The impact of non-technological on technological innovations: do services differ from manufacturing? An empirical analysis of Luxembourg firms

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The impact of non-technological innovation on technological innovation: do services differ from manufacturing? An empirical analysis of Luxembourg firms

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ABSTRACT

Generally speaking, the support of technological innovation has been viewed in terms of input such as R&D and instruments such as legal protection. The literature on innovation highlights the interactive nature of the innovation process in which non-technological activities are essential. However, few works have taken into account the role of other innovative strategies such as marketing and organisational innovation, a role which may differ according to whether the firm is involved in manufacturing or in services. The purpose of this paper is to contribute to fill this gap by highlighting the effects of non-technological innovation strategies on technological innovation. For the empirical work, we used firm-level data drawn from the Community Innovation Survey 2006 for Luxembourg. Our results show that the effects of non-technological innovations differ depending on the phase of the innovation process. Marketing and organisational innovations significantly increase the likelihood of innovation, but not the commercial success of innovation. The study also shows the differentiated effects of the two types of non-technological innovation in manufacturing and service, and confirms the key role of organisational innovation for services.

Keywords: CIS; Innovation; Marketing; Organisation; Technological innovation

JEL Classification: L25, L80, O30, O31, O32

INTRODUCTION

The study of innovation, an on-going priority in most developed countries, is mainly focused on technological aspects and largely concentrates on manufacturing industries. Researches in the field have focused essentially on inputs and support instruments. They have not considered other innovation strategies such as those implemented in the marketing or organisational fields, and have not taken great interest in the service industries. It appears thus of interest to investigate the links between non-technological and technological innovation and to analyse how these may differ depending on whether the firms operate in the manufacturing or service industries. Indeed, it is now recognised that innovation processes are highly interactive in nature and that non-technological activities play a crucial role: "*Firms are inter-dependent in their innovation activities*" (Tether and Tajar, 2008: 722). In line with this approach, the 3rd edition of the Oslo Manual (OECD, 2005), as well as recent Community Innovation Surveys, have stressed the importance and role of non-technological innovation in addition to that of technological innovation. Moreover, it is a known fact that the development of the service sector has been one of the aspects driving the evolution of OECD nations (Vang and Zellner, 2005). As services constitute the bulk of economic activities in many nations today (Tether and Tajar, 2008), it is crucial to understand their innovation activities in further detail. Surprisingly, service firms have so far received relatively little attention, especially as far as their innovation activities are concerned, mostly due to a lack of appropriate data at the firm level (Arvanitis, 2008). Analysing whether the relationship between technological and non-technological innovation differs significantly in the service and manufacturing industries should make it possible to determine the relevance of using conventional models when analysing innovation in services.

Adopting a comparative research strategy (Arvanitis, 2008) that takes the "dissolution of boundaries" (Drejer, 2004: 561) between manufacturing and services into account (Coombs and Miles, 2000), this paper considers both manufacturing and service firms. Moreover, our work is in line with Armbruster *et al.* (2008) who suggested to carry out further research in order to better understand the different types of innovation. Therefore, embracing a view of innovation that accounts for its different forms (Tatikonda and Montoya-Weiss, 2001), the purpose was to investigate the impact of organisational and marketing innovations on product innovation for both manufacturing and service firms. The main originality of this paper lies in investigating these relationships within a unique framework, however distinguishing manufacturing from service firms. The second originality is related to the distinction made between organisational and marketing innovations considered as two separate measures of non-technological innovation. The main hypothesis is that different types of non-technological innovation should lead to significant differences in firm innovation performance, defined first by the likelihood of introducing new or improved products, and second by the extent of the innovation.

The remainder of the paper is structured as follows. Section 2 provides an overview of organisational and marketing innovations and their possible effect on technological innovation. Section 3 outlines the data set, variables and method, based on the large-scale Community Innovation Survey 2006 carried out in 2008 for Luxembourg. Section 4 presents and discusses the results and shows how different initial conditions can lead to different results in technological innovation. Finally, Section 5 presents some conclusions, implications for theory and practice, and derived consequences for policy making.

I. NON TECHNOLOGICAL INNOVATION IN THE MANUFACTURING AND SERVICE INDUSTRIES

Innovation has been defined as the adoption of an idea, behaviour, system, policy, program, device, process, product or service that is new to the organisation (Damanpour 1992). Following Flikkema *et al.* (2007), we distinguish technological from non-technological innovation, new marketing strategies and changes in management techniques or organisational structures are included in the latter category. In our research we studied the relationship between two types of non-technological innovations (marketing and organisational) and technological innovation, and also compared the results between manufacturing and services. Surprisingly little work has addressed the care firms should take when considering the types of innovation that may lead to technological innovation. The question of how these other types of innovation may impact technological innovation is an important issue as it affects its determinants. The emphasis has typically been placed on R&D investment. However, not all firms are R&D intensive, and this is all the more true for the service sector (Tether, 2005). Extending recent interdisciplinary research showing that customer and technological skills have a direct, unconditional effect on firm innovation performance, we here investigated the links between technological and non-technological innovation.

1. TECHNOLOGICAL INNOVATION

Technological innovation is usually seen as encompassing product and process innovation. However, the distinction between product and process innovation, frequently used in manufacturing, is less clear-cut, or even meaningless, in services (Gallouj and Weinstein, 1997; Evangelista, 2000). We concentrated on *product innovation*[1], defined as the introduction of goods or services that are new or significantly improved with respect to their specifications or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness and/or other functional characteristics (OECD, 2005). We looked at the introduction of products that are new to the firm, including small and gradual improvements within firms – and not only more radical types of innovation in terms of products that are new to the market. Our objective was to evaluate the determinants of firms' activity in terms of product innovation. Our approach is output based, and can concern the introduction of new or improved products, or the commercial success of innovative products, as measured as the percentage of sales generated from new or improved products (Cassiman and Veugelers, 2006). We therefore examined two stages in the innovation process (Arvanitis, 2008): the basic decision to innovate in products (the likelihood to innovate) and the decision to aim for a level of innovation activity through the sales share of new products (or extent of innovation[2]). In this section, we address two major non-technological innovation types, organisational and marketing, which have been included in the 2005 OECD Oslo Manual definition of innovation. Considered together and under a unique heading in the CIS4, the latest CIS survey (2006) goes one step further by clearly distinguishing organisational and marketing innovations into detailed methods or practices.

[1] The focus on product innovation should enable us to avoid two traditional pitfalls: that of distinguishing product from process innovation in services, and that of distinguishing process from organizational innovation – in all industries. Indeed, several authors (Preissl, 2000; Tether, 2005; Love and Mansury, 2007; Mansury and Love, 2008) pointed out that innovation surveys do not provide clear results on these distinctions in service industries.

[2] Also called innovation performance by other authors (Love and Mansury, 2007; Schmidt and Rammer, 2007; among others)

2. NON-TECHNOLOGICAL INNOVATION

Empirical research has investigated the numerous factors that influence innovation performance (Hall and Bagchi-Sen, 2007). However, few works take into account the interrelation between different innovation strategies. Schmidt and Rammer (2007), in the unique existing study - to our knowledge - on the subject, showed that the combination of technological and non-technological innovation had a positive impact on innovation performance. However, this effect could only be related to the combination of organisational and product innovations. No other combinations of technological and non-technological innovation lead to higher returns on sales. The impact of organisational and marketing innovations on product innovation may thus differ.

2.1 ORGANISATIONAL INNOVATION

Theoretically, *organisational innovation* is a broad concept that encompasses strategies, structural and behavioural dimensions. According to OECD (2005), an organisational innovation is "*the implementation of a new organisational method in the firm's business practices (including knowledge management), workplace organisation or external relations that has not been previously used by the firm. It must be the result of strategic decisions taken by management*". Firms that are active in technological innovation usually adopt organisational practices to support it. Numerous studies have investigated the complementarity between organisational and technological innovations by highlighting the importance of technological innovation as a driving force for organisational changes within the firm (Dougherty, 1992; Danneels, 2002). These studies have focused on the fact that technological innovation usually leads to organisational innovation. Firms introducing technological innovations would therefore need to reorganise their production, workforce, sale and distribution systems. The effective use of new technologies is seen as also requiring changes in organisational structure, skills and management (Damanpour, 1992). Another research stream points out the inverse relationship by stressing the role of organisational innovation in enhancing flexibility, creativity - that in turn facilitates the development of technological innovation. For instance, studying a sample of firms in the fast-moving consumer goods industry in Germany, Lokshin *et al.* (2008) considered the effect of organisational skills on technological innovation. Firms that successfully combined customer, technological and organisational skills were found to bring more product innovations to the market. Regardless of the perspective, the crucial role played by organisational practices in technological innovation is acknowledged. Organisational practices are viewed as an input for firms' innovation processes and innovation capacity. In line with previous works (Dougherty, 1992; Danneels, 2002), we expected to observe a positive effect of organisational innovation on firms' technological innovation. Firms dedicating more resources to managerial practices or new organisational forms should be in a better position to efficiently use new skills and technologies.

2.2 MARKETING INNOVATION

Firms with relatively lower R&D activities often attribute their innovation performance to strategies that focus on competitiveness, marketing, and distribution channels (Hall and Bagchi-Sen, 2007), i.e. on marketing innovation. Rust *et al.* (2004) view *marketing innovation* in terms of three dimensions: (1) product strategy; (2) price strategy and (3) promotion strategy. These strategies lead to tactical marketing actions such as changes in design or packaging, changes in sales or distribution methods, advertising or permanent exhibitions. The objective is to increase appeal for the firms' products and/or to enter new markets. In the 3rd edition of the Oslo Manual marketing innovation is clearly distinguished from product innovation, as the latter includes technical specifications and functional properties, whereas the first is defined as "*the implementation of a new marketing concept or strategy that differs significantly from the enterprise's existing marketing methods and which has not been used before. It entails significant changes in product design or packaging, product*

placement, product promotion or pricing" (OECD, 2005). Theoretically, marketing initiatives are tactical actions and intangible resources that determine firm performance. Firms focusing on marketing actions are likely to have a better ability to increase customer satisfaction compared to competitors (Baker and Sinkula, 1999), also to successfully adapt to changing market needs, to discover and exploit business opportunities and to access new information and resources in order to develop new competitive products or processes (Day, 1994; Rust *et al.*, 2004). Many empirical studies acknowledge this positive impact (Day, 1994; Slater and Narver, 2000). Also, market orientation leads to higher business profitability when it relates to learning from external relations such as clients or competitors (which is included in organisational innovation).

Thus, a first group of hypotheses (Hypotheses 1) to be tested empirically is that non-technological innovation stimulates product innovation. Thus, organisational and marketing innovations may be expected to increase firms' performance, both in terms of likelihood of achieving product innovation, and in terms of the extent of innovation expressed as the ratio of new products in total sales.

3. Innovation in Manufacturing and Service Firms

Over the last decade the literature on service innovation has represented an increasingly important field of research (Gallouj and Weinstein, 1997; Evangelista, 2000; Tether, 2003, 2005; Drejer, 2004; Van and Zellner, 2005; Flikkema *et al.*, 2007; Love and Mansury, 2007; Arvantis, 2008; Camacho and Rodriguez, 2008; Castellacci, 2008; Koch and Strotman, 2008; Mansury and Love, 2008; Tether and Tajar, 2008; Gallouj and Windrum, 2009). In this stream of research, knowledge intensive business services (KIBS) have received particular attention (e.g., Freel, 2006; Flikkema *et al.*, 2007; Koch and Strotman, 2008). The on-going debate on whether services can be treated like manufacturing with respect to innovation has not been resolved yet and three distinct views on service innovation co-exist (Coombs and Miles, 2000): (i) for the *demarcation* approach, service innovation is different from manufacturing and therefore requires specific theories; (ii) the *assimilation* approach considers that services are similar to manufacturing and attaches little importance to non-technological innovation; (iii) the *synthesis* approach is an integrative view that allows for innovation to take place in manufacturing *and* in services (Gallouj and Weinstein, 1997; Leiponen, 2000; Love and Mansury, 2007; Castellacci, 2008; Gallouj and Windrum, 2009).

Motivated by the need to integrate research on manufacturing *and* service innovation, we explicitly allow for new goods and service introductions as well as for the existence of technological and non-technological innovation. As Arvanitis (2008) suggests, this "comparative" research strategy is designed to compare results for manufacturing and service firms in order to assess the adequacy of using conventional models when analysing innovation in services, and specifically the influence of non-technological innovations on product (goods or services) innovation. This view has recently been made possible in Europe where innovation surveys and European Community Innovation Surveys (CIS) in particular have made remarkable progress, taking into account the specific aspects of services, for instance by extending the definition of innovation to include organisational innovation, which is supposed to be key for service industries. Adopting an assimilation approach, it is now possible to use such surveys in a comparative approach (Arvanitis, 2008), "*technology-oriented" models may prove to be quite useful for understanding innovation also in the service sector*" (ibid: 220). Indeed, this author considers that the similarities with manufacturing firms are high and that the differences between the sectors not dramatic. As service and manufacturing activities are becoming increasingly intertwined, our aim was to contribute towards a common framework for studying these two activities - rather than maintaining the traditional dichotomy between them (Drejer, 2004).

As there is a high degree of diversity among service industries in terms of innovation patterns and behaviours (Miozzo and Soete, 2001; Tether, 2003; Camacho and Rodriguez, 2008), a further question arises. Evangelista (2000) advises against simple generalization where innovation in services is concerned. However, several

authors (such as Camacho and Rodriguez, 2008) point out that this heterogeneity also applies to service firms within a similar activity. "*Some services may be more similar to certain manufacturing industries than to other services*" (Preissl, 2000: 145). Moreover, the on-going process of convergence between manufacturing and service sectors in terms of innovation input and organisational models has been underlined (Evangelista, 2000). Until now, there has been no clear distinction as to how manufacturing and service firms innovate (Tether and Tajar, 2008). It is not surprising therefore that the OECD (through the 2005 version of its Oslo Manual) decided to adopt a unified framework for analysing and measuring innovation activities in both sectors (Evangelista, 2000). Recent results (Love and Mansury, 2007; Arvanitis, 2008) stress that the pattern of service innovation activity is consistent with what is observed for manufacturing, thus supporting the view that service innovation might not be a completely different concept. We thus decided to investigate innovation patterns for the manufacturing and service activities together, allowing however for further distinction within these two industries.

Different types of innovation are found in both industries: "*Market innovation, organisational innovation and input innovation make sense in both manufacturing and services*" (Flikkema *et al.*, 2008: 528). The importance of organisational factors has been underlined in the service sector. Organisational innovation is viewed as being more prominent in services than in manufacturing (Tether, 2005; Mansury and Love, 2008; Tether and Tajar, 2008; among others). Evangelista (2000) suggests that organisational aspects can either be linked to, or be independent from, the introduction of technological innovation. External relationship innovation, the establishment of relationships with partners (Drejer, 2004), and a subset of organisational innovation, has been developed especially for services (Djellal and Gallouj, 2001; Tether, 2003). Service firms are more likely to engage in collaborations with customers and suppliers as part of their innovation process, whereas manufacturers tend to rely more on in-house R&D and links with universities (Leiponen, 2000; Mansury and Love, 2008). We thus expected service firms to engage more in external collaborations and to adopt different types of collaborative arrangements than their manufacturing counterparts. More generally speaking, organisational innovation should play a more important role in services.

Even though most research on innovation in services has focused on organisational innovation (and on its fuzzy boundary with process innovation), the necessary interaction with clients, service delivery and marketing aspects have also been emphasized (Gallouj and Weinstein, 1997; Den Hertog, 2000; Tether, 2005; Flikkema *et al.*, 2007; among others). Innovation in services is mainly non-technological (organisational, marketing, management, service delivery, etc.) with "softer" attributes such as workforce skills or cooperation practices (Tether, 2005). Den Hertog (2000) proposes to analyse service innovation in terms of technological, conceptual, client-interface and service delivery innovation. The latter is considered as key to service innovation (Gallouj and Weinstein, 1997; Evangelista, 2000; Flikkema *et al.*, 2007). Sundbo (1997) also argues that innovation in services tends to be market driven.

Thus, the second group of hypotheses tested (Hypotheses 2) in the empirical section of this paper concerns the role of non-technological innovation on product innovation according to whether the firm is in manufacturing or in service. Previous research leads us to expect organisational and marketing innovations to have a more important impact in the case of service firms.

4 Further Possible Determining Factors for Firm Innovation

Although this paper focuses on an empirical analysis of the impact of non-technological innovations on firm product innovation according to the type of industry, we also paid attention to possible firm-specific determining factors in our empirical models (Koch and Strotman, 2008), in order to analyse the likelihood of innovation in the first place, and the extent of this innovation in the second place. The most studied determining factors for technological innovation in studies on services, either those that concentrate on

services (e.g. Evangelista, 2000; Tether, 2003; Love and Mansury, 2007; Arvanitis, 2008; Koch and Strotman, 2008; Tether and Tajar, 2008) or those that study services in conjunction with manufacturing (Tether, 2005; Castellacci, 2008), are R&D expenditures, appropriability conditions and obstacles to innovation. As the emphasis has always been placed on technological innovation and manufacturing activities, the major factor for innovation was considered to be R&D activity. Most previous empirical findings highlight the essential role played by R&D expenditures in the innovation process, as it governs both knowledge creation and the firms' ability to absorb external knowledge (Crépon *et al.*, 1998). It is also well-acknowledged today that service firms spend much less on R&D than their manufacturing counterparts (Camacho and Rodriguez, 2008), R&D not being necessarily used in services (Tether, 2003, 2005). We also included demand-pull and cost-push variables (type of innovation objectives: cost reduction, quality and satisfying customers, market expansion, etc.), and protection methods. Many studies have stressed the importance of effective appropriability conditions for innovation activities (e.g., Spence, 1984; Becker and Peters, 2000). We expected to observe a positive association between innovation in manufacturing and protection methods but an absence of such association due to the limited appropriability of the results of service innovative activities considering their intangible nature and high information content (Evangelista, 2000). Obstacles to innovation and aspects linked to the type of competition are also included in the models. Furthermore, the fact that an enterprise is part of a group is also expected to have a positive impact on innovation. Finally, firm size, an explanatory variable used in most innovation studies, is expected to be positively related to innovation (Arvanitis, 2008), although research results are still ambiguous (Shefer and Frenkel, 2005; Koch and Strotman, 2008).

II. Data, Statistics And Estimation Model

1. Descriptive Data and Statistics

In this study we used data from the Community Innovation Survey 2006 (CIS 2006) compiled for firms in Luxembourg over the period 2004 to 2006. The survey was coordinated by EUROSTAT. It was carried out in 2008 by CEPS/INSTEAD[3] in collaboration with STATEC[4] and concerned 1491 enterprises: 320 in the manufacturing sector and 1158 in the service sector. The target population covered 99.5% of the enterprises in Luxembourg. A sample of 644 firms received the questionnaire (220 in manufacturing and 411 in services). Due to the very high response rate (88%), a no-response survey was not deemed necessary. After correcting for unusable responses, we were able to use a final sample of 568 innovating and non-innovating firms with more than 10 employees (the target population of Community Innovation Surveys) in manufacturing (212 firms, 37% of total) and services (356 firms, 63% of total). Eight sub-groups of activities (five for services, three for manufacturing) were established according to the NACE sector classification[5]. Table 1 indicates the percentage of innovative firms in each of these categories: the most innovative service firms are found in financial intermediation, computer activities and R&D, engineering and consultancy. The two latter categories

[3] International Network for Studies in Technology, Environment, Alternatives, Development

[4] Central Service of Statistics and Economic Studies

[5] High and medium high tech manufacturing industries (Naces 35.3, 24.4, 30, 32, 33, 31, 34, 24 (excl 24.4), 35.2, 35.4, 35.5, 29); Medium low tech industries (Naces 23, 25, 26, 35.1, 27, 28); Low tech industries (Naces 36, 37, 20, 21, 22, 15, 16, 17, 18, 19, 40, 41); Wholesale trade (Nace 51); Transport and communication (Naces 60, 64); Financial intermediations (Naces 65, 67); Computer activities (72); Research and development – Engineering and consultancy (Naces 73, 74.2, 74.3).

are KIBS (Knowledge-Intensive Business Services). For manufacturing, not surprisingly, the most innovative firms are those in the high and medium high tech sector.

TABLE 1 Innovating and non-innovating firms classified per activity

	Services			Manufacturing	
	Total firms	*% innovative*		*Total firms*	*% innovative*
Wholesale trade	75	36%	High and medium high tech	64	71%
Transport and communication	110	27%	Medium low tech	82	47%
Financial intermediations	83	66%	Low tech	66	39%
Computer /IT	44	64%			
R&D - Engineering and consultancy	44	51%			
Total	**356**	**45%**	**Total**	**212**	**50%**

Of the 568 firms, 52% have less than 50 employees, 21% between 50 and 100, 13% between 100 and 250, and 14% are large firms (> 250 employees, according to the European definition). Table 2 presents the data set structure classified according to industry type and firm size. The percentages per size category are found to be relatively similar in both industries.

TABLE 2 Innovating and non-innovating firms classified per industry and size

	Services		Manufacturing	
	Total firms	*% innovative*	*Total firms*	*% innovative*
Size : 10-49	192	43%	102	40%
Size : 50_99	76	41%	43	48%
Size : 100_249	39	66%	36	75%
Size : >250	49	82%	31	84%
Total	**356**	**45%**	**212**	**50%**

The main objective was to study the effect of non-technological innovation strategies - defined here as organisational and marketing innovation - on technological innovation. Following Veugelers and Cassiman (2004), Love and Mansury (2007) and Arvanitis (2008) we used two dependent variables. The first was the *likelihood of innovation* or product innovation. It is based on the "yes-no" question concerning the introduction by firms of new or significantly improved products during the three years 2004 to 2006. Out of 568 firms, 47 % reported being innovative (50% in industry and 45% in services). The second dependent variable was the *extent of innovation*, and was measured as the percentage of total turnover from product innovation that is new to the firm. Table 3 presents summary statistics of our main variables by industry (See Appendix A for the definition of each variable).

TABLE 3 Summary statistics of principal variables classified per industry

	Services				Industry			
	Mean	***Std. Dev.***	***Min.***	***Max.***	***Mean***	***Std. Dev.***	***Min.***	***Max.***
Innovations								
Extent of innovation	0.04	0.09	0	.7	0.05	0.10	0	.5
Likelihood of innovation	0.45	0.49	0	1	0.50	0.49	0	1
Organizational innovation	0.58	0.50	0	1	0.56	0.50	0	1
Marketing innovation	0.35	0.47	0	1	0.33	0.46	0	1
Detailed organizational practices								
Business practices	0.38	0.49	0	1	0.41	0.49	0	1
Knowledge management	0.36	0.48	0	1	0.27	0.44	0	1
Workplace organization	0.38	0.49	0	1	0.41	0.49	0	1
External relations	0.21	0.41	0	1	0.18	0.38	0	1
Detailed Marketing methods								
Product design	0.12	0.33	0	1	0.13	0.34	0	1
Product promotion	0.16	0.37	0	1	0.20	0.40	0	1
Product placement	0.11	0.32	0	1	0.07	0.26	0	1
Pricing	0.18	0.38	0	1	0.07	0.27	0	1
Obstacles to innovation								
Cost-related obstacles	0.13	0.34	0	1	0.21	0.41	0	1
Knowledge-related obstacles	0.19	0.39	0	1	0.20	0.40	0	1
Market-related obstacles	0.21	0.41	0	1	0.24	0.43	0	1
R&D								
R&D intensity	0.03	0.32	0	6.48	0.04	0.12	0	6.22
Innovation protection								
Strategic protection	0.41	0.49	0	1	0.35	0.48	0	1
Formal protection	0.16	0.36	0	1	0.19	0.40	0	1
Other variables								
Competition intensity	3.51	0.75	1	4	3.45	0.75	1	4
Demand-pull	0.36	0.42	0	1	0.38	0.42	0	1
Cost-push	0.17	0.26	0	1	0.27	0.35	0	1
Firm size	3.42	1.00	2.30	8.03	3.70	1.14	2.30	8.19
Group	0.52	0.50	0	1	0.41	0.49	0	1
Observations	**356**				**212**			

The survey questions in which firms were asked whether they introduced non-technological innovations (organisation and marketing) were of particular interest to this study. The first type of non-technological innovation is *organisational innovation*, which encompasses four types of practices: (a) New business practices for organising work or procedures (i.e. supply chain management, business re-engineering, lean production, quality management, education/training systems, etc.); (b) new knowledge management systems designed to improve information use or exchange, knowledge and skills within the enterprise or to collect and interpret information from outside the enterprise; (c) new methods of workplace organisation for distributing

responsibilities and decision-making (i.e. team work, decentralisation, integration or de-integration of departments, etc.) and (d) new methods of organising external relations with other firms or public institutions (i.e. first use of alliances, partnerships, outsourcing or sub-contracting, etc.) (OECD, 2005). These four organisational innovation practices were introduced and used in our model. 54%, 47%, 54% and 27% of innovative firms implemented respectively, new business practices, knowledge management systems, methods of workplace organisation, and methods of organising external relations. Non-innovative firms introduced these organisational practices less frequently (respectively 25%, 23%, 25% and 14%). For the purpose of our study, a composite measure of organisational innovation was also introduced, taking the value 1 if firms adopted at least one of the above practices, and the value 0 otherwise.

The second type of non-technological innovation was *marketing innovation*, which encompasses four types of practices: (a) Significant changes to product design or to the packaging of goods or services; (b) New media or techniques for product promotion (i.e. the first use of new advertising media, fundamentally new brand to target new markets, etc.); (c) New methods of product placement or sales channels (i.e. first use of franchising or distribution licenses, direct selling, exclusive retailing, new concepts for product presentation, etc.) and (d) New methods of pricing goods or services (i.e. first time use of variable pricing by demand, discount systems, etc.). 24%, 26%, 19% and 24% of innovative firms implement significant changes in product design or packaging, new media or techniques for product promotion, new methods for product placement or sales channels, and new pricing methods. In addition, a composite measure of marketing innovation was introduced, which was attributed the value 1 if firms introduced at least one of these four practices and 0 otherwise.

2. Estimation Model

Concerning the extent of innovation, measured as the percentage of total turnover represented by innovative products, we performed a generalized linear model with a Logit transformation. This led us to estimate a Logit transformed form of the variables as $\ln(Y_i/(1-Y_i))$, the log of the odds of Y_i . We estimated the following function:

$$Y_i = NT_i'\alpha + X_i'\beta + \varepsilon_i \quad (1)$$

where Y_i is the extent of innovation for firm *i*, measured as the share in sales of new products. Equation 1 thus refers only to firms that innovated and contains the determinants of the commercial success of a new or improved product, expressed through the extent of innovation variable. NT_i represents the set of organisational and marketing innovation variables. X_i is the vector of independent variables, including controls for firm-level heterogeneity such as firm size, sector of activity, belonging to a group and also a set of variables which have previously been shown to be relevant determinants of innovation performance at the firm level, such as extend of R&D activity, obstacles to innovation and/or the use of intellectual property rights, demand-pull and cost-push factors. and are the vectors of associated coefficients.

Since the dependent variable measures the percentage of total turnover from innovative products, we only draw on the sub-sample of innovative firms from the data set. Therefore, left-censoring arises when many firms in our sample do not innovate at all. If censoring was not accounted for, there could be a risk that the estimation of innovative performance be biased and misleading. In order to correct for censoring and to assess the impact of organization and marketing innovations on the probability of firms to become innovative, and given that the probability to innovate and the commercial success of innovative products represent two separate phases of the innovation process, we specified a Probit model for the likelihood of innovation. This function can be written as follows:

$$Z_i = NT_i'\gamma + W_i'\delta + u_i \quad (2)$$

where *Zi* is the latent variable corresponding to the likelihood of innovation. Innovating firms have positive values for *Zi* and non-innovating firms have negative values. NT_i is the set of organisation and marketing variables. W_i is the set of control variables, including firm size, sector of activity, foreign ownership and obstacles to innovation. Other variables such as demand-pull and cost-push factors or R&D intensity, which were introduced in the first step in order to estimate the extent of innovation (Equation 1) are not included here (Equation 2) as these data are only available for innovative firms. and are the vectors of associated coefficients.

As the dependent variables in equation 1 and 2 are respectively the percentage of sales represented by new products and the likelihood of innovation, consistent estimates for the parameters of interest can be obtained by maximum likelihood estimation of a generalized Tobit that accounts for censoring in the extent of innovation (Mohnen and Röller, 2005). The inverse Mill's ratio included in the model for correcting left-censoring was not significant. This indicates that the estimation results for the extent of innovation are not influenced by censoring.

III. Empirical Results

1. Likelihood of innovation

Table 4 presents estimation results of the Probit estimation for the first dependent variable. Both aggregated measures of organisational and marketing innovations have a strong positive impact on firms' likelihood of innovation, in manufacturing as well as in services, thus providing support for hypotheses 1 for the first stage of the innovation process. Results of the impact of non-technological innovations on product innovation partially support hypotheses 2 concerning the higher effect in the case of services. No individual organisational practice had a significant impact for manufacturing. However, two practices showed an effect in the case of service firms (knowledge management and external relations), in line with expectations. Service firms implementing knowledge management (management skills or sharing, coding and storing knowledge) are thus more likely to have a higher ability to innovate. This tends to corroborate the idea that knowledge management strategies are associated with more flexibility, adaptability, competitive advantage – which should lead to better organisational performance. Firms have opportunities to increase their innovation capacity when they are able to expand, disseminate and exploit organisational knowledge internally, as well as to share, transfer and receive knowledge from external partners (Kremp and Mairesse, 2006; Spicer and Sadler-Smith, 2006). The impact of marketing innovation is also significant in both sectors, and the effect of this aggregated measure was also higher in the case of services. New product design and promotion are the significant dimensions for manufacturing, whereas product placement played more in the case of services.

Among other explanatory variables, we found that the appropriability conditions were strongly and positively associated with the likelihood of innovation and that strategic protection had a strong and significant effect on product innovation in manufacturing. No evidence was found for service firms, probably due to the non-technical nature of service innovation. These results are in line with our expectations and previous empirical studies (Evangelista, 2000; Arvanitis, 2008). In order to control for differences in innovation behaviour of different sub-sectors of activities, we introduced sub-sector dummies to the model. Results show that more technologically advanced manufacturing industries (high tech and medium low tech) have a higher likelihood of introducing new products than low tech industries. In services, the result is somehow counter-intuitive.

Except for transport and communication, knowledge-intensive business services (KIBS)[6] such as R&D, engineering and consultancy, and computer activities do not show a higher likelihood of innovation than less knowledge-intensive sectors (wholesale trade was taken as reference). For our sample, this result does not allow to confirm previous research highlighting the significant differences between sub-sectors of service activities.

The perception of cost-related obstacles is strongly and positively associated to the likelihood of innovation in services. A closer look at the descriptive details shows that this type of obstacle is reported as being very important by 22% of innovating firms, but only by 9% of non-innovating firms (these figures are, respectively, 26% and 13% for knowledge-related obstacles, 24% and 21% for market-related obstacles). These statistics indicate that, regardless of the type of obstacle, innovating firms perceive more frequently than non-innovating firms the obstacles impeding their innovation activities. Therefore, our result for service firms could suggest that cost-related obstacles (lack of funds or high innovative costs) encourage firms, in particular those that innovate, to introduce product innovation. Firm size is equally important in both industries, enhancing the probability of innovation as the size increases. As they tend to engage in more activities, large firms have a greater scope for innovation. This result is in line with previous research (Sirilli and Evangelista, 1998; Tether, 2003; Love and Mansury, 2007)[7].

2. EXTENT OF INNOVATION

Table 5 presents the estimation results of the Logit-transformed estimation for the second dependent variable. The ratio of new products (goods and/or services) in the total sales is a standard measure of innovation performance in empirical studies (Love and Mansury, 2007). It represents a further step of the innovation process: the commercial success of new or improved products. We found that, except for organisational innovation for service firms, the aggregated measures of organisational and marketing innovations had no significant impact on firms' extent of innovation, thus invalidating hypotheses 1 for the latter stage of the innovation process. Hypotheses 2 are partially supported as the impact for services of non-technological innovations was higher than for manufacturing activities.

[6] A growing number of researches is dedicated to the study of these KIBS. For a general recent overview, see, for instance, Freel (2006) or Koch and Strotmann (2008)

[7] Further splitting firms into size categories (small: 10 to 49 employees, medium: 20 to 249; large: more than 250 employees), as in Tether (2003) for instance, does not lead to any significant change in the models obtained. These are available on demand.

TABLE 4 Estimation results for the Likelihood of Innovation (Probit)

	All sectors		Industry		Services	
	Aggregated	*Detailed*	*Aggregated*	*Detailed*	*Aggregated*	*Detailed*
Organisational innovation	0.513 (0.126)***	-	0.525 (0.254)**	-	0.508 (0.218)**	-
Business practices	-	0.305 (0.176)*	-	-0.006 (0.347)	-	0.290 (0.307)
Knowledge management	-	0.320 (0.167)*	-	0.111 (0.456)	-	0.626 (0.255)*
Workplace organisation	-	0.041 (0.174)	-	0.229 (0.316)	-	-0.025 (0.257)
External relations	-	-0.135 (0.205)	-	0.398 (0.384)	-	-0.544 (0.327)*
Marketing innovation	0.689 (0.148)***	-	0.611 (0.287)**	-	0.218 (0.193)***	-
Product design	-	0.615 (0.219)***	-	0.693 (0.401)*	-	0.652 (0.357)*
Product promotion	-	0.337 (0.180)*	-	0.680 (0.410)*	-	0.214 (0.330)
Product placement	-	0.488 (0.226)*	-	0.680 (0.410)	-	0.695 (0.340)**
Pricing	-	-0.114 (0.212)	-	-0.840 (0.650)	-	0.513 (0.307)
Other variables						
Cost-related obstacles	0.562 (0.181)***	0.618 (0.207)***	0.127 (0.278)	0.278 (0.260)	0.950 (0.323)***	0.728 (0.282)***
Knowledge-related obstacles	0.063 (0.175)	0.069 (0.188)	0.071 (0.280)	0.008 (0.250)	0.015 (0.238)	0.074 (0.261)
Market-related obstacles	0.021 (0.132)	0.022 (0.174)	-0.010 (0.217)	-0.067 (0.240)	0.076 (0.296)	0.208 (0.274)
Strategic protection	0.494 (0.128)***	0.465 (0.142)***	0.709 (0.212)***	0.718 (0.293)**	0.141 (0.230)	0.028 (0.267)
Formal protection	0.364 (0.198)**	0.368 (0.166)**	0.369 (0.252)	0.588 (0.294)	0.115 (0.302)*	0.111 (0.334)
Competition intensity	-0.046 (0.074)	-0.043 (0.094)	-0.119 (0.157)	-0.113 (0.132)	-0.043 (0.136)	-0.043 (0.136)
Firm size	0.212 (0.061)***	0.221 (0.055)***	0.206 (0.085)*	0.255 (0.120)**	0.286 (0.077)***	0.244 (0.09)**
Group	0.469 (0.150)***	0.443 (0.137)***	0.463 (0.202)**	0.426 (0.218)*	0.365 (0.230)*	0.345 (0.274)
Services	-0.207 (0.135)	-0.171 (0.133)	-	-	-	-
S_Transport and Communication					-0.538 (0.289)*	-0.548 (0.288)*
S_Financial intermediations	-	-	-	-	0.419 (0.292)	1.046 (0.261)
S_Computer activities	-	-	-	-	0.216 (0.306)	0.724 (0.337)
S_R&D - Engineering and consultancy	-	-	-	-	0.267 (0.344)	0.810 (0.324)
I_High and medium high tech	-	-	1.055 (0.248)***	0.640 (0.261)***	-	-
I_Medium low tech	-	-	0.230 (0.241)*	0.181 (0.300)	-	-
Constant	-1.813 (0.372)***	-1.743 (0.387)***	-1.462 (0.626)***	-1.423 (0.555)***	-1.789 (0.604)***	-1.686 (0.483)***
Log-Likelihood	-288.9	-289.6	-97.9	-93.6	-167.3	-166.0
Pseudo R2	0.264	0.262		0.363	0.317	0.321
Observations	568	568	212	212	356	356

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors in parentheses

TABLE 5 Estimation results for the Extent of Innovation (Logit-transformed)

	All sectors		Industry		Services	
	Aggregated	*Detailed*	*Aggregated*	*Detailed*	*Aggregated*	*Detailed*
Organisational innovation	0.195 (0.204)	-	-0.160 (0.297)	-	0.413 (0.228)*	-
Business practices		-0.026 (0.195)	-	-1.067 (0.366)***	-	0.388 (0.227)*
Knowledge management	-	-0.131 (0.207)	-	0.542 (0.290)*	-	-0.103 (0.287)
Workplace organisation	-	0.237 (0.211)	-	0.400 (0.314)	-	0.043 (0.265)
External relations	-	0.025 (0.173)	-	0.425 (0.268)	-	-0.424 (0.216)*
Marketing innovation	-0.104 (0.166)	-	-0.239 (0.262)	-	-0.037 (0.265)	-
Product design	-	-0.033 (0.216)	-	-0.212 (0.270)	-	0.140 (0.286)
Product promotion	-	0.203 (0.177)	-	0.394 (0.293)	-	0.067 (0.241)
Product placement	-	-0.312 (0.186)	-	-0.356 (0.295)	-	-0.138 (0.233)
Pricing	-	0.207 (0.215)	-	0.122 (0.411)	-	0.158 (0.259)
R&D						
R&D intensity	0.407 (0.042)***	0.432 (0.058)***	0.435 (1.244)	0.672 (1.160)	0.349 (0.049)***	0.417 (0.067)***
Obstacles						
Cost-related obstacles	0.279 (0.187)	0.267 (0.188)	-0.130 (0.378)	-0.145 (0.322)	0.575 (0.204)***	0.594 (0.214)***
Knowledge-related obstacles	-0.218 (0.201)	-0.207 (0.203)	-0.256 (0.390)	-0.569 (0.385)	-0.300 (0.246)	-0.254 (0.234)
Market-related obstacles	0.262 (0.202)	0.229 (0.205)	0.599 (0.319)*	0.647 (0.326)**	-0.040 (0.220)	0.102 (0.255)
Other explanatory variables						
Demand-pull	0.610 (0.482)	0.618 (0.481)	0.512 (0.745)	0.253 (0.701)	1.803 (0.567)***	2.024 (0.580)***
Cost-push	0.076 (0.282)	0.090 (0.290)	0.250 (0.431)	0.366 (0.395)	-0.499 (0.384)	-0.557 (0.343)
Strategic protection	-0.076 (0.185)	-0.123 (0.194)	-0.228 (0.266)	-0.296 (0.278)	0.009 (0.250)	0.003 (0.259)
Formal protection	-0.021 (0.176)	-0.058 (0.174)	0.132 (0.261)	0.030 (0.236)	-0.048 (0.251)	-0.096 (0.243)
Competition intensity	0.118 (0.115)	0.118 (0.115)	0.247 (0.240)	0.116 (0.225)	0.024 (0.131)	0.034 (0.136)
Control variables						
Firm size	-0.124 (0.057)**	-0.115 (0.058)**	-0.085 (0.092)	-0.102 (0.092)	-0.197 (0.075)***	-0.203 (0.080)***
Group	0.009 (0.177)	-0.008 (0.169)	-0.531 (0.259)**	0.010 (0.230)	0.365 (0.230)	0.420 (0.230)*
Services	0.041 (0.154)	0.073 (0.166)	-	-	-	-
S_Transport and Communication	-	-	-	-	0.452 (0.345)	0.532 (0.294)*
S_Financial intermediations	-	-	-	-	0.471 (0.290)	0.554 (0.296)*
S_Computer activities	-	-	-	-	-0.337 (0.324)	-0.388 (0.339)
S_R&D - Engineering and consultancy	-	-	-	-	-0.577 (0.343)	-0.598 (0.347)
I_High and medium high tech	-	-	0.154 (0.285)	0.145 (0.237)	-	-
I_Medium low tech	-	-	0.203 (0.330)	0.743 (0.372)**	-	-
Constant	-2.466 (0.616)***	-2.470 (0.628)***	-1.560 (1.150)***	-1.803 (0.992)***	-3.570 (0.730)***	-3.758 (0.745)***
Log-Pseudolikelihood	-65.3	-65.0	-25.9	-25.2	-37.5	-37.1
Observations	266	266	106	106	160	160

Note: * significant at 5%; ** significant at 5%; *** significant at 1%. Bootstrapped standard errors in parentheses

As far as individual practices are concerned, knowledge management practices that help to better use external information and internal skills increased the extent of innovation in manufacturing as they reinforce firms' flexibility and adaptability. Rather surprisingly, we found that the introduction of new or improved methods of business practices such as supply chain, re-engineering, lean and quality management contributed negatively to the extent of innovation in manufacturing. This result might be accounted for by two factors: the dominance of small firms in our sample (86% are Small and Medium Enterprises, SMEs) and the substantial time lag usually associated with the return on investment of such long term strategies. Indeed, most manufacturing SMEs have limited resources (Freel, 2000) and may not be able to dedicate financial or human resources to both internal production improvements and to external market actions such as promotion in order to increase the sales performance of their product innovations. The high costs entailed when implementing such business practices may impede the extent of innovation, at least in the short term. In addition, when implementing such organizational innovations, employers and employees are involved in a long term process of adaptation and learning which does not immediately result in substantial improvement in innovative performance (what we have called here the "extent of innovation"). On the contrary, new or improved business practices contributed positively to the extent of innovation in services, as well as external relations, which is in line with previous literature (Evangelista, 2000; Love and Mansury, 2007; Camacho and Rodriguez, 2008; among others).

As for R&D activities, we observed a positive and significant effect on all firms considered together, which indicates that the extent of innovation is higher for firms that invest heavily in R&D. This result reflects the acknowledged role of R&D expenditure in enhancing technological innovation, as largely documented in the literature (Crépon *et al.*, 1998; Griffith *et al.*, 2004). Surprisingly however, R&D intensity has a positive effect only in services. This may be explained by the structure of our sample of innovating firms, which included 30% of KIBS (computer activities and R&D, engineering and consultancy), highly engaged in R&D activities, but mostly small and less technology intensive manufacturing firms (60%), who innovate but are traditionally not very engaged in R&D – or do not have formal R&D departments with specific expenditures. The result for service firms is accordance with recent R&D surveys which have reported R&D as being crucial for services (Tether, 2003; Love and Mansury, 2007), and not only for computer services or telecommunications.

Among the set of other explanatory and control variables, firm size was not significant for manufacturing, but was significant, and negative, for services. This result is in accordance with previous empirical literature (Hipp *et al.*, 2000) showing that firm size increases the probability to innovate but decreases innovation performance. Belonging to a group was positively (but weakly) significant in manufacturing and services. Using innovation protection methods had no effect on the extent of innovation, as was expected. We also found that the perception of costs-related obstacles such as the lack of funds or high innovation costs was, as for the likelihood of innovation, positively associated with the extent of innovation in services. In manufacturing, the perception of market-related obstacles (dominance of established firms or uncertain demand) appeared to be positively related to the extent of innovation. The intensity of competition was found to be not significant for explaining the likelihood of innovation or the extent of innovation. This result is not in accordance with the well-established idea that competition is a key driver for innovation (Baldwin and Scott, 1987; Cohen and Levin, 1989). We also found that the demand-pull variable had a strong and positive effect on the commercial success of product innovation in services. Dedicating attention to improving market conditions (enhanced quality of services, increased range or market share) pays off more for service firms in terms of commercial success of product innovation, in line with the literature.

Overall, we found that determinants for both stages of the innovation process varied more for manufacturing than for services. Indeed, for manufacturing firms, most of the effects that were found to be statistically significant in the estimates for the probability to introduce product innovations become insignificant with respect to the extent of innovation. Non-technological innovation activities, strategic protection, firm size and belonging to a group become no longer relevant for the extent of innovation. For this latter phase, three other effects were identified: business practices (a dimension of organisational innovation) had a negative impact whereas knowledge management and market-related obstacles had a positive effect. For services, three common factors appeared in the two phases: organisational innovation (as an aggregated variable, and mainly the external relations' dimension), firm size (which was positively correlated for the likelihood of innovation, but negatively for the extent of innovation), and cost-related obstacles. Two additional positive effects appeared, due to factors which were not included in the basic model: demand-pull effects of innovation (as services are largely co-produced with customers), and R&D intensity. On the whole, demand-sided factors for manufacturing and financial conditions for services increased the estimates for this outcome-oriented variable, in line with recent results observed with Swiss firms (Arvanitis, 2008).

CONCLUSION

The recent literature highlights the iterative character of innovation processes where non-technological activities play a crucial role (Tatikonda and Montoya-Weiss, 2001; Schmidt and Rammer, 2007; Armbruster *et al.* (2008). Contributing to a better understanding of the relationships between various forms of innovation and using data on manufacturing and service firms, we tested the impact of organisational and marketing innovations on technological innovation in order to capture such effects.

Our study highlights the importance of these two types of non-technological innovation activities with respect to the likelihood to innovate. Both organisational and marketing innovations led to a higher propensity to introduce new or improved products, especially for service firms, confirming previous results reported by Schmidt and Rammer (2007). When considering the extent of innovation, only organisational innovation had a significant effect, as an aggregated variable in the case of services, but only for some practices for manufacturing. This result confirms the importance of "soft" changes (Tether, 2005; Tether and Tajar, 2008) such as organisational factors in the service sector (e.g. Sirilli and Evangelista, 1998; Evangelista, 2000; Drejer, 2004; Tether, 2005; among others). However, the significant effect of R&D on the extent of innovation for services does not fit with this view. In this respect, innovation in services might be more like innovation in manufacturing firms than was thought until now (Arvanitis, 2008). Our results offer little support for the view that service innovation is a completely different concept from that of manufacturing innovation, at least when services as and manufacturing are taken "as a whole", and when dealing with SMEs as was the case in this survey. Moreover, our results show that the effects of non-technological innovation also differ according to whether the firm is in the first step of the innovation process (i.e. being innovative or not), or in a subsequent step (i.e. the extent of innovation). These differences in determinants were higher for manufacturing than for service firms.

These results entail important implications for theory in four directions. First, the importance of organisational innovation for services is confirmed, leading to conceptual and theoretical questions on the link between product, process and organisational innovations for that type of industry. Second, the two stages of the innovation process are determined by different variables. Theoretical works on the determinants of innovation, and on the impact of innovation on firm performance and, more generally, on economic wealth,

should focus on examining what counts more: being innovative or having new products with commercial success? If the latter seems more effective in terms of firm performance, then how can we compare large and small firms, and firms with different economic activities? Third, the effects of non-technological innovations on technological innovation vary according to the type of industry, even though the similarities are not negligible. In particular, non-technological innovations have a significant effect for manufacturing and services in terms of likelihood of innovation, in line with the acknowledged belief that there is a climate for innovation that spreads throughout all aspects of organisational life, thus in technological as well as non-technological areas. Strangely enough, this does not appear to be true for the latter stage, even though research (Teece, 1986) has stressed the importance of complementary assets and competencies for technological innovation. For the extent of innovation, organisational innovation is found to be key for services. Fourth, SMEs do behave differently, especially as they do not possess such complementary assets internally. For this reason external relations appear as the most important determinant in both phases, especially for service firms (due to the very nature of services and their co-production with clients).

Based on these considerations, a number of points may be of use to policy-makers intent on supporting innovation in manufacturing and service industries, especially in SMEs. Some of our results confirm previous observations and works. In particular, the major obstacles for service firms are economic and financial in nature (Evangelista, 2000), but linked to the market for manufacturing. Market-related aspects are less problematic for services, probably due to the co-terminality between production and consumption (Gallouj and Weinstein, 1997) and to the customisation implemented in order to answer to a wide range of users' needs (Evangelista, 2000). As such, service firms are aware of the importance of external links. Public policy has already enforced this aspect of innovation determined by external relations, for instance through incentives for R&D collaborations or through cluster policies. However, this focus on external relations might not be only focused on scientific collaborations, as is often the case in Europe, but also on external relations in general. Moreover, some of our results do not fit with previous findings and should be considered with care by policy-makers. They should be aware of the fact that the broad category of "services" encompasses various kinds of services, some of which (mainly the KIBS) are R&D intensive (with similarities with manufacturing firms), others not (transport, wholesale trade, etc.). Incentives for innovation should therefore take these differences into consideration, and endeavour to be more adapted to the sub-sectors of each industry. Further refinements on organisational and marketing innovation definitions should also be considered for further Community Innovation Surveys as these are still too specific to manufacturing.

Future research on the impact of non-technological innovations on technological innovation, and more generally on firm performance, could allow for an appropriate time lag in order to assess the long-term impact of organisational or marketing innovation. Also, as argued by Armbruster *et al*. (2008), it would be interesting to compare results with other large-scale surveys (NUTEK, DRUID, EPOC, INNFORM, COI) that use other measures both for organisational and marketing innovations, and for technological innovation. We can conclude that, although knowledge about innovation in services has substantially improved over the recent years, as well as knowledge concerning the different types of innovation, these interrelations still remain largely unexplored. Therefore, this present analysis represents only a small step along the path to achieve greater knowledge concerning the variety in innovation patterns between manufacturing and services – notwithstanding that further analysis should also focus on the heterogeneity within these two largely-defined sectors. Much work remains ahead in order to fully understand the complementary effects of different types of innovation.

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APPENDIX A Definition of variables

Variables	Description
Innovations	
Likelihood of innovation	Equals 1 if new or significantly improved goods or/and services were introduced during the three years from 2004 to 2006, 0 otherwise
Extent of innovation	Percentage of the total turnover in 2006 from goods and service innovations introduced from 2004 to 2006 that are new to the firm
Organisational innovation	Equals 1 if at least one of the four organisational innovations were introduced: (1) new business practices; (2) new knowledge management systems; (3) new methods of workplace organisation; (4) new methods of organising external relations , 0 otherwise
Marketing innovation	Equals 1 if at least one of the four marketing innovations were introduced: (1) significant changes to the design or packaging; (2) new media or techniques for product promotion; (3) new methods for product placement or sales channels; (4) new methods of pricing goods or services, 0 otherwise
Detailed organisational innovations	
Business practices	Equals 1 if new business practices for organising work or procedures (i.e. supply chain, business re-engineering, lean production, quality management) were introduced, 0 otherwise
Knowledge management	Equals 1 if new knowledge management systems to better use or exchange information, knowledge, skills within the firm or to collect and interpret information from outside the firm) were introduced, 0 otherwise
Workplace organisation	Equals 1 if new methods of workplace organisation for distributing responsibilities and decision making (team work, decentralisation, integration or de-integration of departments) were introduced, 0 otherwise
External relations	Equal to 1 if introduced new methods of organising external relations with other firms or public institutions (partnerships, outsourcing, sub-contracting), 0 otherwise
Detailed marketing innovations	
Product design	Equals 1 if significant changes were made to the design or packaging of goods or services, 0 otherwise
Product promotion	Equals 1 if new media or techniques for product promotion were introduced, 0 otherwise
Product placement	Equals 1 if new methods for product placement or sales channels were introduced, 0 otherwise
Pricing	Equals 1 if new methods of pricing goods or services were introduced, 0 otherwise
Obstacles to innovation	
Cost-related obstacles	Equals 1 if the score of importance of at least one of three following obstacles (scores between 0 (unimportant) and 3 (crucial)) is "crucial": (1) lack of funds within your enterprise; (2) lack of finance from sources outside your enterprise; (3) innovation costs too high, 0 otherwise
Knowledge-related obstacles	Equals 1 if the score of importance of at least one of four following obstacles (scores between 0 (unimportant) and 3 (crucial)) is "crucial": (1) lack of qualified personnel; (2) lack of information on technology; (3) lack of information on market, (4) difficulty in finding cooperation partners for innovation, 0 otherwise
Market-related obstacles	Equals 1 if the score of importance of at least one of two following obstacles (scores between 0 (unimportant) and 3 (crucial)) is "crucial": (1) market dominated by established enterprises; (2) uncertain demand for innovative goods or services, 0 otherwise

R&D	
R&D intensity	Sum of expenditure for in-house R&D and external R&D in 2006 divided to total turnover i 2006
Innovation protection	
Formal protection	Equals 1 if the score of importance of formal protection method "patent" or "trademarks" or "registration of design patterns" or "copyrights" is "crucial", 0 otherwise (scores between 0, unimportant and 3, crucial)
Strategic protection	Equals 1 if the score of importance of strategic protection method "secrecy" or "complexity of design" or "lead-time advantage on competitors" is "crucial", 0 otherwise (scores between 0, unimportant and 3, crucial)
Other variables	
Demand-pull objectives	Sum of scores of importance of three demand-related objectives of innovation, number between 0 (unimportant) and 3 (crucial): (1) increased range of goods or services; (2) entered new markets or increased market share; (3) improved quality of goods or services (rescaled between 0 and 1)
Cost-push objectives	Sum of scores of importance of four cost-related objectives of innovation, number between 0 (unimportant) and 3 (crucial): (1) improved flexibility of production or service provision; (2) increased capacity of production or service provision; (3) reduced labour costs per units output; (4) reduced materials and energy per unit output (rescaled between 0 and 1)
Competition intensity	Six variables describing the characteristics of the competitive context, on a Likert scale (0 to 3): (1) the actions of competitors are difficult to forecast; (2) the position on the market is threatened by the arrivals of new competitors; (3) the production's technologies and the services are changing quite quickly; (4) the products and services are rapidly old-fashioned; (5) the products of your enterprise can be easily replaced by the products of your competitors; (6) evolution of the demand is difficult to forecast
Firm size	Logarithm of the number of employees
Group	Equals 1 if the firm is part of group, 0 otherwise
Sectors	Dummy variables Services or Industry (reference). Services: S_Transport and communication; S_Financial intermediations; S_Computer activities; S_R&D – Engineering activities and consultancy, Technical testing and analysis and S_Wholesale trade. Industry: I_High and medium high-tech manufacturing Industry; I_Medium low tech manufacturing industry; I_Low tech manufacturing industry

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