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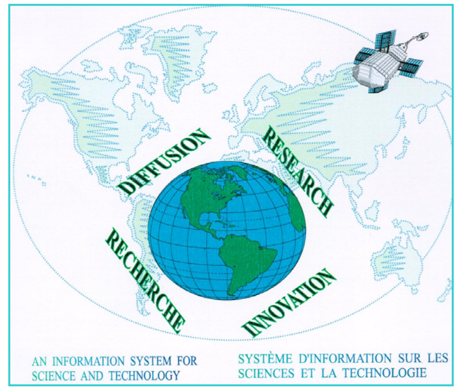

Determinants of Product and Process Innovation in Canada's Dynamic Service Industries

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Determinants of Product and Process Innovation in Canada's Dynamic Service Industries

by

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December 2002

88F0006XIE No.17

Working Papers

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The Science and Innovation Information Program

The purpose of this program is to develop **useful indicators of science and technology activity** in Canada based on a framework that ties them together into a coherent picture. To achieve the purpose, statistical indicators are being developed in five key entities:

Actors: are persons and institutions engaged in S&T activities. Measures include distinguishing R&D performers, identifying universities that license their technologies, and determining the field of study of graduates.

Activities: include the creation, transmission or use of S&T knowledge including research and development, innovation, and use of technologies.

Linkages: are the means by which S&T knowledge is transferred among actors. Measures include the flow of graduates to industries, the licensing of a university's technology to a company, co-authorship of scientific papers, the source of ideas for innovation in industry.

Outcomes: are the medium-term consequences of activities. An outcome of an innovation in a firm may be more highly skilled jobs. An outcome of a firm adopting a new technology may be a greater market share for that firm.

Impacts: are the longer-term consequences of activities, linkages and outcomes. Wireless telephony is the result of many activities, linkages and outcomes. It has wide-ranging economic and social impacts such as increased connectedness.

The development of these indicators and their further elaboration is being done at Statistics Canada, in collaboration with other government departments and agencies, and a network of contractors.

Prior to the start of this work, the ongoing measurements of S&T activities were limited to the investment of money and human resources in research and development (R&D). For governments, there were also measures of related scientific activity (RSA) such as surveys and routine testing. These measures presented a limited picture of science and technology in Canada. More measures were needed to improve the picture.

Innovation makes firms competitive and we are continuing with our efforts to understand the characteristics of innovative and non-innovative firms, especially in the service sector that dominates the Canadian Economy. The capacity to innovate resides in people and measures are being developed of the characteristics of people in those industries that lead science and technology activity. In these same industries, measures are being made of the creation and the loss of jobs as part of understanding the impact of technological change.

The federal government is a principal player in science and technology in which it invests over five billion dollars each year. In the past, it has been possible to say only *how much* the federal government spends and *where* it spends it. Our report **Federal Scientific Activities, 1998 (Cat. No. 88-204)** first published socio-economic objectives indicators to show *what* the S&T money is spent on. As well as offering a basis for a public debate on the priorities of government spending, all of this information has been used to provide a context for performance reports of individual departments and agencies.

As of April 1999, the Program has been established as a part of Statistics Canada's Science, Innovation and Electronic Information Division.

The final version of the framework that guides the future elaboration of indicators was published in December, 1998 (**Science and Technology Activities and Impacts: A Framework for a Statistical Information System,** Cat. No. 88-522). The framework has given rise to **A Five-Year Strategic Plan for the Development of an Information System for Science and Technology** (Cat. No. 88-523).

It is now possible to report on the Canadian system on science and technology and show the role of the federal government in that system.

Our working papers and research papers are available at no cost on the Statistics Canada Internet site at http://www.statcan.ca/cgi-bin/downpub/research.cgi?subject=193.

Abstract

This article is an exploratory study to help identify and characterize innovation practices in Canada's dynamic service industries. The author uses logistical estimates to demonstrate that innovation in the services sector is not homogeneous. For each type of innovation – product, process or both – there is a different business strategy. Small firms do more product innovation, and clients, along with fairs and exhibitions, appear to be the primary sources of information. Product innovation is generally done by technical services industries. Process innovation does not seem to favour any particular sector, but understandably, the factors that have the most impact on this type of innovation are company flexibility and information from patent literature, consulting firms and internal management. The most complex strategy – both product and process innovation – is particularly associated with large firms in the communications and finance subsectors. This type of innovation has a larger number of significant factors than the other two types. Finally, the author shows that there are differences between the forms of innovation, and these differences apply within individual sub-sectors.

Keywords: Product innovation, process innovation, Schumpeter's hypotheses, technological opportunity, technological appropriability, service sector.

Acknowledgements

Many thanks to Frances Anderson for her support and encouragement throughout this project. I am especially indebted to Pierre Therrien and Pierre Mohnen as well as Daood Hamdani and Namatié Traoré for their valuable comments. I would also like to thank Fred Gault, without whom this work would probably never have been completed.

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1. Introduction

Most of what we know about the innovation process comes from our understanding of the manufacturing sector. Our knowledge of the service sector is more limited. But there is growing interest among researchers in service sector innovation – and for good reason, since services have a higher percentage of workers with a university education than manufacturing, as well as one of the highest job creation rates of any industry (Statistics Canada, 2001a). Innovation in services is often the driving force – or at least one of them – behind innovation in manufacturing. So it is vital to understand what factors affect service innovation. It is the type of innovation that helps firms position themselves relative to the competition, penetrate new markets or simply keep the markets they have (Gellatly and Peters, 1999); in other words, the way of innovating is a key component that determines the nature of the innovation strategy.

According to recent studies, certain characteristics such as company size, market structure, market demand, appropriability and technological opportunities, as well as the interactions among the various economic agents[1] in the national innovation system (Leo, 1996) are the main factors influencing innovation activity in the manufacturing sector. Many contributions to the literature have shown the importance of sectoral differentiation in the innovation process (Pavitt, 1994). Other researchers, such as Gellatly and Peters (1999) and Baldwin, Gellatly, Johnson and Peters (1998), have found that the objectives of innovation are important as a possible factor in the decision to innovate.

Several of these characteristics have been debated. One example is technology appropriability, whose purpose is to provide innovators with guaranteed protection for the effort made in taking the risk associated with innovation. Can this protection take different forms, and are they all effective? Does this protection stimulate growth, or impede it by creating temporary monopolies (Baldwin et al., 2000)? Another example is company size and its relationship to market structure. It has often been taken for granted that large firms innovate more, but researchers such as Gambardella (1995) maintain that small companies make the most ground-breaking discoveries. A third example is technological opportunity. Again here, the literature seems to indicate that sectoral differentiation is important in the sense that firms with access to research and development (R&D) networks have a better chance of innovating (Cohen et al., 1996).

In the present article, our aim is not to find an explicit answer to these questions, each of which could be the topic of a separate study. However, the issues will provide us with a reference point in selecting the variables to include in our model. For example, it would be interesting to introduce various forms of appropriation or measure the effect of technological opportunity.

Previous attempts to understand the determinants of innovation have dealt primarily with the manufacturing sector. In an article based on data from about 600 manufacturing firms, Leo (1996) concluded that the same factors govern both product and process innovations. However, most of his results are at best marginally significant, and the number of

[1] Economic agents refer to institutional agents (government, clients, universities, etc.) and agents within the firm (researchers, internal departments such as marketing, management, etc.).

observations is too small to support robust conclusions. Another study, conducted by Kraft (1990), looked at a very specific population in the manufacturing sector, consisting of 56 metallurgical firms in Germany. That study is notable in that it situates the issue of differentiation of product and process innovation at a single industrial classification level. The author showed that the factors governing product and process innovations are not the same. He concluded that product innovation led to process innovation, but not vice versa. This is precisely the opposite of what Leo (1996) found. However, this apparent contradiction could be due to the fact that Leo's data (1996) covered several industries in the manufacturing sector, unlike Kraft's data (1990), which concerned a single industry. Preissl (2000) examined the issue in the service sector and concluded that product innovation can be distinguished from process innovation, but that it makes no sense to separate process innovation and organizational innovation,[2] since in the service sector both types result in the same production function. In the manufacturing sector, on the other hand, the organizational function is distinct from the production function. The few researchers who have addressed the subject have pointed out how difficult it is to arrive at a "diagnosis" on which consensus can be reached, but as we will see in the next section, those differences will help us formulate our hypotheses.

This study uses data from Statistics Canada's Survey of Innovation, 1996, on dynamic services. It covers a much larger population than the three studies cited above (see section 2). With the choice to look at the service sector, this approach more or less complements that of the manufacturing studies. At the same time, it provides an opportunity to examine the constraints and characteristics that are specific to the service sector. For example, the results of this study may lead to questioning the relevance of type of innovation in the services. To better organize the understanding of innovation in the service sector, the study will try to achieve the following two goals: first, identify and describe as best one can the importance of certain factors that can be used to measure the innovation process; and second, determine whether it is reasonable to distinguish between innovation types on the basis of certain criteria, or whether the distinction is not relevant.

2. Survey of Innovation in dynamic services

This study is based on data collected by the Survey of Innovation, 1996, conducted by Statistics Canada as part of the Science and Technology Redesign Project. It was the first survey designed to collect data on service-producing businesses. It covered three subsectors:[3] communications, with a sample of 895 enterprises; finance, with a sample of 90 enterprises; and technical services, with a sample of 1,960 establishments.[4]

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[2] Organizational innovation is often introduced as a third form of innovation in studies of the service sector. According to the definition in the Oslo Manual, however, process innovation includes organizational changes.

[3] For a list of the industries in each subsector, see Table 1.

[4] The potential statistical bias due to different measures would be less than 8% of the values in the technical services subsector. That is, only 8% of the innovating establishments in the subsector have more than 100 employees, and that is the size range that contains the largest number of multi-establishment entreprises (which span several provinces or several classification codes). For the others, one enterprise equals one establishment. Hence the impact is negligible.

To determine the total population, the technical services and finance industries were weighted to reflect the stratification of the sample. In the communications industry, only minor adjustments were made since all the establishments in the population were included in the sample.

The response rate was between 84% and 89%. Most of the questions were qualitative, with respondents being asked to select one of six responses on a Likert scale.

The three industries were chosen for their innovative characteristics and their vitality in terms of growth and R&D efforts in the service sector.

3. Hypotheses, variables and methodology

The strategy pursued by an innovative firm is reflected in the type of innovation it produces. There are a number of elements involved in the innovation process. Those elements are the explanatory variables of innovation (objectives, information sources, appropriabilities, etc.), and the way in which the firm uses them is directly related to its strategy. The important underlying questions that we raised in the introduction come down to whether there are real differences between types of innovation, in other words, between innovation strategies. Logically, the next question is how those differences manifest themselves in the service sector. In the introduction, we saw that there is no single response to these questions. Researchers who studied the issue came up with different answers depending on the industry and economic sector they examined. For all these reasons, we will ask the following question: Can innovation strategies be differentiated? How can such differences be identified at the sub-sectoral and industry group levels?

In the course of this paper, we will attempt to answer these questions. We will describe our approach in the section on methodology. Before that, however, we will provide a quick overview of the reasons for our choice of variables.

3.1 Dependent variables

In its basic definition, the Oslo Manual describes two possible types of innovation: technological product innovation and technological process innovation. The two types have different properties. A technological product innovation may consist in the creation of a technologically new or improved product (good or service).

Hence, this type of innovation is more readily adopted by firms that have a market penetration strategy and hope to gain a direct advantage over the competition. Technological process innovation, on the other hand, relates to firms that want to increase their competitiveness, since the particular aim of this strategy is to reduce production or delivery costs. Following this strategy, the firm will become more competitive in price than in product novelty or quality (Hamdani, 2001 and Sirilli and Evangelista, 1998).

Firms generally pursue both innovation types simultaneously. Doing product innovation alone may seem unusual. It’s hard to imagine introducing a new product without changing the production function. Similarly, a change in the production function usually precedes the introduction of a new product or a new delivery method. As we will see, the boundary between the two types is not always obvious in the service sector. To determine whether there are differences between the innovation types, we created some dichotomous variables to differentiate mutually exclusive innovation categories (see Table 1).

3.2 Independent variables

The service sector is known for its heterogeneity in both industrial structure and activities (Hamdani, 2001). Innovation itself is probably a heterogeneous activity; that's what this paper attempts to determine. The differences are sometimes due to the industry and sometimes due to the firm and the type of activities.

There can be a number of different reasons for industry heterogeneity. The activity differences between subsectors and industry groups (four-digit SICs) are one component of heterogeneity. Other components include the firm's relationship with other economic agents, especially with regard to the information source for innovation, and opportunities for technology alliances.

The company-related differences have to do with the company's size, strategic objectives and means used to protect the innovation.

Finally, the innovation activity itself produces differences. In section 3.1, we discussed several ways of innovating and noted that each way reflects a specific strategy.

The model that we will outline in detail in section 3.3 and the variables that we will describe below are intended to demonstrate the heterogeneity we have just described. However, some aspects of the innovation process will not be used in the model. One of the reasons has to do with the maturity of the process. We are particularly interested in the variables that initiate the innovation process. Certain variables that influence the type of innovation do not come into play until the firm has started the process. For example, barriers to innovation mostly affect firms that encounter them. Obstacles to innovation in the service industries have been discussed in depth by Mohnen and Rosa (1999).

- **Company size and market demand**

In a now famous book, Schumpeter (1942) was one of the first to discuss the relationship between innovation activities and company size. He put forward two hypotheses: innovation activity increases more than proportionally with company size and with market concentration. Without actually providing formal proof of his statements, he suggested the following as possible explanations: ease of access to capital, the economies of scale that large companies can achieve and the level of risk they can assume. The relationship between size and innovation activity was also examined more recently by Cohen and Klepper (1996), who confirmed Schumpeter's assertions and demonstrated more formally that large companies greater advantage from R&D activities for process innovation rather than for product innovation. Even more recently, Mazzucato (2000) reported that it is not so easy to prove a positive correlation between size and innovation.

He showed that when market dynamics, competition and concentration are imperfect, the equilibrium and direction of the correlation between the two variables can fluctuate. The instability of the relationship depends on market conditions.

The foregoing indicates how important company size is. As a result, we have included a measure of company size in our estimate (see Table 1 for details). Size is measured by the number of employees. A combination of number of employees and company revenues would certainly have made a better measure, but they were not available.

The data from the Survey of Innovation, 1996, do not capture Schumpeter's market concentration effect directly. It does, however, have a variable that measures the impact that introducing an innovation has on the range of products provided to clients and on market expansion. That variable's significance is assumed to be positively correlated with market concentration. If a firm expands both its clientele and the geographic area it serves, it is assumed to have taken market share from the competition. It is a zero-sum game; in other words, what is gained by some is lost by others. In fact, geographic expansion is a variable that more specifically captures market demand. Market concentration is construed here as a synonym of market demand. However, this variable also has its limitations. It is possible to extend the range of products provided to clients without necessarily increasing the clientele, simply by increasing the choice of products for the same clientele. In our discussion, we hypothesize that extending both the product range and the geographic area implies an expansion of the clientele.

- **Sector of activity**

Our study deals exclusively with the so-called dynamic service industries. This particular sector includes communications services, financial services and technical services (for details, see Table 1). Using dichotomous variables to differentiate these subsectors should help us capture the difference in economic structure in the service sector. Sirilli and Evangelista (1998) compared the service and the manufacturing sectors and showed that differences in firms' ways of innovating were marginal. This study was based on the 1995 Italian innovation survey in the service and manufacturing sectors.

We also cover in detail the technical services sub-sector (computer services firms, computer equipment maintenance and repair firms, offices of engineers and other scientific and technical services firms), so that we can estimate the structural differences within an industry group. By looking at the service sector's economic structure in detail, we hope to test its heterogeneity.

- **Appropriabilities or intellectual property rights**

Engaging in innovation activities involves a number of risks. First, it takes money to do development work or acquire materials. Second, there is no guarantee that the innovation will result in a marketable product. This implies that there is no assurance of covering the costs of innovating. Third, competitors may copy the innovation and thus avoid the development costs. For all these reasons, the innovative firm looks for ways to protect itself from the risks. The means of protection represent the firm's capability for appropriability. Appropriability is essential if a firm is to engage in the innovation process.

Protection can take a number of different forms. Some firms use patents, while others rely on trademarks. Other means of protection include copyright, trade secrets and industrial designs.

There is agreement in the literature that appropriability is important in the innovation process, but we have little experimental evidence that it promotes innovation (Baldwin et al., 2000). In fact, excessive protection can temporarily generate a monopoly rent for a firm that asserts its intellectual property rights, not only keeping competitors out of the market niche but also deterring any research in the field. Hence, protection can become an argument against innovation (Morck and Yeung, 2001).

With our data, we can exploit various facets of the literature on intellectual property rights. We can test different forms of appropriability and their effects on innovation. To do so, we used three qualitative variables, each of which is a different form of appropriability:

(1) intellectual property
(2) complexity of product design
(3) being first on the market

(For details on how the variables were generated, see Table 1.)

In the Survey of Innovation, 1996, respondents were asked to rate the effectiveness of the means of protection on a scale of 1 to 6, where 1 was "not at all effective" and 5 was "extremely effective" (6 was "not relevant"). To make the measurement of our variables' effectiveness more robust, we used only response categories 4 and 5 ("very effective" and "extremely effective"). Category 6 ("not relevant") was excluded from our calculations. As noted by Mazzucato (2000), the sign of the variables' values depends on the structure of the market.

- **Technological opportunity**

The concept of technological opportunity is not new. As Baldwin, Hanel and Sabourin (2000) have pointed out, it dates back to at least Scherer (1965). It measures how well connected a firm is to scientific research. It is an indication of the extent to which knowledge flows from one firm to another. It indicates the degree to which know-how can be transferred (Baldwin, Hanel and Sabourin 2000). It has often been noted that service firms are less likely than manufacturing companies to have an R&D department in their organizational structure (Sundbo and Gallouj, 2000). It is easy to understand, then, why R&D alliances, as opposed to a simple measure of the amount of R&D performed by a firm, are so important in the service sector. R&D alliances are an alternative source of inputs, and they can sometimes take the place of in-house research in the service sector.

While it is fairly easy to see the relationship between technological opportunity and innovativeness, seeing that relationship in terms of innovation type is probably less common. When Pavitt (1984) made an estimate of the relationship, he found, as expected, that product innovation has a positive correlation with technological opportunity, but also that economies of scale and therefore company size favoured process innovation.

To verify this relationship, we will include in our model a variable that captures technological opportunity. That variable designates firms that entered into R&D alliances with other firms or organizations between 1994 and 1996. We are not so much interested in the firms' R&D activity as in the opportunities (options) they have in the area of alliances and strategic relationships to meet R&D needs.

- **Objective of innovation**

In our approach, we are at least as interested in the innovation process as in the original reasons for engaging in innovation activities. The Oslo Manual strongly recommends measuring the economic objectives of innovation. There are as many objectives as there are business strategies. In other words, not all economic entities are pursuing the same objective. The strategy used will depend on the firm's type of activity, size, maturity and market demand. Consequently, the objective is an action that provides additional information about the firm's innovation strategy. Though seldom used at the empirical level, this variable is often regarded as highly important (Gellatly and Peters, 1999).

To capture the effect that strategy has on innovation type, we will use eight possible objectives (for details, see Table 1).

- **Source of innovation information**

Information sources are an important aspect of the innovation process. They define the context in which a firm operates. This framework in turn defines the network through which contacts and information synergies are established. An effective information network typifies an effective national innovation system. Lundvall (1992) defines a national innovation system as a set of elements that interact in the production and diffusion process by using the knowledge available in a national context. Information source is a variable whose arithmetic mean not only captures the quality of the relational network among economic agents but also identifies the origin of the drive underlying innovation (Leo, 1996). The economic agents are both inside and outside the firm (for details on these economic agents, see Table 1).

To measure this information network, we have internal, external, general and institutional sources. Details for each of these sources are provided in Table 1.

Table 1. Summary of dependent and independent variables in the logit model[5]

Variables	Description
Dependent variables	
Product Process Product and process	- Firms that introduced new or improved products only between 1994 and 1996 and rated extending their product range as very significant or crucial. - Firms that introduced new processes only between 1994 and 1996 and rated extending their product range as very significant or crucial. - Firms that engaged in both types of innovation.
Independent variables	
Size	Number of employees: 0 – 19 20 – 99 100 – 499 500 +
Industry	**Communications**: Radio broadcasting (SIC 4811) Television broadcasting (SIC 4812) Combined radio and television broadcasting (SIC 4813) Cable television (SIC 4814) Telecommunication carriers (SIC 4821) Other telecommunication industries (SIC 4839) **Financial services**: Chartered banks (SIC 7021) Trust companies (SIC 7031) Life insurers (SIC 7311) **Technical services**: Computer services (SIC 7721) Computer equipment maintenance and repair (SIC 7722) Offices of engineers (SIC 7752) Other scientific and technical services (SIC 7759)
Market demand	The innovation was very significant or crucial for product or market expansion.
Objectives of innovation	- **Reducing costs** is very significant or crucial (labour costs, consumption of materials, energy consumption, product design, production lead times, other). - **Replacing phased-out products** is very significant or crucial. - **Maintaining market share** is very significant or crucial. - **Extending the product range (in the main area of production; not in the main area of production)** is very significant or crucial. - **Increasing market share** is very significant or crucial. - **Finding new markets** is very significant or crucial (domestic targets, Europe, United States, Japan, other). - **Improving production flexibility** is very significant or crucial. - **Improving product quality** is very significant or crucial. - **Improving working conditions** is very significant or crucial.
Research and development activity	- Firm engaged in R&D activities in 1994-1996.
Technological opportunities	- Firm entered into R&D alliances with other firms or organizations in 1994-1996.
Technology appropriabilities: **Intellectual property**	- Firms that rated intellectual property rights as a very or extremely effective means of protecting themselves from the competition (copyright, patents, industrial designs, trade secrets, trademarks, integrated circuit designs, plant breeders' rights, other).

[5] All the variables are qualitative, taking a value of 1 if the characteristic exists and 0 if not.

Complexity of product design **Being first on the market**	- Firms that rated complexity of product design as a very or extremely effective means of protecting themselves from the competition. - Firms that rated being first on the market as a very or extremely effective means of protecting themselves from the competition.
Information sources	
<u>Internal sources</u>	
In-house R&D	- Firms that rated in-house R&D as very significant or crucial.
Marketing	- Firms that rated the marketing function as very significant or crucial.
Production	- Firms that rated the production function as very significant or crucial.
Management	- Firms that rated the management function as very significant or crucial.
Other	- Firms that rated other functional units as very significant or crucial.
<u>External sources</u>	
Competitors	- Firms that rated competitors in the same business line as very significant or crucial.
Equipment acquisitions	- Firms that rated equipment acquisitions as very significant or crucial.
Clients or customers	- Firms that rated clients or customers as very significant or crucial.
Consultancy firms	- Firms that rated consultancy firms as very significant or crucial.
Suppliers	- Firms that rated suppliers as very significant or crucial.
<u>Generally available information</u>	
Government programs	- Firms that rated government information programs as very significant or crucial.
Fairs, exhibitions	- Firms that rated fairs and exhibitions as very significant or crucial.
Professional conferences, meetings	- Firms that rated professional conferences and meetings as very significant or crucial.
Social gatherings	
Patent literature	- Firms that rated patent literature as very significant or crucial.
<u>Education and research institutions</u>	
Universities	- Firms that rated universities and other higher educational institutions as very significant or crucial.
Government research institutions	- Firms that rated government research institutions as very significant or crucial.
Private research institutions	- Firms that rated private research institutions as very significant or crucial.

3.3 Model and methodology

Our approach must address the issues raised by the questions we formulated in Section 3: Can innovation strategies be differentiated? How can such differences be identified at the sectoral and industry levels?

To answer these questions, we will begin by identifying and describing the various forms of innovation. In our study, we will distinguish three different ways of innovating: product innovation, process innovation and a combination of product and process innovation. No matter what form innovation takes, it will depend on a number of characteristics. Hence, the probability of innovating should be based on those characteristics. Formally, this relationship can be expressed as follows:

$Y^* = \beta X + \mu$ where X is observable and Y^* is not

$Y = 1$ if $\beta X + \mu > 0$
$Y = 0$ if $\beta X + \mu < 0$

Y represents the type of innovation (product, process, or product and process)

X represents the exogenous explanatory variables.
The conditional probability of innovating at the company level is given by

$E(y_i^* / x_i)$, which gives $Prob(y_i = 1) = Prob(\mu_i > -\beta x_i)$

$$= \Lambda(\beta x_i)$$
$$= \exp(\beta x_i)/(1+ \exp(\beta x_i)) \qquad (1)$$

This expression is a logistic model of the logit type. If we had assumed that error term had a normal distribution, we would have been using a logistic model of the probit type. The difference between the two models is slight, having to do primarily with the collapse of the distribution function, but it does not affect the sign. For practical reasons, we will estimate a logit model as expressed in equation (1). The βx_i term will be replaced by the expression in equation (2).

In the theoretical formulation of our model, we assume that innovation type depends on the following factors: company size, sector of activity, market demand, the objectives of innovation, technological opportunities, appropriability conditions and information sources (see sections 3.1, 3.2 and 3.3).

Our full estimation model can be expressed as follows:

$$Prob(product\_inno) = \beta_0 + \beta_1 Size + \beta_2 Industry + \beta_3 Demand + \beta_4 Objectives \qquad (2)$$
$$+ \beta_5 Opportunities + \beta_6 Appropriabilities + \beta_7 Information\ sources + \mu$$

The same equation will be used to estimate process innovation and product-and-process innovation. The components of equation (2) are described in detail in section 3.3. It should be noted that all our estimates concern only innovators; non-innovators have been excluded. What is original in the issue examined here is not differentiating between innovators and non-innovators, but rather identifying what characterizes the different types of innovation.

If we can prove that the various types of innovation are reflected in different variables and that their impact is significantly different (as measured using odds statistics), we will corroborate the hypothesis that it is important to distinguish between the forms of innovation based on the identified characteristics.

We will do another estimate of this model, this time for the individual sub-groups of industries in one of the three service subsectors, to determine whether there are differences within an industry group. Finally, we will also present the results of equation (2) in its reduced form to correct for possible multicollinearity between certain groups of variables. With regard to the selection of variables for the reduced model, we will carry out a principal component analysis (PCA) to statistically identify the appropriate variables. The PCA is used to select specific variables (eigenvectors) which individually account for a certain percentage of the variation, and in combination, for the majority of the variation in all of the variables. Thus, the selected variables will be independent of one another and will effectively explain the correlations among all the original variables (see Appendix C). The results of the estimates will be presented in Tables 2 through 5 in Section 5.

4. Descriptive analysis

Our exploration of the data on innovative firms in the dynamic services sector reveals a difference in company size between the subsectors. The communications and technical services subsectors are essentially dominated by small firms; respectively, 62% and 78% of them (see Table A1, Appendix A) have fewer than 20 employees. In contrast, the financial subsector consists primarily of medium-sized and large companies, as 57% of them have more than 100 employees. This structural difference becomes much less evident when we take a more detailed look at the technical services subsector, in which between 78% and 86% (see Table B1, Appendix B) of the units in the industry groups (computer services, repairs, offices of engineers, and other services) have fewer than 20 employees.

Company size is not the only distinguishing factor in the service sector. Innovation activity also seems to vary with the type of innovation (see Table A2). In general, the service sector engages in both product and process innovation. At a more detailed level, the technical services subsector engages in product-only innovation proportionally more (47%) than the other subsectors. Such a result is hardly surprising. The innovation activities of the individual technical services industries are most similar to the kind of production done in the manufacturing sector. The communications subsector does proportionally more process innovation (16%). By way of comparison, process-only innovation accounted for just 12% in the manufacturing sector as a whole, according Statistics Canada's 1999 survey, (Statistics Canada, 2001b). This finding supports our hypotheses that the service sector generally does more process innovation than the manufacturing sector; this seems to be even more true of certain service subsectors. The finance subsector ranks highly on a proportional basis in product-and-process innovation (59%).

Some characteristics are common to all three subsectors. For example, maintaining market share, increasing market share and opening up new markets are the most common strategies in the service sector, with rates of 62% to 72% (Table A3). For all three subsectors, the main information source is external, particularly clients and customers. Being first on the market is the preferred means of protection from competitors (Table A6). The proportion of respondents who have difficulty distinguishing between product and process innovation ranged from 9% to 15% in the services. Let's take a closer look at this result. We have already cited several researchers who believe it does not make sense to distinguish between product innovation and process innovation in the service sector, even though it is permissible to do so analytically Preissl (2000). The main reason for this has to do with the nature of activities in the service sector. Many activities in the sector involve intangible services, for example, a computer service contracted by an architectural firm. As a result, product innovation can be confused with process innovation much more frequently in the service sector. Yet our statistics suggest that the 1996 survey respondents did not really have any trouble distinguishing between the two concepts. We can therefore assume either that the respondents were quite well-informed and encountered no major problems in separating the two concepts, or that they made systematic errors, which is unlikely. This indicates that when a respondent has trouble determining the innovation type, it is not because the definitions of the two concepts are difficult to understand but because the nature of the service is not perfectly consistent with the definitions. In those cases, product innovation also describes process innovation (Gallouj and Weinstein, 1997). In addition, according to Preissl (2000), process innovation is more frequent in the service sector. Table A2 shows that this statement needs to be qualified for each subsector.[6]

Finally, there are other characteristics specific to the subsectors. R&D alliances are twice as common in technical services as in communications services (Tables A5 and B4). While being first on the market is the leading means of protection from the risks of appropriability, complexity of product design ranks high in the technical services subsector, at 22%, compared with 7% and 5% in the communications and finance subsectors respectively (Table A6).

5. Multivariate analysis[7]

In the comments below, we will focus primarily on the variables that have the most significant influence on the type of innovation (being the most important and positive sources according to the odds ratio criterion). It should be noted that other variables often play a significant role or sometimes have a negative impact on innovation type (see Tables 2 and 3).

Our first estimate model (full model) uses all the explanatory variables in Table 1. The reference group consists of small firms (with fewer than 20 employees) in the technical services subsector. The results of this logit estimate are presented in Table 2. Let's look at some highlights (first column in Table 2). All things being otherwise equal, small companies in the technical services subsector tend to favour product innovation (first column in Table 2). The main sources of information that have a major impact on innovation are clients or customers and fairs and exhibitions, along with in-house R&D. For these four variables, the odds ratio is 1.50, 1.55, 1.60 and 1.51 respectively,[8] and the values are positive and significant. The communications sector does relatively less product innovation than the technical services sector. Companies with more than 500 employees do relatively less product innovation than very small companies. The only objective that appears to have a positive and significant impact on product innovation is product replacement.

Process innovation (second column in Table 2) is a little more complex. Process innovators tend to be firms for whom flexibility is an important objective and firms whose sources of information are management, other sources, consultancy firms, fairs and exhibitions, and patent literature.

[6] In our analysis, because only a small percentage of respondents found it difficult to distinguish between product innovation and process innovation, we did not remove them.
[7] Estimates were also done (for columns 1 and 3) by adding an additional filter on innovation type. For each innovation type, we estimated those that extended their product range. We wanted in this way to capture the quality of the innovation (significant innovation). However, this filter did not yield results that were significantly different from those shown here (without this filter).
[8] Shown in bold in the tables are the variables that influence the probability of innovation the most with a positive sign.

The third column in Table 2 contains data on the most complex form of innovation. In this case, medium-sized and large firms in the communications and finance subsectors have the greatest relative effect on product-and-process innovation. The variable that captures market demand is also very important in this type of innovation, with an odds ratio of 1.84. These results support Schumpeter's market concentration hypotheses, described in section 3.2. Reducing costs and production flexibility are also desirable qualities for firms that do this kind of innovation. These variables show the importance of the business strategy of firms that are engage in competition by lowering costs and adapting to market conditions. Technological opportunity plays a significant role in this type of innovation. Competitors, equipment acquisitions, social gatherings and government research institutions also drive product-and-process innovation.

Overall, whatever the type of innovation chosen by the company, some variables systematically appear as significant. These include very large company size, the objectives of replacing products, opening up new markets and improving flexibility, and complexity of design as a preferred means of protection. Among information sources, production makes a strong showing, along with clients or customers, fairs and exhibitions and universities. However, the effects are not necessarily always in the same direction independently of the type of innovation engaged in. Curiously, product-and-process innovation are the only innovation type on which R&D alliances have a positive and significant impact. For other innovation types, technological opportunity does not appear to play a crucial role in the decision to innovate.

Surprisingly, improving quality of service is not a key factor. The fact that the service sector consists mostly of small businesses leaves little room for innovation strategies based on economies of scale. This argument may account for the importance attached to production flexibility and client relations (customers, exhibitions, social gatherings, etc.), which are factors in the pursuit of an alternative strategy to make up for the lack of in-house R&D (the latter being more common in large firms). In a sense, it is no surprise to find flexibility as one of the main factors in innovation in the service sector. Most firms are small, and flexibility is probably the critical component that keeps them alive in a competitive, ever-changing environment.

Table 2. Logit estimates by type of innovation, complete specification

	Product innovation		Process innovation		Product and process innovation	
	Full model	Odds ratio	Full model	Odds ratio	Full model	Odds ratio
Constant	0.410**	1.50	-0.635**	0.53	-1.933**	0.14
Size						
20 – 99	-0.294**	0.74	-0.196	0.82	0.421**	**1.52**
100 – 499	-0.139	0.87	-1.697**	0.18	0.730**	**2.08**
500 +	-1.696**	0.18	-1.344**	0.26	1.896**	**6.66**
Sectors						
Communications	-0.383**	0.68	-0.036	0.96	0.473**	**1.60**
Finance	-0.014	0.98	-0.796	0.45	0.421*	**1.52**
Demand						
Expansion	0.029	1.03	-1.697**	0.18	0.609**	**1.84**
Objectives						
Reducing costs	-0.645**	0.52	0.370**	1.45	0.571**	**1.77**
Replacing products	0.280**	1.32	-0.277**	0.76	-0.156**	0.85
Extending product range	-0.415**	0.66	0.187*	1.20	0.313**	1.37
Maintaining market share	0.022	1.02	-0.551**	0.58	0.155**	1.17
Increasing market share	0.113	1.12	0.188	1.21	-0.061	0.94
Opening up new markets	-0.133**	0.88	-0.449**	0.64	0.280**	1.32
Improving flexibility	-0.990**	0.37	0.968**	**2.63**	0.645**	**1.90**
Improving quality	0.029	1.03	0.057	1.06	-0.101	0.90
Improving working conditions	-0.066	0.94	0.360**	1.43	-0.025	0.98
Technological opportunities						
R&D alliances	-0.351**	0.70	0.224	1.25	0.367**	1.44
Means of protection						
Complexity of product design	-0.385**	0.68	-0.788**	0.45	0.594**	**1.81**
Being first on the market	0.236**	1.27	-0.518**	0.60	-0.122	0.88
Intellectual property	0.191**	1.21	-0.778**	0.46	0.049	1.05
Information sources						
In-house R&D	0.414**	**1.51**	-1.283**	0.28	0.113*	1.12
Marketing	0.007	1.00	0.112	1.12	-0.142**	0.87
Production	0.140**	1.15	0.299**	1.35	-0.282**	0.75
Management	-0.007	0.99	0.434**	**1.54**	-0.169**	0.84
Other	-0.463**	0.63	0.702**	**2.02**	0.243**	1.27
Competitors	-0.117*	0.89	-0.896**	0.41	0.518**	**1.68**
Equipment acquisition	-0.600**	0.55	0.075	1.08	0.553**	**1.74**
Clients or customers	0.442**	**1.55**	-0.426**	0.65	-0.200**	0.82
Consultancy firms	-0.124	0.88	0.815**	**2.26**	-0.2182**	0.80
Suppliers	0.120*	1.13	-0.377**	0.69	0.059	1.06
Government programs	0.148	1.16	-0.251	0.77	-0.029	0.97
Fairs, exhibitions	0.468**	**1.60**	0.597**	**1.81**	-0.777**	0.46
Professional conferences, meetings	-0.113*	0.89	0.170	1.19	0.033	1.03
Social gatherings	-0.724**	0.48	0.079	1.08	0.787**	**2.20**
Patent literature	0.136	1.15	0.785**	**2.19**	-0.375**	0.67
Universities	0.236**	1.27	-1.176**	0.31	0.173**	1.19
Government research institutions	-0.963**	0.38	-0.091	0.91	0.904**	**2.47**
Private research institutions	-0.033	0.97	0.230	1.25	-0.013	0.99
Test score	1210.5		1111.4		1535.6	
% prediction correct	66.4		74.8		68.5	
No. observations (weighted)	1789 (7037)		1789 (7037)		1789 (7037)	

** 5% significance level; * 10% significance level.

While they have less impact, the means of protection have opposite effects depending on the type of innovation. For example, being first on the market is a strategy that lowers the probability of process innovation. This result, though significant, seems difficult to interpret. One possible explanation is that being first on the market is an important strategy, but not a sufficient one, and that to be effective, it must be combined with other means of protection. In the case of the most complex form of innovation, being first on the market and intellectual property are strategies that favour innovation.

Table 3. Logit estimates by type of innovation, reduced specification

	Product innovation		Process innovation		Product and process innovation	
	Reduced model	Odds ratio	Reduced model	Odds ratio	Reduced model	Odds ratio
Constant	0.378**	1.46	-0.681**	0.50	-1.776**	0.17
Size						
20 – 99	-0.384**	0.68	-0.167	0.85	0.438**	**1.55**
100 – 499	-0.300**	0.74	-1.560**	0.21	0.755**	**2.13**
500 +	-1.950**	0.14	-1.708**	0.18	2.211**	**9.13**
Sectors						
Communications	-0.427**	0.65	0.146	1.16	0.398**	1.49
Finance	-0.143	0.86	-0.561	0.57	0.431*	**1.54**
Demand						
Expansion	0.035	1.03	-1.625**	0.19	0.600**	**1.82**
Objectives						
Increasing market share	0.156**	1.17	-0.070	0.93	-0.085	0.92
Opening up new markets	-0.166**	0.85	-0.492**	0.61	0.370**	1.45
Improving flexibility	-1.057**	0.35	0.992**	**2.70**	0.715**	**2.05**
Improving quality	-0.073	0.93	-0.024	0.97	0.019	1.02
Improving working conditions	-0.208**	0.81	0.375**	1.46	0.087	1.09
Technological opportunities						
R&D alliances	-0.232**	0.79	-0.010	0.99	0.252**	1.29
Means of protection						
Complexity of product design	-0.218**	0.80	-0.974**	0.38	0.484**	**1.62**
Being first on the market	0.106	1.12	-0.468**	0.63	-0.017	0.98
Intellectual property	0.292**	1.34	-0.683**	0.50	-0.077	0.93
Information sources						
Internal	0.236**	1.27	0.194*	1.21	-0.319**	0.73
External	-0.058	0.94	-0.713**	0.49	0.519**	**1.68**
General	-0.058	0.94	0.028	1.03	0.058	1.06
Institutional	-0.145**	0.86	-0.542**	0.58	0.369**	1.45
Test score	729.3		755.1		1153.1	
% prediction correct	62.5		72.7		66.4	
No. observations (weighted)	1789 (7037)		1789 (7037)		1789 (7037)	

** 5% significance level; * 10% significance level.

Table 3 contains the reduced specification of the full model. We suspect that there is multicollinearity for the variables that capture the objective of innovation and the source of information. To correct for this problem, we conducted a principal component analysis to help us determine which variables to drop or combine. The results of this analysis are presented in Appendix C.

The results obtained with the reduced model estimate had no effect on the conclusions produced by the full model estimate. The estimates in Tables 2 and 3 provide correct predictions for the models between 64% and 75% of the time. Moreover, most of the coefficients are significant and have the same sign as in the full model. Institutional and external information sources are important and significant for both process innovation and product-and-process innovation, although the direction of the effect is opposite for the two innovation types. Internal information sources increase the propensity for product innovation only and process innovation only.

In Tables 4 and 5, we provide data for the full model and the reduced model based on the same methodology as before. This time, however, the estimates relate only to the industry groups in the technical services subsector, as we attempted to determine whether there was a clear difference in the results at the four-digit industry sub-group level. The reference group in this case consists of small firms in other scientific and technical services.

Our estimates corroborate the key results in Tables 2 and 3. It is the same variables that have a significant effect on innovation.

However, the type of industry group is a major factor in the probability of innovating. The computer services and computer equipment industries have significant coefficients and high odds ratios for product innovation (first column of Table 4). The computer equipment industry has a greater probability of process innovation than the scientific and technical services sector. But when it comes to product-and-process innovation, the computer services and computer equipment industries and offices of engineers have a lesser propensity to innovate than the reference industry.

Complexity of product design is the preferred means of protection for product-and-process innovation. This strategic choice is certainly linked to the preponderance of computer services and the complexity of those services in this subsector. In this industry, client demands are often highly specific; in fact, unique demands lead to new services that are difficult to reproduce.

The predictive power of our models for the technical services subsector ranges from 66% to 78%. Regardless of the scenario, the process innovation model has the highest prediction percentage.

Table 4. Logit estimates by type of innovation for the technical services subsector, complete specification

	Product innovation		Process innovation		Product and process innovation	
	Full model	Odds ratio	Full model	Odds ratio	Full model	Odds ratio
Constant	0.086	1.09	-0.281**	0.75	-1.752**	0.17
Size						
20 – 99	-0.258**	0.77	-0.276*	0.76	0.386**	1.47
100 – 499	-0.019	0.98	-2.702**	0.07	0.726**	**2.07**
500 +	-1.862**	0.15	-1.717**	0.18	2.139**	**8.49**
Sectors						
Computer services	0.611**	**1.84**	-0.651**	0.52	-0.452**	0.64
Computer equipment	0.429*	**1.54**	2.257**	**9.55**	-1.013**	0.36
Offices of engineers	0.132	1.14	-0.273**	0.76	-0.014	0.99
Demand						
Expansion	0.028	1.03	-2.025**	0.13	0.669**	**1.95**
Objectives						
Reducing costs	-0.651**	0.52	0.302**	1.35	0.614**	**1.85**
Replacing products	0.202**	1.22	-0.299**	0.74	-0.064	0.94
Extending product range	-0.420**	0.66	0.350**	1.42	0.264**	1.30
Maintaining market share	0.101	1.10	-0.729**	0.48	0.095	1.10
Increasing market share	0.061	1.06	0.413**	1.51	-0.026	0.97
Opening up new markets	-0.190**	0.83	-0.505**	0.60	0.313**	1.37
Improving flexibility	-1.017**	0.36	1.022**	**2.78**	0.676**	**1.97**
Improving quality	0.061	1.06	0.147	1.16	-0.160**	0.85
Improving working conditions	-0.096	0.91	0.283**	1.33	0.057	1.06
Technological opportunities						
R&D alliances	-0.257**	0.77	0.180	1.20	0.287**	1.33
Means of protection						
Complexity of product design	-0.540**	0.58	-0.762**	0.47	0.739**	**2.09**
Being first on the market	0.315**	1.37	-0.652**	0.52	-0.194**	0.82
Intellectual property	0.220**	1.25	-0.979**	0.38	0.065	1.07
Information sources						
In-house R&D	0.378**	1.46	-1.305**	0.27	0.139**	1.15
Marketing	-0.004	0.99	0.058	1.06	-0.127*	0.88
Production	0.129*	1.14	0.265**	1.30	-0.277**	0.76
Management	-0.004	0.99	0.581**	**1.79**	-0.223**	0.80
Other	-0.457**	0.63	0.967**	**2.63**	0.195*	1.21
Competitors	-0.162**	0.85	-0.997**	0.37	0.593**	**1.81**
Equipment acquisition	-0.556**	0.57	-0.188	0.83	0.563**	**1.75**
Clients or customers	0.436**	**1.55**	-0.368**	0.69	-0.187**	0.83
Consultancy firms	-0.115	0.89	0.930**	**2.53**	-0.256**	0.77
Suppliers	0.179**	1.19	-0.426**	0.65	-0.005	0.99
Government programs	0.180*	1.20	-0.232	0.79	-0.069	0.93
Fairs, exhibitions	0.471**	**1.60**	0.586**	1.79	-0.781**	0.46
Professional conferences, meetings	-0.125*	0.88	0.185	1.20	0.057	1.06
Social gatherings	-0.827**	0.43	0.357**	1.43	0.821**	**2.27**
Patent literature	0.200*	1.22	1.118**	**3.06**	-0.449**	0.64
Universities	0.213**	1.24	-1.297**	0.27	0.233**	1.26
Government research institutions	-0.945**	0.39	-0.173	0.84	0.918**	**2.50**
Private research institutions	0.022	1.02	0.033	1.03	-0.0549	0.95
Test score	1269.6		1163.3		1561.9	
% prediction correct	66.6		78.0		68.4	
No. observations (weighted)	1469 (6661)		1469 (6661)		1469 (6661)	

** 5% significance level; * 10% significance level.

The estimates for the reduced model of the technical services subsector lead to exactly the same conclusions as the full model. The complexity of the innovation process is no greater; the system is affected by the same variables or groups of variables (see the figures printed in bold in Tables 2 through 5).

Table 5. Logit estimates by type of innovation for the technical services subsector, reduced specification

	Product innovation		**Process innovation**		**Product and process innovation**	
	Reduced model	Odds ratio	Reduced model	Odds ratio	Reduced model	Odds ratio
Constant	-0.084	0.92	-0.296**	0.74	-1.522**	0.21
Size						
20 – 99	-0.317**	0.73	-0.225	0.80	0.379**	1.46
100 – 499	-0.107	0.90	-2.475**	0.08	0.688**	**1.99**
500 +	-2.185**	0.11	-1.906**	0.15	2.497**	**12.14**
Sectors						
Computer services	0.736**	**2.09**	-0.616**	0.54	-0.481**	0.62
Computer equipment	0.846**	**2.33**	1.289**	**3.63**	-1.326**	0.26
Offices of engineers	0.210**	1.23	-0.312**	0.73	-0.036	0.96
Demand						
Expansion	0.023	1.02	-1.767**	0.17	0.653**	**1.92**
Objectives						
Increasing market share	0.125*	1.13	0.013	1.01	-0.066	0.94
Opening up new markets	-0.260**	0.77	-0.481**	0.62	0.438**	**1.55**
Improving flexibility	-1.052**	0.35	0.988**	**2.69**	0.724**	**2.06**
Improving quality	-0.054	0.94	-0.017	0.98	-0.026	0.97
Improving working conditions	-0.252**	0.77	0.359**	1.43	0.149**	1.16
Technological opportunities						
R&D alliances	-0.112	0.89	0.089	0.91	0.161**	1.17
Means of protection						
Complexity of product design	-0.381**	0.68	-0.889**	0.41	0.628**	**1.87**
Being first on the market	0.171**	1.19	-0.565**	0.57	-0.078	0.92
Intellectual property	0.311**	1.36	-0.811**	0.44	-0.060	0.94
Information sources						
Internal	0.236**	1.27	0.239**	1.27	-0.346**	0.70
External	-0.019	0.98	-0.757**	0.47	0.513**	**1.67**
General	-0.020	0.98	0.057	1.06	0.020	1.02
Institutional	-0.164**	0.85	-0.617**	0.54	0.391**	**1.48**
Test score	841.4		820.3		1198.8	
% prediction correct	63.7		76.0		65.9	
No. observations (weighted)	1469 (6661)		1469 (6661)		1469 (6661)	

** 5% significance level; * 10% significance level.

6. Conclusion

As a result of this study, we can make the following observation: there is substantial heterogeneity in the structure and innovative activities of the service sector. The differences inherent in the sector suggest that we should be cautious about using the terms “product innovation” and “process innovation” as if the sector were perfectly homogeneous. The technical services subsector has more in common with the manufacturing sector in its way of innovating; proportionally, it produces more technological product innovation. However, in the service and manufacturing sectors alike, the most frequently reported innovation type is product-and-process innovation.

The analytical distinction between technological product innovation and technological process innovation is a useful one in the service sector. Nevertheless, we suggest that the concept of process innovation be refined. This could be done, for example, by extending the definition to include the delivery method and the unique alternative way of acquiring technology in the sector. As mentioned, the term “technological process innovation” has a broader connotation in the service sector than in the manufacturing sector.

The first question asked at the beginning of this paper was whether it is valid to distinguish three types of innovations in the service sector. The answer is yes. The factors that encourage innovation are different depending on the type of innovation engaged in. Each type of innovation has a corresponding business strategy in terms of objectives, technological opportunities, acquisition and information sources.

The second question asked was how the differences could be identified at the sub-sectoral and industry sub-group levels? The answer is that they form a hierarchy based on the complexity of the innovation type and the firm’s structural characteristics. Whether we take three-digit industry groupings or four-digit groupings, the factors affecting the level of innovation are the same.

Multivariate analysis showed us that the factors that have an important impact vary depending on the type of innovation. But it is when the innovation involves both product and process that most variables have an impact and exhibit the expected sign. We then observe that large companies are more innovative than smaller ones, and the communications and finance sectors are relatively more innovative than the technical services sector. It is then the objectives of reducing costs and improving flexibility that induce innovation. Under these conditions, demand, competition, equipment acquisition, social gatherings and government research institutions are relatively important in bringing about product-and-process innovation.

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Appendix A. Statistical tables[9]

Table A1. Distribution of innovative firms by size and industry group (%)

	Communications	Financial services	Technical services
Under 20 employees	62.2	6.5	78.0
20-99 employees	23.1	36.3	13.3
100-499 employees	8.3	28.6	4.3
Over 500 employees	6.4	28.6	4.4

Table A2. Distribution of innovative firms by type of innovation and industry group (%)

	Communications	Financial services	Technical services
Type of innovation used:			
Product only	39.3	34.5	46.8
Process only	16.0	6.8	12.0
Product and process	44.7	58.7	41.2

Table A3. Distribution of innovative firms by objective of innovation (rated very significant or crucial) and industry group (%)

	Communications	Financial services	Technical services
Reducing costs	34.4	55.7	49.5
Replacing phased-out products	24.6	24.7	25.7
Extending product range	39.1	50.8	51.0
Maintaining market share	71.6	62.3	65.2
Increasing market share	60.1	71.0	67.7
Opening up new markets	25.8	38.9	54.6
Improving production flexibility	23.4	29.8	35.7
Improving product quality	61.9	53.4	59.2
Improving working conditions	26.0	15.3	26.0

Table A4. Percentage of respondents who have difficulty distinguishing between product and process innovation, by industry group

	Communications	Financial services	Technical services
Product/Process	14.9	9.1	15.0

[9] Note that the statistics apply to innovators only (a population of 7,037 for Appendix A and 6,661 for Appendix B). The observations were weighted, and missing values were omitted.

Table A5. R&D activity rate by industry group and technological opportunity rate (%)

	Communications	Financial services	Technical services
R&D in 1994-1996	25.2	43.0	60.2
R&D alliances in 1994-1996	10.1	14.5	19.1

Table A6. Means of protecting innovations rated as very or extremely effective, by industry group and category of protection (%)

	Communications	Financial services	Technical services
Intellectual property rights	7.3	7.8	14.3
Complexity of product design	6.8	5.3	21.9
Being first on the market	14.5	22.0	25.0

Table A7. Impact of innovation activity on market share rated as very significant or crucial, by industry group (%)

	Communications	Financial services	Technical services
Impact on market expansion	46.0	34.2	50.9

Table A8. Distribution of innovative firms by information source (rated very significant or crucial) and industry group (%)

	Communications	Financial services	Technical services
Internal	**70.4**	**77.9**	**77.2**
R&D	21.7	34.0	59.7
Marketing	42.8	55.8	46.3
Production	29.8	35.0	33.4
Management	58.1	57.1	45.8
Other	11.3	11.6	9.5
External	**84.6**	**79.0**	**85.5**
Competitors in same sector	45.5	63.9	46.0
Acquisition of embodied technology equipment	38.4	22.4	25.8
Clients or customers	67.5	66.3	77.1
Consultancy firms	11.4	22.0	18.3
Equipment suppliers	49.7	14.3	32.5
Generally available information	**46.1**	**28.3**	**55.2**
Government programs	14.9	9.0	15.6
Fairs, exhibitions	17.7	3.9	20.7
Professional conferences and meetings, and technical publications	30.7	20.4	38.8
Social gatherings	10.5	4.0	12.7
Patent literature	5.6	1.3	9.1
Education and research institutions	**14.9**	**11.8**	**30.3**
Universities and other higher education institutions	8.0	5.3	25.2
Government research institutions	4.8	1.4	10.4
Private research institutions	9.6	9.2	13.3

Appendix B. Statistical tables for industries in the technical services subsector (four-digit SIC)

Table B1. Distribution of innovative firms by size and industry (%)

	Computer services	Computer repairs	Offices of engineers	Other scientific and technical services
Under 20 employees	80.2	86.7	72.7	78.1
20-99 employees	11.2	8.8	18.1	13.4
100-499 employees	2.8	3.3	4.9	7.9
Over 500 employees	5.8	1.2	4.3	0.6

Table B2. Distribution of innovative firms by innovation type and industry (%)

	Computer services	Computer repairs	Offices of engineers	Other scientific and technical services
Type of innovation used:				
Product only	52.7	53.6	39.8	38.8
Process only	9.1	19.5	13.1	18.0
Product and process	38.2	26.9	47.1	43.2

Table B3. Distribution of innovative firms by objective of innovation (rated very significant or crucial) and industry (%)

	Computer services	Computer repairs	Offices of engineers	Other scientific and technical services
Reducing costs	51.2	49.7	45.0	50.8
Replacing phased-out products	30.8	40.4	16.8	21.8
Extending product range	55.8	21.7	46.7	45.8
Maintaining market share	64.5	71.7	67.4	63.6
Increasing market share	71.9	71.7	64.4	59.8
Opening up new markets	55.6	68.1	59.6	43.9
Improving production flexibility	34.9	40.6	38.8	33.7
Improving product quality	63.0	67.1	54.8	53.9
Improving working conditions	28.6	64.3	22.0	21.3

Table B4. R&D activity rate and crucial technological opportunity rate by industry (%)

	Computer services	Computer repairs	Offices of engineers	Other scientific and technical services
R&D in 1994-1996	66,8	13,6	58,3	48,2
R&D alliances in 1994-1996	13.5	0.0	27.0	25.6

Table B5. Means of protecting innovations rated as very or extremely effective, by industry and category of protection (%)

	Computer services	Computer repairs	Offices of engineers	Other scientific and technical services
Intellectual property rights	12.7	38.4	18.2	11.5
Complexity of product design	26.7	24.1	18.4	12.9
Being first on the market	25.2	24.1	30.0	17.7

Table B6. Impact of innovation activity on market share rated as very significant or crucial, by industry (%)

	Computer services	Computer repairs	Offices of engineers	Other scientific and technical services
Impact on market expansion	53.9	88.7	46.4	45.6

Table B7. Distribution of innovative firms by information source (rated very significant or crucial) and industry (%)

	Computer services	Computer repairs	Offices of engineers	Other scientific and technical services
Internal	**86.0**	**70.8**	**73.4**	**81.1**
R&D	67.2	46.6	51.5	50.4
Marketing	50.8	51.1	38.2	44.1
Production	34.5	21.0	31.2	34.0
Management	49.0	22.0	45.4	38.9
Other	11.5	0.0	8.0	6.8
External	**87.3**	**71.7**	**81.1**	**87.1**
Competitors in same sector	51.2	44.0	40.8	38.3
Acquisition of embodied technology equipment	20.5	39.4	26.0	39.3
Clients or customers	80.7	71.7	70.2	76.6
Consultancy firms	15.6	18.9	21.5	21.5
Equipment suppliers	29.1	60.1	37.4	33.4
Generally available information	**55.3**	**49.7**	**53.4**	**57.7**
Government programs	14.9	1.0	19.4	13.7
Fairs, exhibitions	23.5	40.6	13.5	21.0
Professional conferences and meetings, and technical publications	38.6	48.5	34.2	44.4
Social gatherings	13.7	0.0	11.6	12.0
Patent literature	7.1	19.8	10.0	12.4
Education and research institutions	**25.5**	**46.5**	**39.4**	**30.3**
Universities and other higher education institutions	21.3	46.5	34.0	22.8
Government research institutions	5.6	18.9	18.4	12.7
Private research institutions	10.6	18.9	15.0	18.0

Appendix C. Summary of principal component analysis results

Table C1. Eigenvalues for the information source variables[10]

	Eigenvectors	Difference	Proportion	Cumulative
R&D	3.863	1.922	0.215	0.215
Marketing	1.941	0.587	0.108	0.323
Production	1.354	0.097	0.075	0.398
Management	1.257	0.235	0.070	0.468
Other	1.022	0.042	0.057	0.524
Competitors in same sector	0.980	0.110	0.055	0.579
Acquisition of embodied technology equipment	0.871	0.050	0.048	0.627
Clients or customers	0.821	0.042	0.046	0.673
Consultancy firms	0.779	0.054	0.043	0.716
Equipment suppliers	0.724	0.023	0.040	0.756
Government programs	0.701	0.086	0.039	0.795
Fairs, exhibitions	0.615	0.030	0.034	0.829
Professional conferences and meetings, and technical publications	0.585	0.005	0.033	0.862
Social gatherings	0.579	0.037	0.032	0.894
Patent literature	0.542	0.026	0.030	0.924
Universities and other higher education institutions	0.516	0.046	0.029	0.953
Government research institutions	0.469	0.088	0.026	0.979
Private research institutions	0.381	0.021	1.000	

Table C2. Decomposition of the first four components for information source variables

	Comp_1	Comp_2	Comp_3	Comp_4
R&D	0.134	**0.251**	-0.344	0.218
Marketing	0.233	**0.355**	-0.052	0.169
Production	0.253	**0.294**	0.038	-0.128
Management	0.235	**0.396**	-0.035	-0.031
Other	0.115	**0.328**	-0.325	-0.134
Competitors in same sector	0.234	0.188	**0.239**	-0.062
Acquisition of embodied technology equipment	0.199	-0.003	**0.474**	-0.175
Clients or customers	0.220	0.215	**0.339**	0.158
Consultancy firms	0.177	-0.245	0.174	-0.254
Equipment suppliers	0.248	-0.095	**0.301**	-0.073
Government programs	0.260	0.106	-0.166	-0.447
Fairs, exhibitions	0.240	-0.109	0.037	**0.465**
Professional conferences and meetings, and technical publications	0.250	-0.178	-0.092	**0.492**
Social gatherings	0.188	-0.092	0.181	**0.141**
Patent literature	**0.284**	-0.202	-0.016	0.023
Universities and other higher education institutions	**0.277**	-0.236	-0.305	-0.104
Government research institutions	**0.287**	-0.304	-0.236	-0.258
Private research institutions	**0.310**	-0.241	-0.182	0.051

[10] Potentially useful variables are shown in bold.

Table C3. Eigenvalues for the objective-of-innovation variables

	Eigenvectors	Difference	Proportion	Cumulative
Reducing costs	3.057	1.804	0.340	0.340
Replacing phased-out products	1.253	0.263	0.139	0.479
Extending product range	0.990	0.151	0.110	0.589
Maintaining market share	0.839	0.126	0.093	0.682
Increasing market share	0.713	0.027	0.079	0.761
Opening up new markets	0.686	0.100	0.076	0.837
Improving production flexibility	0.586	0.082	0.065	0.902
Improving product quality	0.504	0.132	0.056	0.958
Improving working conditions	0.372		0.042	1.000

Table C4. Decomposition of the first two components for objective-of-innovation variables

	Comp_1	Comp_2
Reducing costs	0.323	-0.270
Replacing phased-out products	0.161	0.260
Extending product range	0.300	0.290
Maintaining market share	**0.365**	0.180
Increasing market share	**0.410**	0.318
Opening up new markets	0.276	**0.470**
Improving production flexibility	**0.370**	-0.308
Improving product quality	**0.418**	-0.240
Improving working conditions	0.296	**-0.517**

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