(Revised)

Innovation, Productivity and Growth in US Business Services: a Firm-level Analysis

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Abstract

This paper examines the impact of innovation on the performance of US business service firms. We distinguish between different levels of innovation (new-to-market and new-to-firm) in our analysis, and allow explicitly for sample selection issues. Reflecting the literature which highlights the importance of external interaction in service innovation, we pay particular attention to the role of external innovation linkages and their effect on business performance. We find that the presence of service innovation and its extent has a consistently positive effect on growth, but no effect on productivity. There is evidence that the growth effect of innovation can be attributed, at least in part, to the external linkages maintained by innovators in the process of innovation. External linkages have an overwhelmingly positive effect on (innovator) firm performance, regardless of whether innovation is measured as a discrete or continuous variable, and regardless of the level of innovation considered.

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Key words: Innovation, Services, External Linkages, Productivity, Growth

1. Introduction

In the last decade an increasing body of research has begun to examine the nature, types, and causes of innovation in services. However, there is much less research on the impact of service innovation on business performance, especially at the firm level. As Cainelli et al (2006) point out, this is partly because of the difficulties involved in obtaining micro-level data, which is well developed in manufacturing but less so in services[1], and partly because of methodological problems relating to the availability of appropriate indicators to measure innovation activities in services. Metrics which are standard in manufacturing, such as R&D and patents, may be less meaningful in the case of services (Evangelista and Sirilli, 1995; Djellal and Gallouj, 1999; Love and Mansury, 2007)

It is increasingly recognised that models of innovation developed principally for manufacturing may not apply easily to services. For example, the traditional distinction between product and process innovation is less useful in services, which are often processes that cannot be easily disentangled from the outcomes they produce. And the way in which service firms innovate are often different from manufacturing firms. Tether (2005) analyses data from the European Innobarometer, a telephone survey of managers in over 3,000 firm, and found substantial differences in the way manufacturing and service firms performed innovation. Service firms were much more likely to regard organisational change as important and to develop innovations in collaboration with customers and suppliers, while manufacturers tended to stress the importance of their in-house R&D and research links with universities. In addition, manufacturers tended to emphasise 'hard' strengths such as R&D competence and flexibility of production methods while service providers more frequently stressed 'soft' skill such as workforce skills and collaborative interactions[2].

An important issue is therefore whether and how the different ways in which service firms perform the process of innovation affect the economic performance outcomes which result from innovation. This is the focus of the present paper, which examines

[1] This has been partly mitigated in Europe by the extending the coverage of the Community Innovation Survey to provide more complete data on services.
[2] See also Freel (2005) for an analysis of the differential links between innovation and skills among manufacturing and service SMEs.

the impact of innovation on the economic performance of a sample of service sector firms. The paper adds to our knowledge of service sector innovation in three ways. First, we use data from the United States: most of the previous studies of the effects of innovation in services have been from Europe (e.g. Cainelli et al , 2004, 2006). Secondly, we distinguish between different levels of innovation (new-to-market and new-to-firm) in our analysis, and allow explicitly for sample selection issues. Finally, reflecting the literature which highlights the importance of external interaction in service innovation (Howells and Tether, 2004; Tether, 2005; Kanerva et al, 2006), we pay particular attention to the role of external innovation linkages and their effect on business performance.

2. Service Innovation and Business Performance

Conceptualising Innovation in Services

Traditionally, services have been defined in a rather negative sense; once production industries are defined, everything else is allocated to a tertiary 'services' sector. This bundling of activities of heterogeneity in application and production has added to the difficulties of understanding the most rapidly growing sector in modern economies and has contributed to the tendency in the past to consider services as residual, dependent on manufacturing, technologically backward, and – consequently – not very innovative.

This view of services has now changed. Services are now often defined as activities directed at creating changes or transformations of form, place or time of availability in some entities, and the entities involved may be material objects, goods, people, the natural environment or symbolic representations (data, text, etc.) (Metcalfe and Miles, 2000). While it is now generally accepted that service firms do innovate and that frequently they also conduct R&D, the empirical evidence suggests that, on average, innovation rates in services tend to be lower than those in manufacturing (e.g. Kanerva et al, 2006)[3]. This has tended to suggest that, at least in part, the lower levels of innovation in services arises because service firms innovate differently,

[3] However, much of this information arises from analysis of data arising from the successive Community Innovation Surveys (CIS2, 3 and 4): we know much less about the nature and effects of innovation elsewhere.

which in turn has led to different ways of conceptualising innovation in services. For example, Coombs and Miles (2000) distinguish three approaches to studying service innovation: the assimilation approach, the demarcation approach, and the synthesis approach.

(i) The assimilation approach analyses services in the same way as manufacturing, using technology-based indicators and metrics. 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).

(ii) The demarcation approach argues that service innovation is distinctively different from innovation in manufacturing, following dynamics and displaying features that require new theories and instruments (Sundbo and Gallouj, 2000; Djellal and Gallouj, 2001),

(iii) The synthesis approach suggests that while manufacturing and service innovation share many similarities which allow them to be analysed together, service innovation brings to the forefront hitherto neglected elements of innovation that are of relevance for manufacturing as well as services e.g. the great heterogeneity among services and the need to take a broad view of innovation and the process which underlies it (Gallouj and Weinsten, 1997; Preissl, 2000; Hipp and Grupp, 2005).

Consistent with both the demarcation and synthesis approaches is the recognition that the process of innovation may be different in services; for example, the traditional distinction between product and process innovation may be less meaningful in services. Howells and Tether (2004) suggest a more meaningful distinction may be between inward-looking and outward-looking innovation activity, with the former dealing mainly with how the firm undertakes its activities (i.e. close to the process issue, but with the potential for product effects), while outward-looking innovation is more concerned with the firm's interaction with other actors, notably customers. This is supported by the view that 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.

In a recent contribution Kanerva et al (2006) also note the tendency for service firms to be more outward focussed than manufacturing firms in terms of the use of external knowledge sources in innovation. Examining CIS3 data in manufacturing and services for all 25 EU member states, they conclude that innovation in the service sector cannot easily be measured through indicators developed principally to measure (technical) innovation in manufacturing, and conclude that the main reason for this is because of differences in the nature of innovation in the service sector and in the manufacturing sector. In particular, they argue that service sector innovation could rely much less on the (internal) accumulation of capabilities, permitting service sector firms to move much more rapidly to best practice than manufacturing firms.

Innovation and performance

Since the early work of Joseph Schumpeter (1934), innovation has been recognized as a key element of competition and dynamic efficiency of markets. Innovators (product, process and organizational) should take market share from non-innovators and grow at their expense, until such time as the quasi-monopoly position is undermined first by imitations of new products and processes, and ultimately by yet newer products. In the long run, therefore, innovators will grow faster, be more (dynamically) efficient, and ultimately be more profitable than non-innovators.

There is a wealth of evidence in the academic literature indicating a positive relationship between innovation and firm performance in manufacturing (e.g. Crépon et al, 1998; Lööf and Heshmati , 2001, 2002; Mairesse and Mohnen, 2003). Reflecting the lack of maturity of the analysis of service sector innovation, studies of

the relationship between innovation and business performance in the service sector are still relatively rare. Cainelli et al., (2004) note that much of the evidence in the field is descriptive and not supported by robust evidence, especially at the firm level. Much of what we do know about the link between innovation and performance in services has come from the analysis of CIS data, especially in Italy. Cainelli et al. (2004) match Italian CIS 2 data with longitudinal firm performance data, focussing particularly on the relationship between innovation in the 1993-95 period with economic performance in the subsequent three years (i.e. 1996-98). They find that innovating firms consistently outperform non-innovators in terms of productivity and growth, that a strong positive relationship exists between innovation and subsequent productivity and growth, and that productivity is strongly linked to previous investment in innovation activity. In a subsequent analysis of the same dataset, Cainelli et al (2006) examine the interaction between innovation and performance in more detail, and conclude that there is a two-way relationship: innovative firms outperform non-innovators, but better performing firms are also more likely to innovate, and to devote more of their resources to innovation. They conclude that there is "a cumulative a self-reinforcing mechanism" linking innovation and performance (p 454). Additionally, Evangelista and Savona (2003) report that service firms which spend more on innovation per employee, and those introducing service innovations, are more likely to report a positive impact of innovation on total employment.

Although limited, the evidence on innovation and performance in services suggests a positive effect of innovation on productivity and growth. There is therefore a body of evidence suggesting that external linkages, especially customer linkages, have a positive impact on innovation (Tether, 2005; Leiponen, 2005), and another body of evidence indicating that innovation positively influences performance. The implicit assumption, therefore, is that the performance impact of external linkages is entirely indirect, via the impact on innovation. What is missing from the innovation literature is any explicit consideration of the *direct* impact of external innovation linkages on subsequent economic performance. However, there is reason to believe such an effect may exist. There is evidence (largely from the marketing literature) that firms

that are customer oriented[4] experience an increase in performance (Narver and Slater, 1990; Donaldson, 1993; Bougrain and Haudeville, 2002; Tether, 2002). In the case of service firms, one key aspect of customer orientation is through integrating the customer into the production and innovation process. It is not uncommon for a service firm's client to initiate and stimulate innovations, and frequently customer participation is a necessary condition for success (Preissl, 2000). The close interaction between service provider and customer participation comes in various forms while creating service innovation, and numerous concepts have been developed in order to account for this client participation, such as co-production, servuction and service relationship (Sundbo and Gallouj, 2000): indeed, under some circumstance the customer could become so closely involved with the innovation process as to be virtually an internal rather than an external resource[5].

Since other external linkages such as suppliers, consultants and subsidiaries can also positively influence innovation (Love and Mansury, 2007), it is worth examining whether these linkages too may have a direct effect on performance. In the empirical estimation below we therefore first test whether there is any evidence of innovation affecting performance on a sample of US business service companies, and then look for evidence of a link between the extent of external involvement in innovation and firm performance.

3. Data

Business services (classified as SIC 73) are defined by the US government as establishments primarily engaged in providing services, not elsewhere classified, for business establishments on a contract or fee basis. Data were collected via a postal questionnaire which was mailed in 2004 to all US businesses listed under SIC 73 on the Dunn & Bradstreet business database. The questionnaire collected information on the firms' innovative activity and performance over the previous three years, their

[4] Rafiq and Ahmed (2000) define customer orientation as "A planned effort using a marketing-like approach to overcome organizational resistance to change and to align, motivate and inter-functionally co-ordinate and integrate employees towards the effective implementation of corporate and functional strategies in order to deliver customer satisfaction through a process of creating motivated and customer-oriented employees."

[5] We are grateful to an anonymous referee for making this point.

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, consultants, and competitors. With regard to new service introductions, information on two 'levels' of innovation was obtained: new-to-market and new-to-firm (i.e. introduced by the firm for the first time but not new to the market). The questionnaire was a modified version of that used in the Irish Innovation Panel (Love and Roper, 2007) and was therefore compatible with the OECD Oslo Manual and included most of the questions asked in the EU's Community Innovation Survey, but also included a number of questions relating to the firm's commercial performance. These included questions on turnover, capital investment and input costs, which allowed calculations of value added, as well as employment and sales growth over the period 2000-2003.

Following pilot testing, the questionnaire was administered by US mail, with a post card reminder mailed nine days afterwards. Of the 3140 questionnaires mailed, 206 usable responses were obtained, representing a modest response rate of 6.5 %: unfortunately, resource constraints prevented a further follow-up mailing. 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).

Almost 80% of respondents introduced at least one new service 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. Table 2 shows descriptive statistics for the economic performance and internal resource indicators of the sample, split between innovators and non-innovators. Innovators have higher productivity (value added per employee), sales growth and employment growth than non-innovators, providing prima facie support for the hypothesis that innovation is linked to improved performance. However, innovators are also larger, more export oriented, have a better-qualified workforce and are older than non-innovators. This clearly

suggests that these internal resource differences must be taken into account in estimating the impact of innovation on performance, and also has implications for the estimation procedure, outlined in the next section. The data on external linkages show 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.

4. Model and Estimation

The empirical model relates the economic performance of US business services firms to their innovation outputs and external linkages, conditioning for a set of internal resource and other firm characteristics which may affect performance. The simplest method of estimation would be to assume that the innovation decision and the extent of innovation is simply exogenous to performance i.e.

$$PERF_i = \alpha + \beta_0 R_i + \beta_1 C_i + \beta_2 I_i + \varepsilon_i \qquad (1)$$

Where $PERF_i$ is the performance of firm i, (value added per employee, sales growth, employment growth) expressed in log form, R_i is a set of internal resource indicators, C_i is a set of other firm characteristics, I_i is a measure of innovation.

However, both conceptually and given the data descriptions discussed above, it is unreasonable to assume that innovators and non-innovators are randomly sampled from the population of business services firms, and so allowance must be made for the potential sample selection issues which this entails. For example, we have to acknowledge the possibility that highly productive, high-growth firms self-select to become innovators: if such self-selection is present this could seriously bias the results of estimating equation (1). An obvious solution is the Heckman two-stage estimator for sample selection. This procedure starts with a probit model of the determinants of innovation, where the dependent variable is a dummy variable [0, 1] indicating whether or not the firm has innovated over the previous three years. In the

second stage an equation such as (1) is estimated, but using the predicted values of innovating derived from the probit equation. This can be expressed as follows:

$$PERF_i = \alpha + \beta_0 R_i + \beta_1 C_i + \beta_2 I_i + \varepsilon_i \quad (2a)$$

$$I^*_i = \gamma \boldsymbol{X} + \mu \quad (2b)$$

$$I_i = 1 \text{ if } I^*_i > 0, \text{ and } I_i = 0 \text{ if } I^*_i = 0$$

Where I^*_i is a dummy innovation variable and $\boldsymbol{X}$ is a vector of determinants of innovation. In the above case, because I_i is both the sample selection criterion and a regressor in the second stage of estimation, a variation on the selection model such as the treatment effects model is more appropriate. To allow for correlation between I_i and ε_i equations (2a) and (2b) are estimated using 2SLS, using the predicted probabilities from probit equation (2b) as the instrument for I_i (Greene, 1998, 716-7). A variation on the basic model allows the measure of innovation in equation (2a) to be the *extent* of innovation rather than a dummy innovation variable, measured by the percentage of new-to-market or new-to-firm products in total sales. Here the standard Heckman two-stage procedure can be used, preserving all observations in the second stage.

The basic model implied by equation (2) does not allow for the process by which firms gather knowledge for innovation, an issue which the literature reviewed above indicates is particularly important for service sector firms. At the level of the firm, conceptual models typically see external knowledge sourcing as a substitute for internal knowledge creation (i.e. the classic make or buy decision) giving firms the ability to obtain specialist knowledge and/or accelerate knowledge acquisition. Such alternatives have, until recently, however, only been poorly reflected in the empirical literature with Crépon et al. (1998) and Lööf and Heshmati (2001, 2002) implicitly assuming that undertaking R&D provides a unique route through which a firm may acquire the knowledge on which to base its innovation activities. This assumption is contradicted by much recent evidence, however, which stresses the importance for innovation of knowledge flows which span the boundaries of individual businesses creating 'extended enterprises' and providing the basis for competition between supply chains. At the level of the individual business too, inter-company networks

(e.g. Oerlemans et al., 1998) and intra-group knowledge transfers (e.g. Love and Roper, 2001) have been shown to have positive effects on innovation outputs.

In order to allow for the influence of external knowledge sources operating on performance through their interaction with innovation, the basic model is modified as follows:

$$PERF_i = \alpha + \beta_0 R_i + \beta_1 C_i + \Sigma \beta_3 I_i.E_i + \mu_I \quad (3a)$$

$$I^*_i = \gamma \boldsymbol{X} + \mu \quad (3b)$$

$$I_i = 1 \text{ if } I^*_i > 0, \text{ and } I_i = 0 \text{ if } I^*_i = 0$$

where $I_i.E_i$ represents the interaction between innovation and six forms of external knowledge sources. Because I_i does not appear directly as a regressor in the second stage, estimation of equation (3) can be carried out using the standard Heckman two-stage procedure, preserving all observations in the second stage. As with equation (2), three innovation metrics are employed: a dummy innovation variable, the percentage of new-to-market products in total sales, and the percentage of new-to-firm products in total sales.

In the estimations discussed below, performance is measured in three ways. Productivity is measured by value added per employee in 2003, while growth is measured by the percentage change in sales volume and employment over the period 2000-2003. All estimations are carried out with the dependent variables in logged form.

An important element in the two-stage modelling process is equation (2b), and an appropriate vector ***X,*** the determinants of whether or not firm i undertakes service innovation. Here we employ a model in which innovation depends on the firm's internal knowledge generation (i.e. R&D) and external knowledge linkages, as well as indicators of other internal resources such as size, human capital and ownership structure. This model is detailed in Love and Mansury (2007) where it is shown to have a very good fit with the data and strong predictive properties. The model results are shown in the Appendix (Table AII).

5. Results

Innovation and performance

Table 3 shows the results of estimating equation (2a). Employment shows a U-shaped relationship with growth, but has no effect on productivity. As might be anticipated, capital intensity is positively associated with productivity, while exporting firms are more productive but grow more slowly than non-exporters. The only pertinent finding under 'other service firm characteristics' involves offerings tailored to specific customer groups. This finding suggests that service firms which offer tailored service and product have more sales growth: possible reasons for such sales growth may include niche marketing or an expansion of offering newly tailored services and products to existing customers.

The key finding from Table 3 is the effect of innovation. Innovation has a positive effect on sales and employment growth, a finding valid for both the dummy variable and continuous measures of innovation[6]. Estimated at the mean value of each, the results for sales growth indicate elasticities of 0.20 for new-to-market products and 0.39 for new-to-firm products, suggesting substantial growth effects of introducing products which are new, even if they are not completely new to the market. Innovation has no effect on productivity: intriguingly, the extent of both new-to-market and new-to-firm products have negative (but insignificant) coefficients with respect to productivity. Similar – and indeed stronger – effects have been noted in studies of manufacturing industry. For example, in a study based on data from Ireland Roper et al (2006) find that process innovation has no effect on productivity and product innovation actually reduces productivity. This result, which has been noted elsewhere (Freel and Robson, 2004), they interpret as a disruption effect: the introduction of new products to a plant may disrupt production and reduce productivity in the short term. Alternatively, the negative productivity effect of innovation success may be explained by a product-lifecycle type effect. In this scenario, newly introduced products are initially produced inefficiently with negative productivity consequences before becoming established and the focus of process innovations to improve productive efficiency. Leiponen (2000) also notes the negative

[6] The employment effect of new-to-market innovations is just insignificant at 10%.

effect of product innovation on Finnish manufacturing firms' *profitability*, which she also ascribes to a disruption effect. The lack of significance of innovation's effect on productivity in the present sample suggests that any disruption effects were insufficiently strong to cause actual decreases in productivity.

Table 3 also shows for each equation the inverse Mill's ratio (Lambda), a significant coefficient on which indicates the presence of a significant sample selection effect. In only one case (the impact of new-to-market innovation on productivity) is there a marginally positive lambda coefficient on the Heckman sample selection estimations, suggesting that sample selection issues do not result in a substantial bias in the estimation results.

Innovation, external linkages and performance

Table 4 shows the results of estimating equation (3a). Here the innovation variables are interacted with the extent to which external actors were involved in the innovation process (see Appendix Table AI). The interaction coefficients thus show the impact on productivity and growth of external innovation linkages among innovators. In the first set of estimations (columns 1-3) the interaction is with a service innovation dummy; in the remaining columns external involvement is interacted with the *extent* of new-to-market and new-to-firm product sales respectively. In all cases for non-innovators the interaction terms take the value zero.

The internal resource and firm characteristic indicators show virtually no difference with those of Table 3. The employment, capital intensity and export effects remain unchanged; the only slight difference is that the effect of tailored services disappears. However, there is substantial new information provided by the innovation interaction terms. The first point to note is that, where they have an effect, external innovation linkages are overwhelmingly positive: of sixteen significant interaction coefficients all but two are positive, suggesting that external innovation linkages have a generally positive effect on the performance of US business service firms. This is particularly true of links with alliance or joint venture partners and with customers. The greater are linkages with alliance partners, the higher is sales and (generally) employment growth across all types of innovation. The greater are customer linkages among

innovators the higher is sales and employment growth. Involvement with external consultants in innovation leads to higher productivity but no effect on sales or employment growth. The one negative effect is with respect to suppliers, where greater supplier linkages are associated with reduced growth rates. The coefficients are negative in most cases here, but significant only in the case of new-to-market innovation linkages. As with most of the estimates in Table 2, the insignificant coefficients on the inverse Mill's ratio (lambda) suggest no sample selection bias in the estimation.

Because of the log-linear nature of the estimation, some idea of the scale of the external interaction effects can be gained by calculating the elasticities of significant coefficients at their mean value: these are shown in Table 5. Because of the nature of the interaction terms little significance can be attached to size of the elasticities *per se*, but we can make inferences of which type of external interactions have relatively greater effects. In terms of sales and employment growth it is clear that customer innovation linkages have the greatest effect, approximately double those of alliance/JV innovation interaction. The negative elasticities of new-to-market customer linkages on growth are very small, albeit statistically significant. In all cases differences in how the interaction term is measured makes relatively little difference to the size of the elasticities: for example, the elasticities for customer involvement on sales growth are 0.29, 0.24, and 0.28 respectively. This similarity in elasticities is also the case for linkages with consultancy firms, the only external link that has any effect on productivity,

6. Conclusions

The purpose of this analysis is to add to the relatively limited body of research on the impact of innovation on service sector performance. Previous research suggests a positive relationship between innovation, productivity and growth in manufacturing, but there is limited evidence for services and an apparent dearth of studies on US services. The study has paid particular attention to the role of external linkages and the way in which they interact with innovation to affect performance.

Using data from a survey of 206 US business services firms, we find that the presence of service innovation and its extent has a consistently positive effect on growth, but

no effect on productivity. There is evidence that the growth effect of innovation can be attributed, at least in part, to the external linkages maintained by innovators in the process of innovation. External linkages have an overwhelmingly positive effect on (innovator) firm performance, regardless of whether innovation is measured as a discrete or continuous variable, and regardless of the level of innovation considered. In particular, involvement with customers and alliance or joint venture partners in the innovation process has a consistently positive effect on growth, while there is some evidence that involving external consultants in the innovation process induces a positive impact of innovation on productivity.

The obvious limitation of the study is its cross-sectional nature, with the implications for endogeneity and direction of causality which this implies: does innovation really improve performance, or are well-performing firms simply more likely to become innovators? Within the confines of a cross-sectional study we have attempted to deal with this issue; the structure of the questionnaire allows for a slight lagged effect of innovation on performance, and we have explicitly allowed for sample selection issues by using instrumental variable estimation. However, we are clearly precluded from a detailed consideration of, for example, the lagged effect of performance both on itself and on innovation. Notwithstanding this important issue, one of the clear messages of this research is the important positive influence of external innovation links on performance, coupled with the relatively slight influence of internal resource indicators such as size and workforce qualifications. This may lend support for the argument of Kanerva et al (2006) that the nature of innovation in the service sector relies less on the stock of accumulated capabilities which e.g. R&D and patenting activity provides in manufacturing, providing more leeway in services to use external innovation linkages as a method of rapidly moving towards best practice. This may in turn have implications for the conceptualisation of innovation in services, lending further support for a demarcation or synthesis approach. Such an approach would not only takes a broad view of innovation and the process which underlies it, but would also allow both for the different ways in which innovation occurs in manufacturing and services, and for the effect which these differences have on subsequent economic performance.

Table 1. Sub-sectoral Distribution of Population and Sample

Main sub-sectors	Dunn & Bradstreet (% firms)	Responses (% firms)
Computer Services	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 and Performance Indicators: Innovators and Non-innovators

	Innovators (mean)	**Non-Innovators (mean)**
Performance		
Productivity ($ log)	11.2	10.7
Sales growth (%)	40.3	14.3
Employment growth (%)	20.9	11.5
Internal Resource Indicators		
Employment	16918	1151
Exports (% of sales)	14.1	9.5
Capital intensity ($000)	210.4	121.5
Degree level employees (%)	43.6	27.9
Age (years)	40.5	20.5
Independent (proportion)	0.55	0.74
External linkages		
Alliances/JVs (% of innovations)	16.8	--
Suppliers (% of innovations)	10.1	--
Subsidiaries (% of innovations)	4.9	--
Customers (% of innovations)	29.0	--
Consultants (% of innovations)	5.8	--
Competitors (% of innovations)	13.2	--

All differences except capital intensity are significant at 5% or better on a 2-tailed t-test.

Table 3: Estimation of equation (2a)

	Product Innovation Dummy			New-to-Market Innovation			New-to-Firm Innovation		
Log	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth
Constant	10.407[a]	1.988[a]	1.756[a]	10.818[a]	2.445[a]	2.020[a]	10.769[a]	2.373[a]	1.962[a]
	(0.577)	(0.388)	(0.396)	(0.508)	(0.339)	(0.346)	(0.512)	(0.341)	(0.371)
Internal Resource Indicators									
Employment (10^{-5})	-0.844	-2.474[a]	-2.977[a]	-0.514	-2.417[a]	-2.914[a]	-0.669	-2.281[a]	-2.846[a]
	(1.4038)	(0.943)	(0.961)	(1.418)	(0.946)	(0.966)	(1.407)	(0.935)	(0.956)
Employment Squared (10^{-5})	0.044	0.085[b]	0.115[a]	0.031	0.082[c]	0.112[a]	0.037	0.075[c]	0.108[a]
	(0.065)	(0.044)	(0.045)	(0.066)	(0.044)	(0.045)	(0.066)	(0.043)	(0.044)
Capital Intensity (10^{-5})	0.041[a]	0.001	-0.005	0.040[a]	0.002	-0.005	0.041[a]	0.002	-0.005
	(0.009)	(0.006)	(0.006)	(0.009)	(0.006)	(0.006)	(0.009)	(0.006)	(0.006)
Exports	0.013[c]	-0.008[c]	-0.008[c]	0.013[c]	-0.007[c]	-0.008[c]	0.014[c]	-0.008[c]	-0.008[c]
	(0.007)	(0.005)	(0.005)	(0.007)	(0.004)	(0.005)	(0.007)	(0.005)	(0.005)
Workforce with Degree	-0.002	-0.001	-0.001	-0.001	0.001	0.001	-0.002	-0.002	-0.001
	(0.006)	(0.004)	(0.004)	(0.006)	(0.004)	(0.004)	(0.006)	(0.004)	(0.004)
Workforce with no Qualifications	-0.008	-0.003	0.006	-0.007	-0.001	0.009	-0.006	0.004	0.005
	(0.012)	(0.008)	(0.008)	(0.012)	(0.001)	(0.009)	(0.012)	(0.008)	(0.008)
Other Service Firm Characteristics									
Firm Vintage	0.004	-0.003	-0.004	0.004	-0.001	-0.002	0.005	-0.003	-0.003
	(0.005)	(0.003)	(0.003)	(0.005)	(0.003)	(0.004)	(0.005)	(0.003)	(0.003)
Business Type	0.227	0.265	0.202	0.217	0.152	-0.074	0.200	0.203	-0.042
	(0.354)	(0.235)	(0.240)	(0.354)	(0.234)	(0.239)	(0.354)	(0.233)	(0.238)
Customised Services	-0.384	-0.102	-0.108	-0.344	-0.036	-0.095	-0.326	-0.095	-0.132
	(0.360)	(0.238)	(0.243)	(0.364)	(0.241)	(0.245)	(0.364)	(0.239)	(0.244)
Tailored Services	0.287	0.531[b]	0.377	0.260	0.414[c]	0.313	0.227	0.543[b]	0.2395
	(0.365)	(0.243)	(0.248)	(0.367)	(0.243)	(0.248)	(0.369)	(0.243)	(0.249)
Large Customer Groups	-0.230	0.038	0.081	-0.201	0.009	0.074	-0.229	0.026	0.083
	(0.371)	(0.245)	(0.250)	(0.376)	(0.247)	(0.252)	(0.374)	(0.245)	(0.251)
Standardised	0.052	-0.284	-0.247	0.067	-0.425[c]	-0.323	0.019	-0.374	-0.296
	(0.385)	(0.259)	(0.263)	(0.392)	(0.262)	(0.267)	(0.388)	(0.258)	(0.264)

Table 3 (contd.)

	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth
Innovation									
Innovation (dummy)	0.503	0.921[a]	0.560[c]						
	(0.466)	(0.314)	(0.320)						
Innovation (percent sales) (10^{-3})				-8.395	14.576[b]	8.452	-0.923	9.613[a]	6.289[c]
				8.825	(5.840)	(5.934)	4.981	(3.275)	(3.342)
Lambda				1.486[c]	-0.154	-0.868	1.222	-0.063	-0.850
				(0.872)	(0.653)	(0.617)	(0.872)	(0.632)	(0.595)
Adj. R squared	0.072	0.098	0.067	0.070	0.085	0.067	0.065	0.096	0.075
Durbin-Watson	2.00	1.89	1.98						
Rho	-0.002	0.053	0.005	0.685	-0.105	-0.583	0.564	-0.044	-0.573
Number of Observations	179	184	184	179	184	184	179	184	184
Estimation	2SLS	2SLS	2SLS	Heck-man	Heck-man	Heckman	Heckman	Heckman	Heckman

Notes: Standard Errors are in parentheses. Significant at [a]1%, [b]5%, [c]10%

Table 4: Estimation of equation (3a)

	Product Innovation Dummy			New-to-Market Innovation			New-to-Firm Innovation		
Log	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth
Constant	10.381[a]	2.132[a]	1.796[a]	10.709[a]	2.421[a]	1.979[a]	10.674[a]	2.416[a]	2.022[a]
	(0.535)	(0.353)	(0.358)	(0.492)	(0.324)	(0.331)	(0.500)	(0.331)	(0.325)
Internal Resource Indicators									
Employment (10^{-5})	-1.291	-2.225[b]	-2.636[a]	-0.747	-2.099[b]	-2.666[a]	-0.972	-2.031[b]	-2.494[a]
	(1.423)	(0.939)	(0.953)	(1.379)	(0.906)	(0.925)	(1.403)	(0.929)	(0.941)
Employment Squared (10^{-5})	0.067	0.072[c]	0.099[b]	0.041	0.069[c]	0.101[b]	0.057	0.062	0.092[b]
	(0.066)	(0.043)	(0.044)	(0.064)	(0.042)	(0.043)	(0.065)	(0.043)	(0.044)
Capital Intensity (10^{-5})	0.038[a]	0.032	-0.003	0.042[a]	0.001	-0.006	0.038[a]	0.003	-0.003
	(0.009)	(0.063)	(0.006)	(0.009)	(0.006)	(0.006)	(0.009)	(0.006)	(0.006)
Exports	0.013[c]	-0.009[b]	-0.010[b]	0.013[c]	-0.009[b]	-0.009[c]	0.011	-0.011[b]	-0.011[b]
	(0.007)	(0.005)	(0.005)	(0.007)	(0.004)	(0.005)	(0.007)	(0.005)	(0.005)
Workforce with Degree	-0.003	0.001	-0.001	-0.001	0.001	0.000	-0.002	-0.002	-0.001
	(0.006)	(0.004)	(0.004)	(0.006)	(0.003)	(0.004)	(0.006)	(0.003)	(0.004)
Workforce with no Qualifications	-0.010	-0.001	0.005	-0.006	0.001	0.008	-0.012	-0.007	0.001
	(0.012)	(0.008)	(0.008)	(0.012)	(0.008)	(0.008)	(0.012)	(0.008)	(0.008)
Other Service Firm Characteristics									
Firm Vintage	0.003	-0.002	-0.004	0.004	-0.002	-0.003	0.003	-0.003	-0.005
	(0.005)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)
Business Type	0.302	0.351	0.129	0.134	0.313	0.050	0.283	0.334	0.052
	(0.368)	(0.240)	(0.244)	(0.350)	(0.229)	(0.234)	(0.358)	(0.235)	(0.237)
Customised	-0.443	-0.153	-0.197	-0.440	-0.095	-0.130	-0.488	-0.082	-0.132
	(0.360)	(0.243)	(0.238)	(0.356)	(0.231)	(0.236)	(0.361)	(0.236)	(0.239)
Tailored	0.319	0.298	0.149	0.341	0.145	0.093	0.359	0.372	0.251
	(0.372)	(0.243)	(0.247)	(0.370)	(0.241)	(0.246)	(0.367)	(0.241)	(0.244)
Large Customer Groups	-0.190	0.151	0.151	-0.316	0.025	0.082	-0.251	0.126	0.136
	(0.371)	(0.242)	(0.245)	(0.364)	(0.236)	(0.242)	(0.367)	(0.240)	(0.244)
Standardised	0.042	-0.349	-0.239	0.137	-0.370	-0.291	0.052	-0.373	-0.265
	(0.387)	(0.255)	(0.259)	(0.384)	(0.253)	(0.258)	(0.387)	(0.259)	(0.260)

Table 4 (contd.)

	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth
Innovation and External Linkages									
(Interaction Variables)									
Strategic Alliance or Joint Venture x Innovation (10^{-3})	1.473	15.494[a]	11.109[b]	-0.142	0.506[a]	0.391[b]	-0.110	0.189[b]	0.111
	(7.891)	(5.146)	(5.221)	(0.257)	(0.168)	(0.172)	(0.127)	(0.084)	(0.085)
Suppliers x Innovation (10^{-3})	7.112	6.952	-4.249	-0.250	-0.429[b]	-0.338[c]	-0.063	-0.033	-0.132
	(9.975)	(6.571)	(6.667)	(0.303)	(0.199)	(0.204)	(0.184)	(0.122)	(0.124)
Subsidiaries x Innovation (10^{-3})	1.556	17.979	15.420	0.084	0.396	0.291	-0.154	0.315	0.203
	(1.790)	(11.86)	(12.022)	(1.021)	(0.643)	(0.662)	(0.000)	(0.232)	(0.235)
Customers x Innovation (10^{-3})	6.567	12.321[a]	13.598[a]	0.102	0.631[a]	0.551[a]	0.096	0.213[a]	0.209[a]
	(6.462)	(4.146)	(04.205)	(0.298)	(0.181)	(0.185)	(0.092)	(0.056)	(0.057)
Consultants x Innovation (10^{-3})	27.212[c]	-15.904	-13.437	1.895[a]	-0.476	-0.517	0.650[b]	-0.203	-0.150
	(16.669)	(10.96)	(11.111)	(0.604)	(0.379)	(0.397)	(0.312)	(0.202)	(0.205)
Competitors x Innovation (10^{-3})	10.643	-0.176	-0.858	-0.397	-0.027	-0.112	0.091	-0.001	-0.027
	(9.033)	(0.059)	(6.063)	(0.552)	(0.357)	(0.365)	(0.134)	(0.089)	(0.090)
Lambda	0.797	0.326	-0.572	-0.204	0.656	-0.238	0.696	0.470	-0.486
	(0.887)	(0.603)	(0.596)	(0.985)	(0.625)	(0.664)	(0.897)	(0.599)	(0.606)
Adj. R squared	0.068	0.121	0.105	0.090	0.161	0.119	0.075	0.125	0.108
Rho	0.376	0.231	-0.399	-0.097	0.474	-0.168	0.330	0.333	-0.340
Number of Observations	179	184	184	179	184	184	179	184	184

Notes: Standard Errors are in parentheses. Significant at [a]1%, [b]5%, [c]10%
All estimations use the Heckman two-stage estimator.

Table 5: Elasticities estimated at variable means

	Product Innovation Dummy			New-to-Market Innovation			New-to-Firm Innovation		
	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E	(b) Sales Growth	(c) Employment Growth	(a) V.A.P.E.	(b) Sales Growth	(c) Employment Growth
Alliance or JV x Innovation	--	0.20	0.14	--	0.14	0.10	--	0.14	--
Suppliers x Innovation	--	--	--	--	-0.06	-0.05	--	--	--
Customers x Innovation	--	0.29	0.32	--	0.24	0.21	--	0.28	0.27
Consultants x Innovation	0.13	--	--	0.17	--	--	0.17	--	--

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Appendix Table AI: Variable Definitions

Performance Measures	
V.A.P.E. (value-added per employee)	Calculated as revenue minus operating costs divided by number of employees in 2003
Sales Growth	The percentage of sales growth since 2000
Employment Growth	The percentage of employment growth since 2000
Innovative Measures	
New Service & Product Dummy	A dummy variable taking the value 1 if the service firm introduced a new service or product and zero otherwise
New-to-market innovation	Proportion of current sales consisting of new services/products introduced to the market for the first time by the firm
New-to-firm innovation	Proportion of current sales consisting of new or improved services/products previously produced by this or other firms
Internal Resource Indicators	
Employment	Service firm employment in 2003
Capital Intensity	Capital expenditure divided by employment
Exports	Percentage by value of sales exported
Workforce with Degree	The percentage of the service firms' workforce with a bachelor's degree
Workforce with no qualifications	The percentage of the service firms' workforce with no post-school vocational training
Other Service Firm Characteristics	
Firm Vintage	Age of the firm in 2003
Business Type	A dummy variable taking the value 1 if the service firm is stand-alone and zero otherwise
Customised Offerings for Individuals	A dummy variable taking the value 1 if the service/product offering is customised and zero otherwise
Tailored Offerings for Groups	A dummy variable taking the value 1 if the service/product offering is tailored to specific customers and zero otherwise
Suitable for Large Customer Groups	A dummy variable taking the value 1 if the service/product offering is suitable for large customer groups and zero otherwise
Standardised	A dummy variable taking the value 1 if the service/product offering is standardised and zero otherwise
External Linkages	
Strategic Alliance or Joint Venture	Percentage of new services derived from SA/JV
Suppliers	Percentage of new services derived from suppliers
Subsidiaries	Percentage of new services derived from subsidiaries
Customers	Percentage of new services derived from customers
Consultancy Firms	Percentage of new services derived from consultancy firms
Competitors	Percentage of new services derived from competitors

Appendix Table AII: Determinants of Service Innovation (Equation 2b)

Constant	-3.67***	-3.73***
	(1.40)	(1.42)
Internal Resource Indicators		
Employment	0.001**	0.001***
	(0.000)	(0.000)
Employment Squared	-0.000***	-0.001***
	(0.000)	(0.000)
Workforce with Degree	0.019*	0.020*
	(0.011)	(0.011)
Workforce with no Quals	-0.061	-0.069
	(0.099)	(0.097)
R&D in house	1.39**	-
	(0.673)	
Formal R&D	-	1.88**
		(0.871)
Informal R&D	-	1.03
		(0.827)
Other Firm Characteristics		
Firm Vintage	0.004	-0.0004
	(0.017)	(0.018)
Business Type	1.45	1.49
	(0.938)	(0.939)
Customised services	-0.298	-0.243
	(0.916)	(0.890)
Tailored services	-0.897	-0.912
	(0.966)	(0.929)
Suitable for Large Groups	0.759	0.916
	(0.859)	(0.879)
Standardised	-0.461	-0.686
	(1.05)	(1.09)
External Linkages		
Alliance or Joint Venture	0.687	0.647
	(81.8)	(47.3)
Suppliers	0.142	0.129
	(65.5)	(35.9)
Customers	452.03***	564.71***
	(105.3)	(96.4)
Log Likelihood Function	-12.11	-11.77
Restricted Log Likelihood	-102.79	-102.55
Chi squared	181.36	181.57
R-squared ML	0.596	0.598
Number of Observations	200	199

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

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