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External Linkages, R&D and Innovation Performance in US Business Services

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Abstract
This paper examines the innovation performance of 206 US business services firms. Results suggest that external linkages, particularly with customers, suppliers and strategic alliances, significantly enhance innovation performance in terms of the introduction of new services. A highly qualified workforce increases the probability of service and organisational innovation, and increases the extent of a firm's innovation, but unqualified employees also play an important role. Contrasting with some earlier research on services, the presence of formal and informal R&D significantly increases the extent of new-to-market and new-to-firm innovation.

Keywords: Innovation, external linkages, R&D, US business services

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1. Introduction

By 2003, the service sector accounted for well over 60% of GDP in all OECD countries, and in major economies such as the United States, United Kingdom and France the average figure was already over 70%. In the same year, business services averaged around 25% of GDP for the OECD as a whole[1]. Services are now a major contributor to GDP growth as manufacturing industry in the developed countries increasingly finds it difficult to compete with the low-cost locations of China and South-East Asia. Given this, coupled with the now well-established observation that innovation and technological progress are the keys to long-term economic growth, it is surprising that innovation in services has not received a great deal of attention until recently.

In part this may be because of the traditional tendency to view services as being relatively 'low-tech' and non-innovative recipients of supplier-dominated technology when compared with the manufacturing sector, a tendency exacerbated by the fact that services often do not produce outputs which evidently embody advanced technology. However, the nature of service output, and the fact that service providers are less likely to engage in traditional R&D activities than their manufacturing counterparts, does not mean that service firms are not innovative: the consensus in the literature is that service firms do innovate, but may not do so in quite the same way as manufacturers (Barras, 1986; Gadrey, et al., 1993; Miles, et al., 1994; Sundbo, 1997; Coombs and Miles, 2000; Gallouj, 2002). For example, Tether (2005) shows that service innovation often depends on 'softer', skills-based innovation, relying heavily on the abilities of their workforce and on cooperation with outside organizations such as suppliers, customers, and other sources.

This paper adds to our knowledge of service sector innovation by examining one of the largest yet least researched areas: innovation by business service firms in the United States. Using survey results from 206 firms in SIC 73 (business services) in the United States, the research focuses on the determinants of innovation, with special attention being paid to the role of both internal R&D and a range of external sources of knowledge. We find that external sources, and especially customers, are important

[1] Source: OECD in Figures (2005 edition).

sources of knowledge for innovation in business services. The involvement of strategic alliances, suppliers and, in some cases competitors, also helps to increase the extent of innovation, and the role of workforce skills is important in some forms of innovation. However, we also find that internal R&D, both formal and informal, plays an important role which may have been underestimated in previous work on service innovation.

The remainder of the paper is organised as follows. Section 2 discusses the conceptualization of services in the theoretical and empirical literature, while Section 3 discusses the role of external knowledge sources in service innovation. The data are described in Section 4, and the econometric estimation is carried out in Section 5. Section 6 concludes.

2. Conceptualising Innovation in Services

Traditionally, innovation in services has largely been studied on the basis of theories of innovation in the manufacturing sector (Gallouj and Weinstein, 1997; Sundbo, 1997; Preissl, 2000; Gallouj, 2002; Drejer, 2004). This research base built upon manufacturing innovation theories thus prompts the question as to whether innovation in services should be a distinct research area, having its own conceptual foundation. Coombs and Miles (2000) distinguish three approaches to studying service innovation: the demarcation approach, the assimilation approach, and the synthesis approach.

Demarcation Approach

This approach argues that service innovation is distinctively different from manufacturing innovation (Coombs and Miles, 2000). Research under this approach takes a specialised view of innovation in services. The primary focus of studies under a demarcation approach is not to compare innovation in services directly with innovation in manufacturing, but instead to study distinctive features of service innovation (Drejer, 2004). Numerous authors (e.g. Gadrey, et al., 1995; Sundbo, 1998; Sundbo, 2000; Sundbo and Gallouj, 1998; Sundbo and Gallouj, 2000; Gallouj, 2000; Djellal and Gallouj, 2001) have argued that service innovations comprise

unique attributes which distinguish them from product or manufacturing innovations, such as their intangible nature, inseparability, and enhanced interactivity between client and firm (Fuchs, 1968; Gallouj, 2002; Blind and Hipp, 2003; Chapman and Hyland, 2003). Also associated with services is its immaterial nature, further defined as 'an offering' or 'a benefit' instead of a physical tangible object (Jiao, et al., 2003).

Research under this approach takes a specialised view of services, thus possibly creating a problem inferring that particular attributes of innovation are unique to services. Intangible attributes could exist in organisational, process, technological, or service innovations. Drejer (2004) argues that these particular features, assumed to be unique for services, may actually be characteristic of manufacturing, despite being ignored in the traditional product/process dichotomy. For example, Madsen's (1998) research, with regard to client interactivity, found collaboration on product development amongst Danish manufacturing firms. This research of product development actually found that innovating manufacturing firms often collaborated with suppliers of materials and components as often as they did with clients or customers. DeBresson et al. (1998) confirms that in 44% of the product developing firms a variety of partners were involved in product development. These findings demonstrate that innovation via interactivity is not unique for services. Additionally, the concept of modulization means that the service products are standardized, but as modules which can be combined by the customer (Sundbo, 1994; Tether, et al., 2001). With respect to the demarcation approach, modulization suggests a convergence between manufacturing and service organisations. This suggests that the peculiarities ascribed to services may not be so unique after all.

Assimilation Approach

Other researchers in the field of service innovation believe that an assimilation approach, which treats services similar to manufacturing, is useful (Sirilli and Evangelista, 1998; Gallouj, 2002). These studies group service and manufacturing firms together under one heading. Research under the assimilation approach focuses on a manufacturing based technology product-process approach to innovation, thus potentially ignoring other pertinent forms of service innovation (e.g. organisational innovation). Specifically, research via this assimilation method may pose a limited

perception of innovation, especially with regard to technological innovation (Coombs and Miles, 2000; Djellal and Gallouj, 2000; Drejer, 2004).

A technology-focused view of innovation may be too narrow for understanding the dynamics of services as well as manufacturing (Drejer, 2004). While the assimilation approach solves the issue of dismissing the importance of unique aspects, it does little to tackle the importance of non-technological innovation. Technological and non-technological innovations may well be important to both service and manufacturing organisations. As mentioned above, innovation may arise in numerous ways such as product, process, technological, organisational, or service. Both service and manufacturing organisations may well innovate in each of these various aspects.

Gadrey, et al. (1993) suggest that a specific, new service innovation theory is not necessary, because the manufacturing theories may be applied to services. However, they propose that the innovation concept should extend to include the development of a new service idea or concept. This particular view of extending innovation directly relates to a more inclusive approach, leading in turn to the third approach.

Synthesis Approach

The synthesis approach is an integrative approach to innovation which encompasses both manufacturing and services and also applies to technological and non-technological innovations (Gallouj and Weinstein, 1997; Preissl, 2000). Therefore, this approach attempts to address the missing aspects of both the demarcation and assimilation approaches. Simply addressing product or manufacturing innovations and service innovations, as does the demarcation approach, may leave out other types of innovation. Additionally, as compared to the assimilation approach, the synthesis approach allows for the inclusion of technological innovations. This addition of the terms technological and non-technological is imperative for understanding and studying innovation.

More specifically, service innovation, under the synthesis approach, brings to the vanguard neglected elements of manufacturing innovation relevant to services as well (Drejer, 2004). Product, process, technological, organisational, and service innovations should all be accounted for equally as they each provide organisations

opportunities to innovate. In other words, with this dynamic approach a vast array of organisational activities and processes within services and manufacturing are taken into consideration. "The ultimate aim of the synthesis approach is to create both theoretical… and empirical approaches to innovation that are able to embrace all economic activities, including manufacturing and services, without favouring some activities (and their modes of innovation) over others." (Tether, 2005 p 156)

The present research is in the spirit of the synthesis approach. It allows for both new product/service introductions as well as organisational and technologically-driven innovations, and explicitly allows for both internal and external sources of knowledge generation which may be relevant in both manufacturing and service-sector innovation.

3. The Role of External Sources in Service Innovation

Innovation cannot be regarded purely as an internal matter as firms' external linkages or networks may also play a potentially important role (Oerlemans, et al., 1998). Financially the role of external linkages may increase a firms' ability to appropriate returns from innovation (Gemser and Wijnberg, 1995). Also, Powell (1998) argues that external linkages may help by stimulating creativity, reducing risk, accelerating or upgrading the quality of the innovations made, and signalling the quality of firms' innovation activities. Previous empirical research has found that participation in collaborations is indicative of an ability for interactive knowledge sharing that may prove very beneficial for further exploitation of knowledge, and thus inter-firm linkages seem to promote innovativeness (Caloghirou, et al., 2002).

The use of external sources may be particularly important for the service sector. In a comparison of the innovation process of manufacturing and service firms, Tether (2005) finds that while manufacturers are more likely to innovate through using in-house R&D and collaborations with universities and research institutes, service firms are more likely to make use of collaborations with customers and suppliers, especially where they have an organisational orientation to their innovation activities. Leiponen (2005) finds support for this view. In a survey of Finnish business service firms, she finds that external sourcing of knowledge, especially from customers and competitors,

positively affected both the probability and extent of innovation, while in-house R&D intensity had no discernible effect.

The present study examines the role of these internal and external knowledge sources in the context of innovative performance among US business service enterprises. In addition to internal R&D, the roles of six potential external sources of inputs into innovation are examined; strategic alliances and joint ventures, suppliers, subsidiaries, customers, external consultants, and competitors. Each of these has to some extent received attention in the academic literature.

A firm's participation in strategic alliances or joint ventures has been widely researched topic. Strategic alliances and joint ventures include activities such as R&D partnerships, collaborative manufacturing, distribution, or complex co-marketing arrangements. The most common rationales offered for corporate partnering and external collaboration involve some combination of risk sharing, obtaining access to new markets and technologies, speeding products to market, and pooling complementary skills (Kogut, 1989; Kleinknecht and Reijnen, 1992; Hagedoorn, 1993; Eisenhardt and Schoonhoven, 1996). Additionally, firms use external relations, such as collaborations, as a temporary mechanism to compensate for capabilities a firm has not yet mastered and to expand all their competencies often by means of vertical integration (Powell, et al., 1996). Meyer-Krahmer and Reger (1999) stress the importance of not only large multinational firms joining together for R&D and technology but also countries in order to coordinate innovation strategies. Additionally, Linnarsson and Werr (2004) found that some of the challenges of radical innovation could be reduced by engaging in alliances for innovation.

Suppliers and their role in the value-added chain regarding innovation is also an important topic, particularly so due to the often close relationship existing between firm and supplier. This relationship allows for both formal and informal interaction, possibly a hotbed for originating innovative ideas and or suggestions (Hipp, 2000; Hughes and Wood, 2000; Freel, 2000; Bougrain and Haudeville, 2002; Sobrero and Roberts, 2002; Chung and Kim, 2003; Tether, 2005). The role of subsidiaries in service innovation has not been widely researched. Leiponen (2005) hypothesises that, due to the fact that subsidiaries may share the same corporate culture,

communication for new and improved developments may easily flow not only from parent to subsidiary, but also from subsidiary to parent, and so the role of subsidiaries is also considered in the empirical analysis below.

Existing customers can be an excellent source of information to service firms on areas in which their services could be improved, or suggesting new areas of activity which are either not being provided at all, or are currently being provided only (or better) by competitors. As a result, such customer interaction could be the source of both 'radical' and improved or imitated services. Customers' involvement in a firm's innovation process, either formal or informal, has been the subject of considerable research (Shostack, 1984; Gadrey, et al., 1995; Miles, et al., 1994; Strambach, 1994; Hughes and Wood, 2000; Preissl, 2000; Bougrain and Haudeville, 2002; Caloghirou, et al., 2002; Leiponen, 2005; Tether, 2005), with a general consensus that, where it exists, such input is generally favourable to service innovation.

With respect to the role of consultancy firms, it is suggested that the development of client–consultancy relations requires to be viewed as an interactive process, with both partners playing an equally important role (Hislop, 2002). Where this is the case, the use of consultancy firms has been shown to be another positive source for innovation (Hughes and Wood, 2000; Hipp, 2000), especially where the firms is considering moving into completely new areas of service delivery.

Closely monitoring the competition is an obvious tactic for many business firms, and can be an important source of ideas for new and improved products. Hughes and Wood (2000) report business service firms highly regarding the importance of competitors in the same line of business, and there is evidence that this can lead to innovative behaviour. Hipp (2000), for example, found a positive effect in knowledge-intensive business services (KIBS) which utilise competitors as an external source of innovation, and Leiponen (2005) found that completely new services are most often introduced by firms that engage in external knowledge sourcing particularly from customers and competitors.

4. Data

Data were collected via a postal questionnaire which was mailed in 2004 to all US businesses listed under SIC 73 (business services) on the Dunn & Bradstreet business database. Of the 3140 questionnaires mailed, 206 usable responses were obtained, representing a response rate of 6.5 %. In common with the population of SIC 73, the largest grouping of respondents comes from computer services (32%), business services not elsewhere classified (20.4%) and advertising (5.3%). No other sub-2-digit grouping represented more than 5% of respondents, and despite the relatively low response rate the sub-sectoral distribution of respondents is statistically representative of the Dunn & Bradstreet SIC 73 database (Table 1)[2].

The questionnaire collected information on the firms' innovative activity over the past three years, their own R&D activity, and the extent of the involvement in their innovative activity of six external linkages: strategic alliances or joint ventures, suppliers, subsidiaries, customers, consultancy firms, and competitors. The questionnaire also asked about different forms of innovative activity: the introduction of new services; organisational innovations; and technological innovations. With regard to new service introductions, information on three 'levels' of innovation was obtained (new to market; introduced by firm for the first time but not new to the market; and improvements). As the distinction between product and process innovation is often blurred in services (Sirilli and Evangelista, 1998), as is that between organisational and process innovation (Tether, 2005), the questionnaire avoided discussing process innovations and dealt with organisational innovations. However, in keeping with the synthesis orientation of the research, an attempt was made to distinguish between new organisational practices which did not involve the use of new technology, and changes of a process or organisational nature which were technologically driven[3].

[2] Although the overall response rate was disappointingly low, responses were received from 24 of the 32 four-digit groupings in SIC 73. No responses were received from: (7313) radio, television, and publishers' advertising representatives, (7334) photocopying and duplicating services, (7335) commercial photography, (7338) secretarial and court reporting services, (7377) computer rental and leasing, (7378) computer maintenance and repair, (7383) news syndicates, (7384) photofinishing laboratories. These eight categories represent only 2.94 per cent of the Dunn & Bradstreet database for SIC 73.

[3] The questions asked here were: 'Have you introduced any significant new or improved organizational practices (changes in work practices), that did not include technology, at this business since 2000?'; and 'Have you introduced any significant new or improved technological driven developments at this business since 2000? (e.g. real-time sales monitoring, e-commerce etc)'

Descriptive information, given separately for firms above and below 500 employees, is given in Table 2. The mean size of firms is very large, although almost half of the sample has mean employment of only 113. Over half of respondents have some in-house R&D facility, with one third claiming that they have a formal R&D department, suggesting that US business service firms are more active in R&D than is the case in other surveys (Tether, 2005; Leiponen, 2005). Although very few SMEs have a formal R&D department, it is notable that SMEs tend to be more R&D intensive (in terms of personnel and expenditure) than their larger counterparts.

Almost 80% of respondents introduced at least one new product in the previous three years, with an average of 41% of current sales being accounted for by services introduced or improved within the previous three years, almost half of which was represented by improvements to existing services. Although often characterised as relatively non-dependent on technology for their process/organisational changes, technologically-driven developments were experienced by over 60% of firms, and more than half of SMEs. Organisational innovation without a technological dimension was less common. Although the levels of innovation are generally lower overall for SMEs, there is not a massive difference in innovative performance between smaller and larger firms.

The data on external linkage shows the importance of this source of knowledge and ideas for innovation in US business services. The relevant question asks for the percentage of new services or products deriving from suggestions and/or ideas from each of the six external sources. Customers are, perhaps unsurprisingly, the single largest source of innovative ideas, followed by strategic alliances, competitors and suppliers: consultants and subsidiaries play a very minor role. This pattern of results holds for both SMEs and larger firms.

5. Econometric Estimation

a) Model

The econometric estimation considers two aspects of innovation performance. The first (probit analysis) estimates the determinants of whether the firm undertakes new

service, organisational, and technological innovation respectively. The second (tobit analysis) estimates the determinants of the extent of innovation, using the proportion of new services in total sales as the dependent variable. The model takes the form:

$$\mathbf{I}_i = \alpha + \beta_0 \mathbf{R}_i + \beta_1 \mathbf{C}_i + \beta_2 \mathbf{E}_i + \varepsilon_i$$

where $\mathbf{I}_i$ is the relevant measure of innovation, $\mathbf{R}_i$ is the set of internal resource indicators, $\mathbf{C}_i$ is the set of other firm characteristics, and $\mathbf{E}_i$ represents indications of external linkages.

The independent variables are derived from the literature; they are detailed in the appendix and summarised in Table 2. The internal resource indicators, are: firm size, level of qualification for employees, and internal R&D. Other firm characteristics include: age of the firm, type of business (independent/parent or part of a group), main type of service and products supplied (customised, tailored to specific customer groups, suitable for large customer groups, standardised or other). Lastly, the involvement of various external links are included as outlined earlier.

Size is a standard question for almost all studies of innovation, whether for manufacturing or service (Shan, et al., 1994, Tether, 1998; Antonelli, 2000; Antonelli, et al., 2000; Grupp and Maital, 2000; Meeus and Oerlemans, 2000; Hagedoorn and Cloodt, 2003; Galende and de la Fuente, 2003; Swamidass, 2003; Tether, 2005). The educational level of employees is also a standard variable (Love and Roper, 1999; Garrone and Colombo, 1999; Hipp, 2000; Bougrain and Haudeville, 2002; Ong, et al., 2003; Galende and de la Fuente, 2003; Swamidass, 2003; Tether, 2005). Having a qualified workforce is suggested to aid in a firm's innovative efforts. For example, Freel's (1999) research on SMEs reports that innovative firms are significantly more likely to employ graduates than their less innovative counterparts.

One of the most important determinants of innovation is research and development. Countless research regarding R&D and its role on innovation has been conducted (Love and Roper, 1999; Veugelers and Cassiman, 1999; Antonelli, 2000; Hipp, 2000; Preissl, 2000; Bougrain and Haudeville, 2002; Furman, et al., 2002; Love and Roper, 2002; Silverberg, 2002; Hagedoorn and Cloodt, 2003; Leiponen, 2005). Previous

research has shown that firms which conduct internal R&D are better able to use externally gathered information (Freel, 2000), an issue of absorptive capacity relevant when the addition of external linkages for innovation will be discussed. R&D is measured in two ways: first by a simple dummy variable indicating whether or not the firm undertakes R&D in house; and secondly by splitting R&D into formal and informal dummies.

Questions regarding firm vintage is a fairly common measurement in order to determine at which stage of the business life cycle the firm is (Love and Roper, 1999; Garrone and Colombo, 1999; Avermaete, et al., 2003; Tether, 2005). A dummy variable for independent/parent companies is used to allow for any possible effect of being a subsidiary or part of a larger group (Love and Roper 1999, 2001). Previous research in manufacturing suggests that the nature of the product offered by the firm may affect its capacity to innovate (Nijhof, et al., 2002; Love and Roper, 2005). Dummy variables relating to the predominant type of service offered by the firm are included to allow for this potential effect in services.

b) The likelihood of innovation (probit analysis)

Here the dependent variable takes the value 1 if the firm innovates and zero otherwise. New service, organisational, and technology-driven innovations are estimated separately (Table 3). Unfortunately, because of the number of independent variables and resulting collinearity issues, in the probit estimates not all the external sources could be entered into the estimating equation simultaneously. The internal resource and other firm characteristic variables proved robust to different combinations of external linkage variables, and the results in Table 3 show the estimates which offered the best fit with the survey data.

Service Innovation

Columns 1 and 2 of Table 3 show the results of probit analysis for service innovation (i.e. the introduction of a new service). There is a clear inverse U-shaped relationship between employment and employment squared i.e. the probability of innovation increases as the firm size increases, but at a decreasing rate. Having a higher proportion of the workforce with a degree also increases the likelihood of innovation,

as does the presence of in-house R&D. However, it is clearly a formal R&D department which has this effect: informal R&D has no effect on the probability of innovating[4]. Firm age does not have any affect on the likelihood of introducing service and product innovations.

As indicated in Table 3, customer involvement is the most common form of external involvement for the sample firms, and this is reflected in the probit results. The greater the input of customers in terms of ideas or suggestions, the higher the probability of innovation: this is a large and highly significant effect. There is no corresponding effect from strategic alliances or involvement with suppliers. The probit estimates show an excellent fit with the data, incorrectly allocating only four observations.

Organisational Innovation

Columns 3 and 4 of Table 3 are concerned with organisational innovations i.e. significant new or improved practices. The relevant question asks whether has the firm introduced any significant new or improved organisational practices (changes in work practices), that did not including technology. Gjerding's (1996) definition is similar regarding it an 'important organizational change'. Typically organisational innovations have been referred to as non-technological as firms often report these forms of innovation (Drejer, 2004). Moreover, this organisational change encompasses both product and process innovations; Preissl (2000) points that innovation surveys do not provide significant results for the distinction between process and organizational innovation in services.

Firm size has no effect on the likelihood of organisational innovation, but similar to service innovations, having qualified human capital increases the likelihood of being innovative. Intriguingly, having degree-level employees and employees with no post-school education both proves significant, with almost identical coefficients. Such findings may suggest that employing a workforce with various skill sets and backgrounds is important for internally originating innovations, or that once an employee joins a firm they then understand the corporate culture and are capable of

[4] R&D intensity, measured both by expenditure per sales and proportion of total employment, was also used as an alternative to the R&D dummies, but proved insignificant in all regressions.

aiding in the introduction of organisational developments. The importance of informal instruments and the formation of a corporate culture are often underestimated in innovation (Meyer-Krahmer and Reger, 1999), and these results suggest that it is not just highly qualified workers who can play a role in generating organisational innovation. Unsurprisingly, R&D has no effect on organisational innovation.

Age of the firm affects the probability of a service firm to initiate organisational innovations: the older a firm, the more likely it is to have made some organisational change in the previous three years. At first sight this may seem surprising, but it may simply reflect the fact that, as a rule, older firms are larger and more hierarchical with more layers and may need to introduce organisational changes more often than firms at the earlier stages of the life cycle, which tend to be characterised by reduced layers of hierarchy, greater lateral communication and greater empowerment to lower-level employees (Kanter, 1983). Lastly, the use of external linkages shows no significance for organisational innovation. Organisational innovation is internal and directly affects the operations of a service firm, thus it is possible that these various external sources for ideas and suggests are not knowledgeable regarding the internal business structure. Therefore, it is suggested that due to the internal nature of organisational innovations, these innovations usually derive from top management and not so much external links.

Technology-driven Innovation

Columns 5 and 6 of Table 3 relate to process/organisational developments which are technologically based, as opposed to those which have no specific technological component. Apart from a positive size effect and an effect related to firms which specialise in tailored services, there is little evidence of any other influence of the independent variables on the likelihood of innovation. The lack of significance of R&D is less surprising than it may appear, as most of the technologically driven developments are likely to be brought in rather than developed in-house (e.g. e-

commerce applications)[5]. There is no evidence of external links having an effect on the probability of performing this type of innovation.

c). The extent of innovation (tobit analysis)

This section concentrates on the introduction of new services by the respondent firms, and deals with the extent rather than the likelihood of innovation. The dependent variable for this analysis is the proportion of new products and services in total sales, which is a standard measure of innovative performance in empirical studies. This is measured in two ways: narrowly (new to the market i.e.'radical' innovations) and broadly (new to the firm, including improvements). As is standard in the literature for continuous but censored dependent variables of this type, tobit is used to estimate the model (Love and Roper, 1999; Leiponen, 2005). Unlike the probit models, in these models all of the questionnaires' six external links were able to be incorporated into the analysis simultaneously[6].

Table 4 shows the result of the tobit estimation for both measures of the extent of innovation. There are broad similarities, but some important differences, in the results. In neither case does size have any effect on the extent of innovation. R&D proves crucial for both definitions, but in slightly different ways. For new-to-market innovations both formal and informal R&D are highly significant, while for new-to-firm innovations informal R&D is both more significant and has a larger coefficient value than its formal counterpart. Coupled with the fact that the proportion of both qualified and unqualified workers proves significant for the broader definition of innovation only, this seems to lend some support for the view that service innovation often depends on skills-based innovation, relying heavily on the abilities of all of their workforce (Tether, 2005), at least in the case of less 'radical' introductions[7].

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[5] Part of the reason for the lack of effect of R&D on organisational or technologically-based innovation may lie the definition of R&D. For example, Djellal et al (2003) argue that R&D should be more widely defined to take account of, inter alia, the hybrid and composite nature of R&D projects in services.

[6] Tests of sectoral effects within SIC 73 were also carried out using sub-two digit SIC dummies. These always proved insignificant.

[7] It is possible, as pointed out by an anonymous referee, that the link between innovation and skill levels may run from innovation to skills i.e. innovation in services leads to the substitution of skilled for unskilled labour. However, one would therefore expect the coefficient sign on the proportion of unskilled labour to be negative rather than positive.

Despite some differences in the levels of significance, the coefficients on type of service provided show essentially the same pattern: customised and tailored services are negatively related to the extent of innovation, while firms which have more standardised offerings tend to have a higher level of innovation. It seems likely that this is a reflection of the ability of innovators to spread the cost of introducing new services over a wider customer base in the latter case.

The results for external linkages are striking. All have positive coefficients, and many are highly significant, showing that the greater is the input from these sources in terms of ideas and suggestions, the more innovative are the firms concerned. Alliances/JVs, customers and suppliers are all important sources of input into the innovative process in both measures of innovation. These finding, especially concerning service firms' interactions and relationships with customers, support those of previous empirical research (Gallouj and Weinstein, 1997; Gadrey and Gallouj, 1998; Djellal and Gallouj, 2000; Sundbo and Gallouj, 2000; Tether, 2003). There is also support for other empirical work: Hipp (2000) for example, found a positive effect in knowledge-intensive business services (KIBS) which use competitors as an external source of innovation. Additionally, Hughes and Wood (2000) report business services highly regarding the importance of competitors in the same line of business. In the present analysis consultancy firms matter for new-to-market innovations but not new-to-firm, with the reverse pattern for competitors. This is intuitively plausible. Consultants are more likely to have a major input and be relevant when the firm is contemplating a radical new introduction: by contrast, much of the input from competitors is likely to be imitation of their existing range of services, which by definition applies only to new-to-firm introductions.

6. Conclusions

Recent research on innovation in services has suggested that such firms rely heavily on the abilities of their workforce and on cooperation with outside organizations such as suppliers, customers, and other sources, and that in-house R&D plays little or no role in either becoming innovative or in the intensity of innovation (Tether, 2005; Leiponen, 2005). The present survey of 206 US business services firms suggests

some areas of both support and disagreement with previous research. In-house R&D is a significant determinant of becoming an innovator, but only if the R&D is formalized in some way. However, both informal and formal R&D are positively associated with increasing the extent or intensity of innovation, with informal R&D being particularly important for the introduction of services which are new to the firm or improvements on existing services, but not necessarily new to the market.

The role of workforce skills and abilities is also highlighted by the present research. The finding that graduate-level skills are positively associated with innovation is unremarkable. But the importance of a relatively high proportion of unqualified staff, especially in organisational and new-to-firm innovation, suggests that business service firms in the United States are capable of harnessing the skills of employees at all levels of the organisation, but in addition to, not as a substitute for, the more traditional R&D-based capabilities

Perhaps the most striking results concern the use of cooperation with outside sources in the innovation process. Six possible sources of outside cooperation were examined, and in all cases where they have an effect it is overwhelmingly positive. Customer involvement in particular proved very effective, both in helping firms become innovators, and in becoming more innovative. The involvement of alliances/JVs and suppliers also help to increase the extent of innovation, but do not encourage non-innovators to become innovators: the same is true of links with suppliers. Outside consultants can also help in the development of the most highly innovative new services, and competitors prove to be a highly effective source of ideas for imitated and improved products.

There is therefore mixed support for the view that service innovation often depends on 'softer', skills-based innovation, relying heavily on the abilities of their workforce and on cooperation with outside organizations such as suppliers, customers, and other sources (Tether, 2005). Clearly, these sources of ideas and skills are indeed important, but the crucial importance of 'harder', more traditional sources of innovation such as in-house R&D is emphasized in the present research, even in the context of business services. In this respect, service innovation might be more like manufacturing firms than has previously been realised; certainly the results above

give little support for the view that service innovation is a completely different concept from that of manufacturing innovation.

One possibility for the importance of R&D in the current sample compared with much of the earlier work on services could be because they are American firms; most empirical studies service innovation have looked at European firms, which may have a different attitude towards the organisation of innovation. For example, Love and Roper (2004) show that manufacturing firms within Europe have quite different organisational approaches to the process of innovation: these differences may be even greater between service-sector firms in Europe and the United States. This suggests one possible avenue for future research. Alternatively, the importance of (formal) R&D may derive from the relatively high proportion (32%) of sample firms from the computer services sub-sector. While such firms are not over-represented relative to the population (see Table 1), we cannot rule out the possibility that these firms are more likely than others within SIC 73 to use R&D within their innovation process. In addition, the limitations of the present research must be noted. It is a relatively small (albeit representative) cross-sectional survey of a large industry, and can tell us little about the dynamics of the innovation process. Nevertheless, the findings suggest that the role of R&D, workforce skills and especially external linkages on business service innovation in the United States is worthy of closer attention.

Table 1. Sub-sectoral distribution of population and sample

Main sub-sectors	Dunn & Bradstreet (% firms)	Responses (% firms)
Computer Services and Products	27.9	32.0
Business Services NEC	15.9	19.9
Advertising Services	8.2	7.8
Other	47.9	40.3
Total	100	100
χ^2 (3 df)	6.01	
p-value	0.111	

Table 2. Descriptive statistics

	All Firms	SMEs*	Large Firms**
Number of Observations	206	95	111
Internal Resource Indicators			
Size (employment mean)	13,611	113	25,042
Workforce with Bachelor's Degree (% mean)	40.3	44.2	37.1
Workforce with Bachelor's & Assoc. Degree (% mean)	50.6	49.1	52.3
R&D Activity in 2003 (% of firms)	55.6	40.4	68.5
R&D Dept. in Firm (% of firms)	34.3	17.2	48.7
R&D Intensity (% employment)	3.6	4.7	2.6
R&D Employees (number)	43.1	2.6	82.0
R&D Expenditure (% of sales revenue)	13	26.4	1.4
Other Service Firm Characteristics			
Age (in years)	36.3	17.2	52.7
Type of service offered (mean)			
- Customised services	39.3	38.0	40.5
- Services tailored to specific customer groups	35.4	34.7	36.0
- Services suitable for large customer groups	30.0	24.2	35.1
- Standardised services	25.4	19.0	30.6
- Other	16.2	11.6	19.8
Innovative Activity			
Service & Product Innovation (% firms)	79.1	71.6	85.6
Percentage of total sales accounted for by:			
- New Service introduced to market for the first time	13.0	12.5	13.3
- Newly Introduced Service (previously provided by other firms)	8.7	10.0	7.7
- Improved Service	19.6	17.0	21.8
- Unchanged Service	59.0	61.0	57.6
Organisational Innovation (% firms)	44.7	42.1	46.9
Technological Innovation (% firms)	61.7	53.7	68.5
External Linkages			
Percentage of ideas and/or suggestions from:			
- Strategic Alliances or Joint Ventures	13.3	11.3	15
- Suppliers	8.0	9.5	6.7
- Subsidiaries	4.0	1.5	6.0
- Customers	23.0	23.2	22.8
- Consultancy Firms	4.6	2.9	6.0
- Competitors	10.5	11.0	10.4

Notes: *Firms with less than 500 employees (not necessarily independent), ** Firms with 500 or more employees

Table 3: Determinants of innovation (probit models)

	Service Innovation		Organisational Innovation		Technological Innovation	
Constant	-3.67***	-3.73***	-4.66***	-4.71***	-1.76***	-1.82***
	(1.40)	(1.42)	(1.23)	(1.24)	(0.569)	(0.576)
Internal Resource Indicators						
Employment	0.001**	0.001***	0.000	0.000	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment Squared	-0.000***	-0.001***	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Workforce with Degree	0.019*	0.020*	0.026***	0.027***	-0.002	-0.001
	(0.011)	(0.011)	(0.010)	(0.010)	(0.005)	(0.006)
Workforce with no Quals	-0.061	-0.069	0.027*	0.030*	0.005	0.006
	(0.099)	(0.097)	(0.016)	(0.017)	(0.009)	(0.009)
R&D in house	1.39**	-	0.179	-	-0.152	-
	(0.673)		(0.465)		(0.376)	
Formal R&D	-	1.88**	-	0.112	-	-0.430
		(0.871)		(0.559)		(0.472)
Informal R&D	-	1.03	-	0.235	-	0.001
		(0.827)		(0.583)		(0.492)
Other Firm Characteristics						
Firm Vintage	0.004	-0.0004	0.016**	0.016**	0.000	0.000
	(0.017)	(0.018)	(0.008)	(0.008)	(0.008)	(0.008)
Business Type	1.45	1.49	0.336	0.292	0.430	0.422
	(0.938)	(0.939)	(0.556)	(0.571)	(0.393)	(0.409)
Customised services	-0.298	-0.243	-0.836	-0.707	-0.142	-0.063
	(0.916)	(0.890)	(0.839)	(0.843)	(0.392)	(0.399)
Tailored services	-0.897	-0.912	0.411	0.440	0.771**	0.830**
	(0.966)	(0.929)	(0.554)	(0.562)	(0.378)	(0.380)
Suitable for Large Groups	0.759	0.916	0.913*	0.972*	0.107	0.160
	(0.859)	(0.879)	(0.571)	(0.573)	(0.394)	(0.397)
Standardised	-0.461	-0.686	1.09*	1.12*	0.393	0.366
	(1.05)	(1.09)	(0.673)	(0.662)	(0.400)	(0.404)

(Table 3. contd)

External Linkages						
Alliance or Joint Venture	0.687	0.647	1.87	1.86	0.851	0.844
	(81.8)	(47.3)	(2928.7)	(2928.2)	(3044.2)	(3059.5)
Suppliers	0.142	0.129	8.33	8.45	1.78	1.75
	(65.5)	(35.9)	(4359.6)	(4340.4)	(3575.9)	(3606.3)
Customers	452.03***	564.71***	1.84	1.83	3.92	3.87
	(105.3)	(96.4)	(2530.9)	(2531.3)	(1480.5)	(1490.4)
Log Likelihood Function	-12.11	-11.77	-20.11	-19.95	-38.83	-38.11
Restricted Log Likelihood	-102.79	-102.55	-137.19	-136.60	-133.74	-132.80
Chi squared	181.36	181.57	234.15	233.31	189.83	189.40
R-squared ML	0.596	0.598	0.690	0.690	0.613	0.614
Number of Observations	200	199	200	199	200	199

	Predicted		
Actual	0	1	Total
0	42	0	42
1	4	154	158
Total	46	154	200

	Predicted		
Actual	0	1	Total
0	112	0	112
1	7	81	88
Total	119	81	200

	Predicted		
Actual	0	1	Total
0	77	1	78
1	14	108	122
Total	91	109	200

Notes: Standard errors in parentheses. Significant at *** 1%, **5%, *10%. Actual v. predicted tables refer to the first column of each set of results

Table 4: Determinants of extent of innovation (tobit models)

	New to market		New/improved to firm	
Constant	-32.72***	-30.36***	-33.93***	-25.84***
	(8.28)	(8.03)	(11.33)	(9.57)
Internal Resource Indicators				
Employment	0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Employment Squared	-0.000	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Workforce with Degree	0.027	0.005	0.448***	0.381***
	(0.077)	(0.076)	(0.107)	(0.092)
Workforce with no Quals	0.046	0.024	0.507**	0.496***
	(0.151)	(0.156)	(0.214)	(0.187)
R&D in house	19.03***	-	20.44***	-
	(5.36)		7.33	
Formal R&D	-	23.75***	-	13.93*
		(6.24)		(7.42)
Informal R&D	-	19.63***	-	20.81***
		(6.34)		(7.57)
Other Firm Characteristics				
Firm Vintage	-0.057	-0.069	0.129	0.125
	(0.066)	(0.065)	(0.092)	(0.079)
Business Type	4.65	3.87	5.71	2.79
	(5.06)	(5.05)	(7.06)	(6.19)
Customised services	-6.40	-6.80	-1.78	-1.16
	(4.83)	(4.74)	(6.89)	(5.91)
Tailored services	3.99	3.16	-20.19***	-16.57***
	(5.00)	(4.92)	(7.25)	(6.21)
Suitable for Large Groups	6.77	5.83	12.61*	10.74*
	(5.00)	(4.93)	(7.11)	(6.09)
Standardised	9.72*	8.73*	6.12	2.90
	(5.29)	(5.17)	(7.73)	(6.56)
External Linkages				
Alliance or Joint Venture	0.333***	0.294***	0.683***	0.588***
	(0.104)	(0.103)	(0.149)	(0.128)
Suppliers	0.504***	0.504***	0.462**	0.431***
	(0.138)	(0.135)	(0.194)	(0.167)
Subsidiaries	0.004	-0.019	-0.149	-0.112
	(0.222)	(0.217)	(0.317)	(0.275)
Customers	0.260***	0.245**	0.591***	0.497***
	(0.087)	(0.086)	(0.124)	(0.105)
Consultancy Firms	0.445**	0.442**	0.385	0.387
	(0.214)	(0.209)	(0.301)	(0.262)
Competitors	0.055	0.054	0.492***	0.499***
	(0.129)	(0.125)	(0.176)	(0.151)
Log Likelihood Function	-565.55	-563.96	-738.31	-806.55
Pseudo R^2 (Anova)	0.246	0.109	0.330	0.237
Pseudo R^2 (Decomp)	0.129	0.264	0.299	0.248
Number of Observations	200	199	200	199

Notes: Standard errors in parentheses. Significant at *** 1%, **5%, *10%

Appendix: Variable definitions

Dependent variables	
Service innovation	Dummy variable taking the value 1 if the firm introduced a new or improved service in the last three years
Organisational innovation	Dummy variable taking the value 1 if the firm introduced any significant new or improved organizational practices (changes in work practices), that did not include technology
Technological innovation	Dummy variable taking the value 1 if the firm introduced any significant new or improved technological driven developments
New to market	Proportion of current sales (by value) that consist of new services introduced to the market for the first time in the last three years
New/improved to firm	Proportion of current sales (by value) that consist of new or improved services to the firm in the last three years
Internal Resource Indicators	
Employment	Number of employees
Workforce with Degree	Percentage of employees with at least a Bachelor's degree
Workforce with no Qualifications	Percentage of employees with no post-school qualifications
R&D in house	Dummy variable taking the value 1 if the firm has in-house R&D
Formal R&D	Dummy variable taking the value 1 if the firm has an R&D department
Informal R&D	Dummy variable taking the value 1 if the firm has R&D but no formal department
Other Firm Characteristics	
Firm Vintage	Age in years
Business Type	Dummy variable taking the value 1 if the firm is independent or a parent company
Customised services	Dummy variable taking the value 1 if the firm mainly supplies services customised to individual customers
Tailored services	Dummy variable taking the value 1 if the firm mainly produces services tailored to specific customer groups
Suitable for Large Groups	Dummy variable taking the value 1 if the firm mainly produces services suitable for large customer groups
Standardised	Dummy variable taking the value 1 if the firm mainly produces Standardised services

(contd)

External Linkages	
Alliance or Joint Venture	Percentage of ideas/suggestions for innovation derived from strategic alliances or joint ventures
Suppliers	Percentage of ideas/suggestions for innovation derived from suppliers
Subsidiaries	Percentage of ideas/suggestions for innovation derived from subsidiaries
Customers	Percentage of ideas/suggestions for innovation derived from customers
Consultants	Percentage of ideas/suggestions for innovation derived from consultants
Competitors	Percentage of ideas/suggestions for innovation derived from competitors

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