in a given innovation system. ICT are drives, facilitators and agents of four non-independent types of services innovation: product and process, organization, interfaces and co-production schemes, and business services and KIS-related innovation.

Bearing these issues in mind, the present paper emphasizes the multidimensional character of innovation in service industries in the sense that, as has been said, this may reflect not only enlarged output or a lesser use of inputs (i.e. increases in productivity levels) but also incorporate other non-material or disembodied nature aspects. As a result, measuring innovation impacts in services by means of conventional indicators such as sales increases does not seem to be an appropriate method to capture fully the peculiarities of service innovation. Impact assessment of service innovation should be correspondent to its several dimensions so that indicators based on the co-productive nature of services (e.g., quality, trust, timing, motivation) may be as important as other traditional indicators (e.g., costs, productivity, employment, turnover, internationalisation). In most of the old and

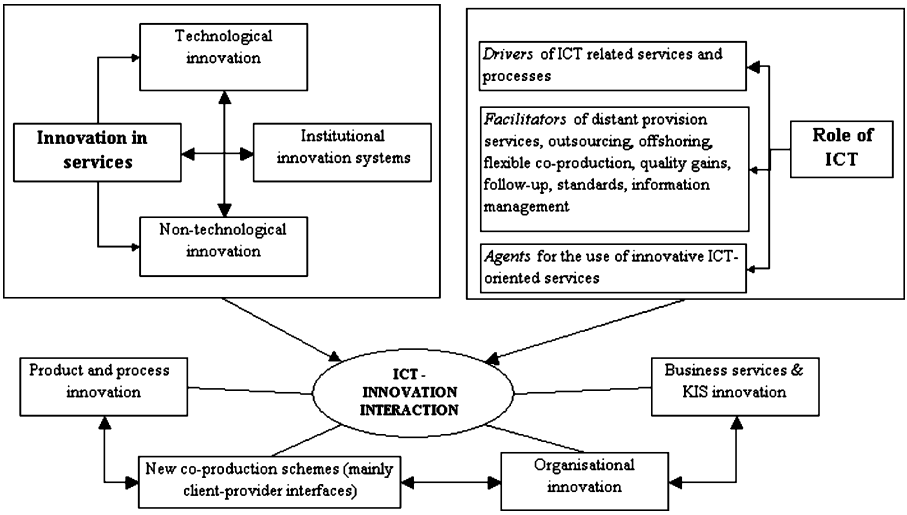

Fig. 1 Interactions between ICT and service innovation. Source: Own elaboration

new indicators for impact assessment, we expect to find significant links with the driving role of users–clients and ICT.

The rest of the article is organized as follows. The first section briefly describes the database, namely the Survey on Innovation 1998–2001 carried out in 2002–2003. In the second section, the analysis focuses on a brief description and justification of the econometric method used, whereas in the third section some methodological aspects related to the model are put forward – basically the description of the selection bias problem – as well as the final specification adopted to circumvent this problem and to avoid the harmful effects it may cause on the estimation. The fourth section contains the core results of the essay, as it provides the results of the estimation as well as the interpretation. We then finish with some concluding remarks and suggestions for further research.

2 The database: the Madrid Survey on Service Innovation

The Madrid Survey on Service Innovation was undertaken between 2002 and 2003. Valid data of 557 enterprises were collected through a mail survey of Madrid service firms. The response rate was around 45% and the sample error was below +−5% (to be exact +−3.99%).

Ten different types of services were considered in the survey: hotels and restaurants, transports, telecommunications, temporary work, engineering and architectural services, and security and other ancillary business services. These are the services that have traditionally been more exposed to innovation (Sirilli and Evangelista 1998). The justification of the choice lies in the fact that one of the main objectives of the Survey was to study in depth certain aspects directly linked to the dynamics of innovation, rather than merely studying the percentage of innovative enterprises, and so it seems plausible to focus the analysis on the service activities more prone to innovation.

Amongst other aspects, enterprises surveyed were asked about the existence/non existence of innovation, thus distinguishing among product and process on the one hand, and organizational innovation on the other. In this respect, it is worth mentioning that some scholars have long stressed the difficulties in determining the orientation of innovation in services. A good example is Hipp and Tether (2002), who argue that there is often a close nexus between the service provided, the process of provision and the organization of provision, such that it is often difficult to change one without impacting on the others.

This paper explicitly considers this peculiarity of service innovation by presenting product and process innovation results jointly, but aside from organizational innovation, as it underpins impacts of a different nature. In fact, the specific focus of the paper on impacts of innovation has called for a particular presentation of the traditional categories of innovation, so as to tackle the objectives of the analysis, bearing in mind that they are so much interrelated. In order to ensure proper understanding of the categories by respondents in our survey, explanations and precise guidelines about what is termed product, process or organizational innovation were given, including examples of each type.

The survey, which accomplishes the first ever comprehensive attempt to measure service innovation impacts in Spain, is based on the widely accepted European CIS III methodological framework. Nevertheless, some particular issues that did not deserve special attention in the Community Survey are analyzed in detail in this survey.

In the first place, the Madrid survey emphasizes the key role played by the Information and Communication Technologies (ICT) as sources of service innovation, echoing the aforementioned major services use as well as the evidence on the ample complementarities between investments in ICT and innovations (Brynjolfsson and Hitt 2002).

Secondly, the Survey is organized under a graduation of product, process and organizational innovation impacts on a *Likert* scale, which means that the interest not only lies on the mere occurrence/non occurrence of innovation, but also on the degree of such impacts. This is in accordance with the Oslo Manual (different editions), which clearly distinguishes amongst 'new products and processes and significant improvements in such products or processes'.

On the other hand, a complete coverage of agents that may promote innovation has been considered in the Survey, thus distinguishing amongst the enterprise and linked entities (such as the competition, professional associations, etc.), providers, clients and institutions linked to the Public Administration.

Following some previous attempts such as the Canadian Service Innovation Survey (1996) or the Mannheim Innovation Panel for the Service Sector (MIP-S), the impacts of innovation captured by the Survey go beyond the traditional effects on productivity and costs to allow for others, such as service quality, employment and skills or market/product growth. In relation to this, the Survey also includes a specific question on organizational innovation, which is based on the capabilities induced by innovation to centralize/de-centralize service tasks, enterprise re-location, task outsourcing, higher levels of enterprise co-operation either by strategic alliances or networking.

On the other hand, unlike the still large neglect of services as arenas for government intervention policy (Howells 2000), the Survey is somehow policy oriented, in the sense that it includes an assessment (according to the enterprises surveyed) of the alternative policies at the disposal of public bodies to promote service innovation. However, these policy issues are not discussed here since they are not of importance in the present paper.

In short, the pioneering character of the surveys is due to the following arguments: inclusion of the services more prone to innovation (more appropriate coverage of the innovation phenomenon); particular treatment of ICT as sources of innovation; distinction amongst levels of innovation impacts; a complete coverage of agents promoting innovation; systematization of innovation impacts; specific treatment of organizational impact; applied orientation of the survey: analysis of alternative policies to promote innovation.

3 The model

The econometric model attempts to measure the influence of different variables on various dimensions of service innovation. The enterprises surveyed were required to

rank different impacts on innovation according to a *Likert scale*, which ranges from 1 to 5, the value 1 being of 'negligible important', while 5 is 'strategically important'.

Thus, impacts of product and process innovation were gathered on five main dimensions. At the same time, every impact is made up of different manifestations:

A) *Impact on productivity and enterprise costs.* A.1) Costs savings. A.2) Enhancement in labor productivity. A.3) Higher levels of employees' motivation. A.4) Increasing production capacity.
B) *Product or market expansion*. B.1) Increasing income revenue; B.2) More variety of services B.3) Presence in other regions. B.4) Higher degree of internationalization.
C) *Employment and skills*. C.1) Acceleration of the employment generation process. C.2) Capital/employment substitution. C.3) Higher use of skilled labor. C.4) Higher use of non skilled labor.
D) *Service quality.* D.1) Flexibility in adjusting to customers needs. D.2) Delivery speed. D.3) Temporal availability. D.4) Service user friendliness. D.5) Reliability.
E) *Environmental impact*. E.1) Fulfillment of ecological and sanitary standards and regulations.

On the other hand, impacts brought about by organizational innovation are listed as follows: *A) Change in the number of employees. B) Expansion in the number of premises/establishments (multi-location). C) Decentralization of tasks. D) Task specialization. E) Promotion of networking/strategic alliances. F) Higher levels of department autonomy. G) Outsourcing of routine tasks. H) Outsourcing of non-routine (advanced) tasks. I) Enterprise re-location. J) Relocation of certain activities (partial relocation)*.

Independent variables depict a priori sources/agents prompting impacts of innovation of any kind. The influence of enterprise size is captured through the variable *employment*, which is approached by the number of employees by 31st December 2001 and expressed in logarithms in order to avoid scale problems that may cause non-convergence in this type of model. The *ICT* variable, on the other hand, measures the investments on ICT as a driving and enabling source of different innovation impacts. The variable is of qualitative character, and is built using the aforementioned Likert scale, ranging from zero to five. Value zero is interpreted in the sense that the enterprise has carried out no ICT investments whatsoever, and assessment of the influence on innovation is thus not possible. By contrast, value five implies that the enterprise has indeed carried out ICT investments that are considered as 'strategically important' in terms of sources of innovation. The same applies for the *software* variable, which is included aside from ICT on the grounds of an a priori differential impact of this ICT component in relation to the others.

Inclusion of the variables *international clients* and *domestic clients* may be justified on rather different grounds. The first must be interpreted as the importance attached to *international clients* as a source of innovation, while the latter is referred to the role played by *domestic clients*. Consequently, the inclusion of both variables is intended to grasp the contribution that external knowledge may have on different dimensions of service innovation. The same rationale lies behind the variable that reaps the role played by *computer services providers*.

The variable *character* is built by classifying service activities into four different types, according to its higher (or lesser) dynamic character, ranging from one (the lesser dynamic category) to four (the most advanced). Seven *dummy* variables are included in the model so as to control for sectoral effects. The twelve service activities from the survey are reduced to eight groups[1] for the sake of clarity. Consequently, final groups are the following: 1) *Hotels* (which is made up of hotels, restaurants and travel agents); 2) *Transport* (road transport); 3) *Telecom* (made up by telecommunications and computer services); 4) *Consultancy* (management consultancy and financial intermediation); 5) *Engineering* (architectural and engineering services); 6) *Advertising*; 7) *Personal* and 8) *Security*. The latter category is used as the reference to avoid the so-called *dummy* trap.

3.1 Justification of the model and methodology

In order to assess the importance of the different dimensions of innovation, an ordered probit model with selection bias correction is used, as it is the model that better fits the profile and characteristics of the data.

The ordered probit model is based on the following specification:

$$\begin{aligned} & y_i^* = \beta' x_i + \varepsilon_i, \varepsilon_i \approx N[0,\ 1] \\ & y_i = 0 \text{ if } \mathrm{y_i^*} = \mu_0 \\ & \quad 1 \text{ if } \mu_0 < y_i^* \leq \mu_1 \\ & \quad 2 \text{ if } \mu_1 < y_i^* \leq \mu_2 \\ & \quad 3 \text{ if } \mu_2 < y_i^* \leq \mu_3 \\ & \ldots\ldots\ldots\ldots\ldots\ldots \\ & J \text{ if } \mathrm{y_i^*} \rangle \mu_J \end{aligned} \tag{1}$$

The observed counterpart to y_i^* is y_i. The variance of ε_i is assumed to be one since, as long as y_i^*, β and ε_i are unobserved, no scaling of the underlying model can be deduced from the observed data. The ordered probit model was developed by Zavoina and McElvey (1975). Since the μs are free parameters, there is no significance to the unit distance between the set of observed values of y. They merely provide the ranking. Estimates are obtained by maximum likelihood. The probabilities which enter the log likelihood are:

$$Prob[y_i = j] = Pr\,ob\left[y_i^* \text{ in the rank } j\right] \tag{2}$$

A *pseudo* R^2 based on the formula used by Zavoina and McElvey (1975) in their paper on the ordered probit model is computed as a measure of the model goodness of fit:

$$E\left[\frac{y^*}{y}\right] = yf = b'x + \lambda, \tag{3}$$

[1] Groups have been constructed according to the evident affinities amongst the service activities.

where λ is the inverse of Mills ratio, defined as the quotient between density and distribution function. Mathematically:

$$\lambda = \frac{f\left(\frac{x'b}{\sigma}\right)}{F\left(\frac{x'b}{\sigma}\right)} \tag{4}$$

Hence, the pseudo R^2 may be specified as:

$$R^2 = [\mathrm{var}(yf)/(1 + \mathrm{var}(yf))] \tag{5}$$

3.1.1 The selection bias problem

The selection bias problem includes different truncation phenomena, that is, sample extractions where the variable of interest is not used as the guide for the sample selection. In other words, the selection of the truncated population distribution from which the sample was extracted was undertaken using a different variable from what is labelled as the *observed* variable (the one under study). In the model here devised, enterprises answering questions regarding the impacts of innovation are exclusively those where the impact is, to some extent, visible, and the sample subject to study is obtained from a dychotomic variable (i.e. the existence/non-existence of impacts on innovations).

Selection bias causes severe estimation troubles in the event that the problem is not dealt with properly, As it may be deduced from the earlier explanation, the observed variable *y*, which assesses the degree of the innovative impact according to a Likert scale), is not randomly selected from the population, but is determined by taking other variable that captures the existence/non-existence of the innovative impact (labelled *z**) as reference. Variable *z** can only take zero (no innovation) and one (innovation) values, so that only when the variable reports one is it then considered in the experiment. In this context, if the observed variable is regarded as a random variable (despite the fact it is obtained from variable *z**), estimators may be biased. The general solution to circumvent this selection bias problem lies in building up an auxiliary model of the process generating the variable *z**.

The model, once the selection bias has been accounted for, may be expressed as follows:

$$\begin{aligned} y^* &= \beta' x + \varepsilon, \\ z^* &= \alpha' v + u, \\ \varepsilon,\, u &\approx N\left(0,\, 0,\, \sigma_\varepsilon^2,\, \sigma_\mu^2,\, \rho\right) \end{aligned} \tag{6}$$

Variable *z** (as well as *y**), may not be directly observed. Conversely, the counterpart *z* may be observed, and expressed in this way:

$$\begin{aligned} z &= 1 \text{ if } z^* > 0 \\ z &= 0 \text{ if } z^* \leq 0 \end{aligned} \tag{7}$$

Accordingly, *y* values (the observed counterpart of *y**) may be observed if and only if $z = 1$.

4 Results

4.1 Product and process innovation

Results for every manifestation of product and process service innovation are listed in tables one to five of the Statistical Annex, grouped around the five dimensions introduced above, namely: impact on productivity and costs, product or market expansion, employment and skills, service quality and environment.

Overall, it must be stressed that variables that turn out to be statistically significant are quite similar, not only amongst impacts pertaining to the same dimension, but also across impacts attached to different dimensions. In fact, variables such as presence of *international clients*, importance attached to *ICT*, importance attached to *software*, and to *computer services suppliers* as a source of innovation are statistically significant (up to 10 per cent levels), in more than 50 per cent of the regressions undertaken. The clustering of the effects on virtually the same variables for every service innovation dimension grants the results a higher degree of robustness and a certain degree of internal coherence. The homogeneity in the variables that report statistically significant results is reflected on very close pseudo ICT^2 for all dimensions of innovation (0.45 in most cases).

Amongst the variables included in the regression, *ICT* clearly stands out from the rest, as it yields positive significant effects in sixteen out of eighteen regressions, and mostly at a 1 per cent level. This result must be interpreted in line with the recent focus on the role of ICT as a source of innovation in services (Van Ark et al. 2003) and the tight connection between the fast pace of ICT developments and the emergence of new forms of service delivery and the creation of new services (Gago 2001), which is amplified by the use of these technologies from the services side.

Conversely, it is worth emphasizing the lack of statistical significance in two variables that, a priori, are expected to influence the appreciation of innovation, such as the higher or lesser advanced *character* of the service, and also the sectoral *dummies*.

As far as disaggregated results for different dimensions are concerned, the first dimension refers to the most traditional and conventional effects of innovation, namely those occurring on level costs — productivity and production capacity. The only two variables bearing statistically significant coefficients are the *ICT* and *computer services providers*. Positive coefficients are obtained for *ICT* in all regressions.

Computer service providers also report positive coefficients, ranging from 0.083 at 'employees motivation' up to 0.119 at the 'saving costs' manifestation. The *software* variable is highly significant on all manifestations, except on 'employees' motivation'. Moreover, 'employees' productivity' and 'higher production capacity' are better explained by *software* rather than by generic ICT. The intuition behind this result may be that software systems (which are included in the ICT variable as a part of it) are endowed with a higher degree of flexibility to respond adequately to the changing profile of the current economic context. As a consequence, implementation of software systems may enhance productivity levels by the presence of network externalities (Licht and Moch 1999, *op. cit.*).

The outstanding role of clients on the productivity/costs dimension is obvious. Not only is this result evident for *international clients*, but also for *domestic clients*, even though with very distinctive patterns. Hence, *international clients* seem to have played a major role as factors promoting 'costs savings', while *domestic customers* have especially triggered the achievement of 'higher productivity' and 'higher production capacity'. On the other side, the influence on innovation dimensions exerted by variables *character* and *employment* is quite selective but salient in those cases in which it turns out to be statistically significant. From the latter it may be concluded that the more innovative a service is, the higher the chances are that, as a consequence, it may increase its production capacity. As far as the other innovation effects on this first dimension are concerned, the evidence is elusive. On the other hand, enterprise size approached by *employment* does affect positively cost saving achievements, in such a way that the bigger (the smaller) the size of the enterprise, the higher (the lesser) the chances that cost savings may be obtained.

On the other side, *dummy* variables accounting for sectoral effects show no significant effects as far as this dimension of innovation is concerned. The only exception is made up by 'productivity of employees', where the activities Hotels and travel agents, Transports (both statistically significant at 5 per cent), Telecommunications and Computer services (at 10 per cent) display a significant effect. Eventually, the pseudo R^2 are quite similar, being the category 'higher production capacity' the one reporting the highest goodness of fit (0.47), and 'employees' motivation' the lowest (0.40).

The second dimension is clustered around four different manifestations related to market or product expansion issues, and thereby the most traditional aspects of innovation linked to productivity and costs are set aside.[2] Results seem again to emphasize the role of ICT as carriers of different realms of innovation, thus confirming theoretical evidence on their influence on scope (approached by 'higher variety of services') and scale economies, the latter both in terms of the most traditional perspective ('increasing income revenues') and the most sophisticated conception linked to geographical expansion ('presence in other regions' and 'higher levels of internationalization'). Scale economies seem to flourish only at their conventional conception, that is, associated with a production increase.

Computer services providers command some explanatory power on a higher achievement of scale economies, but not on scope economies. On the other side, the innovative content of the services reported here seems to play a more substantial role on this dimension linked to market/product enlargement than that associated with productivity enhancement. In fact, coefficients are statistically significant at the 5 per cent level for 'higher income revenues' and 'presence in other regions', and at 10 per cent for 'variety of services'. Larger enterprises are relatively more prone to create a higher variety of services as a particular manifestation of this second dimension.

[2] In any case, manifestations must not be considered as watertight departments in the sense that in some points may be heavily intertwined. In fact, market expansion may be underpinned by productivity motivations.

Besides, from the inspection of Table 1 in the annex it may be deduced that the higher the international orientation of the enterprise, the higher the chances that their innovative trajectories may be turning into impacts promoting further levels of internationalization. This is undoubtedly an intuitive result that assures internal coherence to the survey and is especially relevant since it is the only manifestation of innovation that is statistically significant. No sectoral effects are found either on this dimension, with the only exception of Hotels and travel agents as a sector where innovation is oriented towards international expansion. Eventually, the pseudo R^2 report very homogeneous coefficients close to 0.45, being ' higher degree of internationalization' a major exception, since the goodness of fit is slightly lower (0.42).

The third dimension of innovation refers to the effects exerted on labor markets, at the heart of which the issue of creation/destruction of employment or the impacts on skills underpinned by innovation must be stressed. Results show conclusive evidence on the often controversial role of ICT on employment. In fact, and in accordance with the enterprises surveyed, *ICT* are a source of employment, since the coefficient reported, 0.14, is positive and statistically significant at 1 per cent, and is an explaining factor of a significant skills upgrading. The latter result is entirely in accordance with a variety of studies that show a strong connection between investment in high technology equipment and the demand for skilled, educated workers (Berndt et al. 1992; Autor et al. 1998, amongst others). Effects of ICT on downskilling and the substitution of employment by capital are consequently discarded. The conclusions must be qualified in relation to software systems in the sense that no upskilling effects are found here.

It may be worth stressing the unbalanced influence of *international* and *domestic customers* as sources of innovation on this dimension linked to the labor market. Both variables share their role as upskilling agents, but notably differ in relation to the character of the capital/employment substitution processes they may trigger. In fact, from the inspection of the tables containing the results, it may be deduced that Spanish customers may give rise to the creation of employment, while international customers may be at the core of the opposite effect, namely a substitution of employment by capital, in other words, an employment decline.

Other relevant results point to the higher possibilities of employment creation on the relatively most advanced service sectors as well as the (positive) correlation between enterprise size and skills. Nevertheless, in the light of the results, no conclusive evidence is found about the allegedly distinctive capacity of larger enterprises to foster employment resulted from innovation.

Finally, sectoral effects captured by *dummy* variables turn out to be statistically significant as far as employment creation and upskilling are concerned. In relation to this, as security services have been taken as the reference to construct the *dummies*, the minus sign should be interpreted as heavier relative effects in this sector with respect to the other seven sectors. In other words, innovation in security services more often implies a higher ability to create employment or upgrade employees' skills.

The goodness of fit of the model is quite even on 'employment creation' and 'more skilled employment' (pseudo R squared slightly over 0.44), while is slightly

Table 1 Statistical annex: impacts of product and process innovation

	First dimension: (enterprise) productivity and costs				Second dimension: market or product expansion			
Dependent variables / Independent variable	Cost savings	Employees productivity	Employees motivation	Production capacity	Increasing income revenue	Higher variety of services	Presence in other regions	Higher degree of internationalization
Constant	−0.716	0.318	−0.382	−0.378	−0.789[a]	−1.649**	−2.14**	−2.75**
CHARACTER	−0.101	−0.003	0.03	0.036	0.226*	0.258[a]	0.152	0.254*
EMPLOYMENT	0.167**	0.096	0.079	−0.051	0.042	0.155**	0.102*	−0.006
INTERNATIONAL	0.018	−0.058	0.041	0.0314	−0.03	−0.033	0.003	0.302**
INTERN. CLIENT	0.077*	0.086[a]	0.045	0.044	0.099*	0.108**	0.064[a]	0.239**
DOMES. CLIENT	0.032	0.088*	0.043[a]	0.044*	0.078*	0.341	0.05[a]	−0.012
ICT	0.1**	0.134**	0.108**	0.155*	0.109**	0.167**	0.129**	0.154**
SOFTWARE	0.114*	0.262**	0.084	0.281**	0.11*	0.124*	0.069	0.057
C. SERV. PROVIDERS	0.119**	0.083**	0.115**	0.159**	0.081*	0.05	0.062[a]	0.084*
HOTELS	−0.394	−1.181*	−0.178	0.179	−0.274	−0.066	0.605	1.026*
TRANSPORT	−0.016	−1.258*	−0.302	−0.351	−0.537	−0.451	0.208	0.193
TELECOMP	−0.185	−1.086[a]	−0.213	−0.19	−0.388	0.019	0.1	0.096
CONSULTANCY	−0.377	−0.683	−0.258	−0.059	−0.811[a]	0.030	0.212	−0.057
ENGINEERING	0.127	−0.879	−0.245	0.077	−0.365	−0.623	0.418	0.154
ADVERTISING	0.003	−0.837	−0.097	0.36	−0.47	−0.117	0.335	0.088
PERSONAL	−0.679	−1.379*	−0.475	0.079	−0.832[a]	−1.004*	−0.372	−0.683
Pseudo R^2	0.456	0.423	0.406	0.471	0.459	0.464	0.446	0.422

			Third dimension: employment and skills	Fourth dimension: service quality						Fifth dim.: regulation
Dependent Independent variables variable	Acceleration of employment generation	Capital/ employment substitution	Skilled labor use	Non-skilled labor use	Flexibility to customer demands	Delivery speed	Temporal availability	User friendliness	Reliability	Regulations, standards
Constant	−0.749[a]	−2.11**	−0.181	−1.97**	−0.817	−0.77[a]	−1.23**	−1.32**	−0.382	−1.36**
CHARACTER	0.237*	0.0689	0.155	0.123	0.221	0.043	−0.021	0.099	0.03	0.142
EMPLOYMENT	0.038	0.127	0.11*	–	0.062	−0.051	0.076	0.043	0.79	0.0042
INTERNATIONAL	−0.126	−0.045	−0.134[a]	−0.241	0.105	0.034	−0.091	0.023	0.041	0.065
INTERN. CLIENT	0.047	0.084*	0.094*	0.021	0.205**	0.113*	0.12**	0.094*	0.0453	0.061
DOMES. CLIENT	0.072*	0.032	0.08*	0.005	−0.017	0.073[a]	0.05[a]	0.051*	0.042[a]	0.065[a]
ICT	0.142**	0.029	0.115**	−0.062	0.231**	0.092*	0.063[a]	0.122**	0.108**	0.039
SOFTWARE	0.109*	0.098	0.073	0.167	0.284**	0.165**	0.109*	0.176**	0.084	0.248
C. SERV. PROVIDERS	0.092**	0.085*	0.15**	0.059	0.262**	0.172**	0.065[a]	0.107**	0.015**	0.08*
HOTELS	−0.988**	−0.149	−1.138**	0.234	−0.397	0.395	0.161	0.374	−0.178	0.402
TRANSPORT	−0.731*	−0.033	−1.433**	0.144	−0.355	0.191	0.121	0.108	−0.30	0.324
TELECOMP	−0.7[a]	0.237	−0.933*	0.234	−0.488	0.341	0.104	0.406	−0.213	−0.351
CONSULTANCY	−1.16*	−0.214	−1.028*	0.013	−1.172*	0.676	0.33	0.414	−0.258	−0.707
ENGINEERING	−0.685[a]	0.092	−1.061*	−0.368	−0.725	0.46	0.144	0.298	−0.245	0.402
ADVERTISING	−0.69*	0.35	−0.957*	0.178	−0.085	0.748	0.23	0.379	−0.097	−0.01
PERSONAL	−0.612	−0.271	−1.498**	−0.059	−0.532	0.03	−0.199	−0.057	−0.475	−0.668
Pseudo R^2	0.447	0.436	0.44	0.3	0.416	0.451	0.445	0.446	0.452	0.406

Notes: Estimation method is Ordered Probit Maximum Likelihood with sample selection using Limdep econometric software
**Implies 1% significance, *implies 5% significance, [a]implies 10% significance

lower at 'capital/employment substitution', and, overall, at 'less skilled employment' (0.3).

The fourth dimension, which encapsulates service quality issues, recalls most of the results pointed out in the other dimensions, even though lack of significance in some prominent variables, such as size (approached through *employment*) or the advanced *character* of the service, must be stressed. The latter is found in every manifestation making up the dimension, either 'flexibility in adjusting to customer needs', 'delivery speed', 'temporal availability', 'service user friendliness' and 'reliability'. The *ICT* role as a source of innovation becomes decisive when it comes to making different manifestations of service quality flourish, even though the most affected ones refer to the increasing capacity to adapt to changing customer needs and the service user-friendliness. These results are in line with the theoretical evidence identifying ICT as revolutionary technologies or, in Bresnaham and Trajtemberg (1995) words, as *general purpose technologies*, as well as simple and intuitive technologies in nature so that their use is not solely restricted to specialists.

Software systems are fully governed by these two features, and accordingly, coefficients are statistically significant in every manifestation of service quality, except on 'reliability'. The other variable linked to ICT (*computer services providers*) also reports significant and positive-sign coefficients in every manifestation. *International customers* become statistically significant in four out of five service quality manifestations (either at 1 or 5 per cent), with 'reliability' being the only exception. This result must be put in contrast with the results reported on *domestic customers*, whose global influence is weaker (as significant coefficients are only at 10 per cent) and only partial (as coefficients are significant on 'reliability', but not on 'flexibility in adjusting to customer demands').

At this point, it may be interesting to ask ourselves about the factors hindering the (relative) more prominent role of *international customers* as sources of innovation. The rationale behind it is related to the increasing importance that quality standards may have as a competitive weapon to create international market niches within a global world. Sectoral effects remain virtually non-existent, whereas the goodness of fit is around 0.45, except for 'flexibility in adjusting to customer needs', where the coefficient reported is slightly lower (0.416).

The last dimension of service innovation included in the survey is related to the fulfilment of standards and regulations. It is indeed a minor dimension in the light of the results obtained, as the influence of the independent variables is almost negligible and the goodness of fit of the regressions is weaker. In fact, even *ICT*, which is critical on the other dimensions, displays only modest coefficients here (statistically significant at 10 per cent). Besides *ICT*, *computer services providers* are the only source of innovation with relative explanatory power on the fulfilment of standards or regulations. Nor is the impact of innovation substantially different across different service activities.

4.2 Organisational innovation

So far the analysis has been focused on product and process innovation but, as was previously discussed, one of the main distinctive features of the survey is the

inclusion of organizational innovation and the specific impacts it may engender, which are related to restructuring, not only at an internal but often at an external level (Vickery and Wurzburg 1998). A summary of the results obtained from the estimation of the model is listed on Table 2 of the Annex.

As a general conclusion, it must be stressed that the influence of the independent variables derived by organizational innovation is not homogeneous for different impacts, in contrast to what may be observed for product and process innovation. Hence, the pseudo *R* squares that approach the fit of goodness of the regressions show a more dispersed behavior, ranging from 0.40 for 'outsourcing of non-routine tasks' to 0.55 for promotion of 'networking/strategic alliances'.

In spite of this a priori somewhat heterogeneous behavior, some regular patterns may be found as far as the variables influencing impacts of organizational innovation are concerned. Hence, *ICT* keep the privileged role as agents influencing the impacts of organizational innovation, since the variable report statistically significant sign (up to 10 per cent) in nine out of ten impacts of innovation. The only exception is 'multi-location', whereby it may be concluded that *ICT* does not seem to contribute effectively to the promotion of the expansion in the number of establishments in Madrid. Results seem to favor the capacity of these technologies to engender both internal (in terms of 'higher degree of task decentralization') and external flexibility (approached by 'networking and external alliances promotion'). An implication of the latter result is that, as Brynjolfsson et al. (1994) has pointed out, the rise of the value-added partnership is not simply a management fad, but rather may have a technological and theoretical basis. As the authors put it, companies evaluating success strategies in an environment of increasingly inexpensive information technology will benefit from considering alternative forms of organizing which depend more heavily on market coordination.

By contrast, it is not clear that *ICT* may give rise to radical changes in terms of the physical space occupied by the enterprise whether through relocation or, as was said, through the expansion of the number of establishments. *ICT* also command a great effect on 'specialization of employees', in the sense that it contributes to making the content of the tasks more specialized. The *software* component follows the evidence reported by *ICT* very closely, but some distinctive features seem to flourish. For example, *software* seems to enable an enlargement of firm size, increasing the number of establishments of the firm, but it is not useful in promoting geographical relocation, especially if it is complete. Additionally, *software* may only be slightly useful when outsourcing of non-routine (advanced) tasks is undertaken.

The major role of *ICT* is additionally confirmed when analyzing the hierarchy of *computer services providers* as agents promoting impacts of organizational type. In fact, they bear a significant effect (up to 10 per cent of statistical significance) in nine out of ten impact categories, the 'expansion in the number of premises' being the only category with a non-statistically significant coefficients. In this respect, it is worth mentioning that *computer services providers* are considered as a mechanism positively influencing firm decisions to re-locate (especially when it comes to changing the location of certain activities), as well as the convenience of implementing outsourcing.

Table 2 Impact of organisational innovation

Dependent variable	Number of employees	Multi-location	Task decentralization	Specialization in employees tasks	Networking	Department autonomy	Routine tasks outsourcing	Non-routine tasks outsourcing	Enterprise relocation	Relocation of certain activities
Constant	−0.422	−2.060**	−0.808*	0.188	−2.266**	−0.887*	−1.804**	−1.727**	−1.564**	−1.458**
CHARACTER	0.238*	0.057	0.029	0.114	0.024	0.081	0.098	−0.074	0.006	−0.070
EMPLOYMENT	−0.002	0.108*	−0.039	−0.047	0.113	0.081	0.019	−0.021	−0.195	0.061
INTERNATIONAL	−0.108	0.031	0.101	−0.038	0.038	−0.009	0.130	0.069	−0.012	−0.115
INTERN. CLIENT	0.068[a]	0.024	0.130**	0.124*	0.114**	0.073*	0.109*	0.035	0.090[a]	0.073[a]
DOMES. CLIENT	0.074*	0.065[a]	0.018	0.051**	0.067[a]	−0.011	−0.023	0.077*	0.021	0.056[a]
ICT	0.068*	0.034	0.055	0.090*	0.112**	0.101**	0.118**	0.111**	0.099*	0.117**
SOFTWARE	0.178**	0.229*	0.111[a]	0.154**	0.130[a]	0.099[a]	0.080	0.083	0.092[a]	0.121[a]
C. SERV. PROVIDERS	0.062[a]	0.034	0.077*	0.126**	0.066[a]	0.104**	0.096*	0.131**	0.083[a]	0.140**
HOTELS	−1.296**	−0.600	−0.655[a]	−1.063**	0.104	−0.560[a]	−0.422	−0.083	−0.593	−0.601[a]
TRANSPORT	−0.881**	−0.478	−0.697[a]	−1.083**	−0.059	−0.399	−0.096	0.271	0.210	−0.291
TELECOMP	−1.045**	−0.313	−0.402	−0.852*	0.548	−0.329	−0.323	0.096	0.264	−0.032
CONSULTANCY	−0.985*	−0.452	−0.298	−0.698	0.422	−0.345	−0.365	−0.319	0.104	−0.603
ENGINEERING	−0.828*	−0.085	−0.437	−1.161**	0.156	−0.444	−0.115	0.370	0.203	0.221
ADVERTISING	−0.766*	−0.663	−0.365	−1.063**	0.223	−0.191	−0.288	0.153	0.415	−0.152
PERSONAL	−1.314**	−1.031	−0.440	−1.186**	−0.042	−0.625	0.040	0.195	0.490	0.150
Pseudo R^2	0.422	0.453	0.429	0.473	0.549	0.427	0.479	0.400	0.417	0.469

Notes: Estimation method is Ordered Probit Maximum Likelihood with sample selection using Limdep econometric software
**Implies 1% significance, *implies 5% significance, [a] implies 10% significance

As far as clients as a source of organizational innovation is concerned, they command a significant influence with respect to organizational impacts focused on 'number' and 'specialization of employees', favoring the creation of more jobs and a higher level of specialization on the tasks carried out. Moreover, a strong client base stimulates the achievement of strategic alliances or a better use of networking. Nevertheless, the analysis highlights the distinctive role of *international clients* (in relation to *domestic* ones) as regards as impacts such as 'outsourcing of routine tasks', 'firm relocation' and 'decentralization of tasks', bearing positive and significant signs. By contrast, *domestic clients* seem to favor an expansion of the enterprise through a 'higher number of establishments', as well as promoting 'non-routine tasks outsourcing'.

By contrast, the advanced *character* of the service, the degree to which the service is based at an international level, and enterprise size are the variables reporting the weakest influence on these organizational dimensions of innovation. With regards to the *character* of the service, the only robust relation found is that the more advanced the content of the service the firm belongs to, the higher the chances that employment may be created as a consequence of the organizational innovation (at 5 per cent). As for the international variable, if the firm is *international based*, it is more likely that the organizational impact may be translated into the creation of 'networks/strategic alliances' (at 5 per cent), the 'outsourcing of routine tasks or firm re-location' (at 10 per cent). Finally, enterprise size is only relevant as a variable promoting the 'multi-location' of the enterprise. These results are fully in line with what may be expected. Indeed, one of the most desired effects of organizational change for firms running at an international level is the creation of a robust and strong grid of professionals that may help them consolidate this position abroad.

Finally, it cannot be concluded from an inspection of the results that impacts of an organizational nature are significantly different for every sector covered in the survey. The exceptions are made up of impacts most closely related to aspects of employment, namely the creation of a 'higher number of employees' and the promotion of an 'increased specialisation in employees' tasks'. In both cases, organizational innovation in security services implies a substantial higher capacity to increase the number of employees and the specialized content of employees' tasks.

5 Concluding remarks

The co-productive nature of services is at the heart of the multidimensional character of innovation processes in the tertiary sector, and this result goes hand in hand with the fact that services and manufacturing are becoming increasingly intertwined. Indeed, a service may be defined as organizing a solution to a problem by placing a bundle of capabilities and competencies (human, technological, organizational) at the disposal of the clients' needs (Gadrey et al. 1995), and, from that point of view, service innovation must necessarily involve dimensions of different kinds (product, process, organisational and business services–KIS). The interaction between the different types of services innovation and the role of *ICT* is theoretically too strong

to argue the opposite statement as a hypothesis. In many cases, *ICT* are not drivers but still facilitators of service innovations.

The present exercise, based on the exploitation of an '*ad hoc*' survey in Spain, has considered product, process and organizational impacts of service innovation, thus enlarging the scope of innovation impacts, traditionally anchored on productivity and costs. At the same time, product and process impacts of innovation distinguish amongst four alternative dimensions, each comprising different manifestations. Service productivity dimensions include product or market expansion, employment creation and skills, service quality enhancement, client–provider relationships and the fulfilment of standards and regulations. Impacts derived from organizational innovation are organised under ten different categories, comprising the promotion of decentralization/centralization of service tasks, enterprise re-location, autonomy of departments, the degree of task specialization, creation of employment and outsourcing of different activities.

The results seem to ratify the multimodal character of innovation in services, at least in the service activities under scrutiny. The prominent role of *ICT* as agents enabling plural manifestations of the innovative phenomenon has also been clearly pointed out, in line with the evidence and conclusions reported in other studies on service innovation (Licht and Moch 1999; Van Ark et al. 2003, op cit. amongst others). In this sense, *ICT* may be best described not as traditional capital investment, but as a general purpose technology the economic contributions of which are substantially larger than would be predicted by simply multiplying the quantity of capital investment devoted to them by a normal rate of return. Instead, such technologies are economically beneficial mostly because they facilitate complementary innovations (Brynjolfsson and Hitt 2000). The evidence reported may also help explain the so-called *productivity paradox*, firstly pointed out by Roach (1987) and summarized in his well-known remark that '[Y]ou can see the computer age everywhere, except in the productivity statistics', since these the complementary investments, and the resulting assets, may be as much as an order of magnitude larger than the investments in computer and telecommunications technology itself. However, they may not be captured in the national accounts, suggesting that computers have made a larger real contribution to the economy than previously believed.

External knowledge sources, which are addressed in the paper by *computer services providers* and *domestic-international customers*, also play a relevant role as agents enabling different service innovation manifestations, especially the latter.

The higher or lesser advanced *character* of services activities under scrutiny is determined only on particular manifestations of innovation, namely the ones related to the expansion of income revenue, enlargement of production capacity, employment creation or the promotion of higher levels of internationalization. Enterprise size, which is addressed by the *number of employees*, is relevant in increasing productivity levels and expanding market or product. By contrast, the influence of the *character* of the service is almost negligible in terms of organizational impacts. On the other hand, *international-based* corporations deploy a substantially different innovative pattern in the sense that innovation is often catalyzed through strategies of internationalization and the creation of solid networks

and strategic alliances. Finally, no sectoral effects are detected in any of the five dimensions of innovation, except in service quality (with regards to product and process innovation) and number of employees (with regards to organizational innovation).

The strong role of both *ICT* in promoting innovation in services firms suggest that changes in services in conjunction with technological shifts are much deeper than what usually is accepted and, in this sense, services innovation and goods innovation are not so different. Besides, the co-production in services – whether produced in manufacturing or services firms – leads to innovations based on new ways of interfaces between clients and providers, which is certainly something specific to the highly interactive nature of many services. Further research should explore the horizontal nature of services innovation, in whatever industry is produced and even when it is directly associated to the production of goods, because service innovations and goods innovations are probably somewhat interconnected in this way. It has been a long time since services changed the macroeconomic profile of the 'industrialized' countries, and many studies (e.g., based on input–output tables) have captured the magnitude of those changes in the connection with the growing integration between goods and services. Now inter-sectoral changes can be found at the base of economic and entrepreneurial dynamism. Service innovation matters, but more attention is needed from researchers, statisticians and policy-makers. Current levels of information, data and political attention are still rather low, which explains the need for a more accurate knowledge about service innovation and its economic and social impacts.

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