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Abstract

The aim of this paper is, firstly, to contribute to the understanding of innovation patterns in services. To this end, firms which are similar in terms of a large set of innovation indicators were grouped into clusters. For the Swiss case, it was possible to identify five clusters which exhibit clearly different configurations of a large number of innovation-related factors (appropriability, etc.) and several structural properties of firms (size, etc.). The clusters may thus be interpreted as specific „innovation modes". Secondly, we investigated whether these modes are „economically equivalent". In such a case, the unordered classifying of similar firms would be more appropriate than the ranking of industries according to their innovativeness. The evidence supports the classification approach quite well; however, the ranking procedure cannot be completely refuted. Finally, this paper yields some insights into the differences between the innovation patterns prevailing in services and in manufacturing.

Keywords: Innovation Patterns in Services, Knowledge Networks, Innovation Ranking vs. Classification, Non-technological Innovations

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1. Introduction

The innovation process is a complex phenomenon. It typically takes place over the course of several stages, ranging from basic research to market penetration by means of new products, and the introduction of new production techniques within firms. Therefore, an entire series of indicators is necessary, if we are to adequately describe and measure a firm's innovative activities. Each indicator stresses certain specific aspects of the innovative activities. Using the information provided by this system of indicators, we developed in earlier work an aggregate measure of innovation intensity and used it to rank firms and industries in the manufacturing (Hollenstein, 1996), as well as in the service sector (Arvanitis et al., 1998).

The ranking of industries implicitly assumes that these are (more or less) homogeneous entities with respect to the innovativeness of firms. This assumption is at variance with the evolutionary view of technological change (Gallouj, 1999). According to this approach, one would rather look for groups of firms characterised by similar patterns of innovation (irrespective of industry affiliation), which are conceptualised as unordered categories („innovation modes"). The classificatory procedure reflects the heterogeneity of an industry with respect to the innovation strategies pursued by its firms. Moreover, it allows for the co-existence of different innovation modes which, at a certain point in time, are equivalent in terms of economic performance. Which of these innovation strategies is sustainable over the long run is decided during the course of a market-driven selection process, the outcome of which is not predictable (Metcalfe, 1995).

We explored the classificatory approach in a previous study of the Swiss manufacturing sector (Arvanitis and Hollenstein, 2001). The analysis yielded five innovation modes, which exhibited similarities to those identified by other authors (Pavitt, 1984; Cesaratto and Mangano, 1993; Arundel et al., 1995). The differences were explained to a large extent by several structural characteristics typical of the Swiss economy (e.g. limited scope for scale-intensive production).

In the present paper, we search for innovation patterns in the Swiss service sector, applying the same methodology used in our study devoted to manufacturing. The aim of the analysis is twofold: Our first goal is to contribute to a better understanding of innovative activities in this heterogeneous sector. Secondly, we explore the relative merits of the classification and the ranking approach as a means of analysing the innovation process. In this way, we hope to define the extent to which the two ways of looking at the matter can be applied. Our initial decision was to concentrate on services, although there are good arguments in favour of including manufacturing as well (see below). Proceeding this way, we are in a better position for comparing our results with other work.

Empirical research devoted to innovation in services is still quite scarce, despite the high and growing importance of this sector.[1] This unsatisfactory situation is attributable to conceptual problems („what makes service innovations different?") as well as to a lack of (suitable) data. At the conceptual level,

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[1] It is very revealing that the „Handbook of the Economics of Innovation and Technological Change" edited by Stoneman (1995) does not treat the service sector at all.

the literature, according to Evangelista and Sirilli (1995), identifies four main features that are specific to production and innovation in services: a) the close interaction between production and consumption (co-terminality), b) the increasing information content of services, c) the large and growing role played by human resources in service production, and d) the great importance of organisational change as a means of producing and delivering (new) services. This characterisation implies that non-technological innovations are an important feature of the service sector (Miles, 1995; Djellal and Gallouj, 1999). However, as a consequence of the tendency towards industrialisation in services and customisation in manufacturing, the distinctions between the two sectors have been blurred (see, for example, Coombs and Miles, 2000); it is perhaps co-terminality which is the most specific characteristic of production and innovation in services.

The second factor hampering the empirical investigation of innovative activities in services is data deficiency. This problem has been alleviated to a certain extent thanks to the second wave of the „Community Innovation Survey", carried out in EU member countries in 1996/97 (CIS II) and similar surveys conducted in other countries (Canada, Switzerland, etc.), which covered the service sector as well. However, some researchers (e.g. Djellal and Gallouj, 1999) are of the opinion that the questionnaires used in these surveys did not properly take into account the specific features of innovation in services (concentration on technological innovation, neglect of organisational innovation). Other researchers, such as Hughes and Wood (2000) or Evangelista and Sirilli (1995), maintain that this critique, though not without substance, is overrated. They refer, for example, to the growing importance of technology in service production, or to the specific definition of service innovations used in CIS II, which also includes new ways of delivering services. We shall address this problem again in Section 3.

In view of these difficulties, it is not surprising that there are only a few studies which examine innovation patterns in the service sector. The primary source of reference for most contributions is the well-known taxonomy developed by Pavitt (1984), which deals mainly with manufacturing. Pavitt distinguishes between four sectors: „Science-based industries", „Specialised producers", „Scale-intensive producers" and „Supplier dominated industries", with service industries included in the last category. In later work, Pavitt (and his co-authors) modified this taxonomy; a new category called „Information-intensive firms" was introduced, covering industries such as the financial sector or retailing, while other service industries (e.g. software) were identified as „Specialised producers" (Pavitt et al., 1989). Soete and Miozzo (1989) took Pavitt's original taxonomy as their starting point and added the category „Network-based industries", which covers two subgroups, namely „Scale-intensive industries based on physical networks" (transport, wholesaling) and „Industries relying on information networks" (finance, insurance, communications). These industries draw heavily on information technologies (IT). Evangelista (2000) recently developed a taxonomy generated by applying a formal statistical procedure (cluster analysis of industry data). He identified nine clusters which, in turn, were reduced into three main groups. The first and the second group are quite similar to Pavitt's „Supplier dominated industries" and „Science-based industries", while the third

(„Interactive and IT based industries“) reflects the importance of producer-user links and the widespread use of IT.

The taxonomies mentioned thus far are based on an industry level analysis; it is therefore (implicitly) assumed that innovation patterns at this level of aggregation are homogenous. Moreover, they are static in nature, since nothing is implied with respect to their evolution over time. In addition, they almost exclusively take technological innovations into consideration. Against this background, Gallouj (1999) developed an analytical framework based on a functional approach to service provision, which yields a multiplicity of service trajectories. The latter build on four specific technology-based methods of transforming basic competencies into (new) services (handling/transformation of tangibles, handling/treatment of codified information, interactive service production, method-based knowledge transformation), as well as on one mode of service provision, which does not rely on technology („direct“ transformation of competencies into services). At each point in time, innovation patterns can be characterised by the way new services are developed in terms of combinations of the five basic modes of service production. Over time, such trajectories evolve through changes in the proportions of the five constituent elements (ascribing different weights to the various elements, adding new ones, dropping old ones, etc.).

In principle, this evolutionary concept overcomes the limitations of the taxonomies mentioned above. It allows for different innovation modes within sectors and firms, it is dynamic in nature, and non-technological innovations are taken into account as well. However, in view of the multiplicity of innovation modes and the extensive data (highly differentiated panel data) required to identify them empirically, the detection of generalised regularities might prove difficult.

Taking the previous approaches to developing a taxonomy of service sector innovation as our point of reference, our method can be characterised as follows: a) it is based on an analysis of firm-level data; it is therefore not assumed that industries are homogenous in terms of innovation modes; in contrast, we explicitly investigate whether there is a correlation between innovation modes and industry affiliation (see Section 4); b) we use a formal statistical procedure in the identification of innovation modes (cluster analysis); of the taxonomies described above, only that developed by Evangelista (2000) is based on such an approach; c) at this stage, our analysis remains static (as is the case in most other taxonomies), although expanding our work towards a more dynamic view would be feasible (see Section 6); d) the database we use is better suited than the CIS data for taking into account the non-technological character of many innovations in services (see Section 3).

The remainder of the paper is structured as follows: In the next section, we describe the data base and the methodology used in searching for innovation modes. The empirical results of our attempt to identify innovation modes are presented in Section 3. Next, we analyse the sectoral distribution of innovation modes and the variation of economic performance across these categories of firms; this enables us to assess the relative merits of the classification and ranking procedures. In Section 5, we investigate whether the differences between innovations in services and those in manufacturing, as identified in the literature, are confirmed by our findings. Finally, we discuss the main results and draw some conclusions.

2. Data and Procedure

2.1 Data

The data used in this study were collected as part of the Swiss Innovation Survey 1999, which was based on a stratified random sample (28 industries and three industry-specific classifications of firm size, with full coverage of large companies). The firms were asked to fill in a questionnaire (downloadable from www.kof.ethz.ch) on their innovative activities, which yielded a large number of innovation indicators (in this paper we use seventeen). In addition, the survey provided information on many variables, which can be used to describe the innovation process in some detail, and to explain the level and intensity of innovative activity. Most variables refer to the period 1997/99.

The analysis is confined to the subsample "services" (2731 firms; nine industries). We received valid answers from 880 firms, i.e. 32.2% of the underlying sample. The response rates do not much diverge across industries and firm sizes (with a few exceptions), as illustrated by Table A1 in the appendix. In view of the rather low (overall) response rate, it was necessary to conduct a survey among a sample of non-respondents using a few core questions related to innovative activity (response rate 90%). The non-response analysis did not indicate any signs of a serious selectivity bias with respect to the structure of the basic sample. By imputing missing values in the case of item non-response („multiple imputation"; see Rubin, 1987 and Donzé, 2001), we were able to avoid a loss of observations that would have introduced a bias to the final data set.[2] As a whole, the data set may be considered representative of the underlying sample. For obvious reasons, the search for innovation modes is based on the subsample of innovative firms only, which amounts to 54% of the respondents (see Table A1).

2.2 Procedure

The present analysis searches for innovation modes using firm-level information. We assume that a firm pursues only one type of innovation strategy. Since our data refer to the firm's main activity, this assumption should not be too much of a simplification.

In the first step, a cluster analysis is performed in order to group firms into homogeneous categories with respect to seventeen indicators of innovation. These cover the input and the output sides of the generation of innovation, as well as the introduction of new products to the market or new processes in the firm (for details, see Section 3). Cluster analysis, however, was not directly applied to these variables. Instead, we started by synthesising the information contained in these measures by means of a factor analysis into a small number of variables („factors"). The latter are uncorrelated

[2] As shown by Donzé (2001), "multiple imputation" is a method that yields robust estimates for missing values. It is, for example, clearly superior to "simple imputation" which is used by EUROSTAT in producing the CIS data base.

(standardised) variables containing the information common to the original variables.[3] Then, we performed a (non-hierarchical) cluster analysis of these factors, in order to group the firms into a number of categories which are, with respect to the variables under investigation, as homogenous as possible (small within-cluster variance) and at the same time as different as possible (large between-cluster variance).[4]

In a second step, the analysis examined whether the clusters previously identified can really be interpreted as different modes of innovation. To this end, the clusters are characterised and interpreted in terms of a) the innovation indicators used in cluster analysis itself, b) a series of important determinants of innovation activity, such as innovation opportunities, appropriability, human resources (supply side), as well as market prospects and intensity of competition (demand side), c) a set of variables capturing the firms' position in knowledge networks (use of various external knowledge sources, formal co-operation), d) structural characteristics of firms (size, age, industry affiliation, export orientation), and e) two measures of performance. The distinction between innovation indicators (used in clustering) and determinants of innovative activities (used in characterising the clusters) is based on a microeconomic model of innovation behaviour, which was developed and empirically confirmed in earlier work on manufacturing (Arvanitis and Hollenstein, 1994, 1996), as well as on services (Arvanitis, 2000).[5]

As mentioned in the introductory section, a second aim of this paper is to evaluate the relative merits of ranking firms according to innovativeness and classifying them by modes of innovation. To this end, we investigate the relationship between innovation modes and industry affiliation. If the industrial composition of the clusters and that of the service sector as a whole are similar, industries are heterogeneous in terms of innovation patterns. In this case, classification is a more sensible procedure than sectoral ranking. The same holds true if economic performance does not significantly differ between clusters.

3. Empirical Results I

3.1 Identifying modes of innovation

The identification of innovation modes is based on the seventeen indicators of innovation listed in Table 1. On the input side, in addition to R&D expenditures, we take into account expenditures on IT

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[3] The choice of the number of factors depends not only on statistical criteria, but also on the plausibility and interpretability of the resulting factor pattern in terms of innovative activity; see Manly (1986) for an introductory treatment of this method.

[4] This procedure involves partitioning the sample, allowing observations to move in and out of groups at different stages of the analysis. At the beginning, more or less arbitrary group centres („cluster seeds“) were chosen and individual observations were allocated to the nearest one. An observation was later moved to another group, if it proved to be closer to that group's centre than to the centre of the initial group. This process, during which close groups were merged and distant ones split, was continued until stability was achieved with a predetermined number of clusters (see Manly, 1986).

[5] See Cohen (1995) for a detailed survey of the empirical literature dealing with the explanation of innovative activities.

(hardware and software) as well as the level and composition of innovation-related follow-up investments (the purchase of innovative machinery; the acquisition of external knowledge, such as licences, trademarks, etc.; human capital investments; and marketing outlays). The output side of innovative activity is captured firstly by the firms' assessments of the technical and economic significance of the innovations. In addition, we include a variable which measures the IT content of innovation output; moreover, we also use two indicators which represent the innovation output of firms in terms of patent applications and licences granted. Finally, the sales share of innovative products and cost reductions induced by process innovations, both representing innovation-related improvements in a firm's market position, are used as market-oriented indicators of innovation. Most of these variables are qualitative, either binary (yes/no) or ordinal with five response levels ranging from „very low" (value 1) to „very high" (value 5). As has been shown in earlier econometric work (e.g. Arvanitis and Hollenstein, 1996), the information content of these subjective (assessment) measures is high.

Table 1

As pointed out in Section 1, it is desirable that the indicators we use also capture some elements of non-technological innovations. To a certain extent, this is the case in the study at hand. The definition of „innovation" used in our questionnaire does not make any direct reference to technology. Moreover, several indicators (for example, the economic significance of innovations, the outlays for innovation-related training, expenditures on the introduction of innovations to the market or the sales share of new or improved products) also capture non-technological aspects of innovation. As a consequence, we consider our database to be more appropriate for a comprehensive analysis of innovation in services than the information collected by the CIS II, in which innovation is explicitly defined as "technological innovation".

The results of the preliminary step in the identification of innovation modes, i.e. of the factor analysis used to synthesise the information contained in the seventeen innovation indicators, are satisfactory (see Table 2). The five factors extracted account for 56% of the total variance. The first factor, which captures 20% of the total variance, reflects the various components (and their sum) of innovation-related follow-up investments. The second factor, which accounts for 11% of the variance, represents primarily the R&D input and the science-oriented innovation output (patent applications, licences granted). The third factor (10% of total variance) refers to the technological and IT dimension of service innovations. While the first three factors do not differentiate between product and process innovations, the last two factors do. Both factors stress the economic side of innovation, with the fourth one capturing product market-orientation and the fifth one reflecting cost reductions based on process innovations. We conclude that the factor pattern convincingly reflects the most important dimensions of the underlying innovation indicators.

Table 2

Next we performed a non-hierarchical cluster analysis based on the scores of the factor analysis. Solutions with four, five or six clusters were of comparable quality according to the usual statistical criteria (approximate expected overall R^2, cubic clustering criterion, etc.). In order to determine the final number of clusters, we took three criteria into account, namely a) the statistical properties in terms of the relationship between within-cluster and between-cluster variance, b) the plausibility of the clusters identified („can the clusters convincingly be interpreted as innovation modes“?), and c) the number of firms per cluster. Based on the last criterion, the version with six clusters was dropped (one cluster contained very few observations). The result containing four clusters was inferior to that with five in terms of criteria a) and b). Therefore, we ultimately arrived at a five cluster solution, which is satisfactory in statistical terms; the approximate expected overall R^2 of 0.45 suggests an acceptable fit of the data to the underlying cluster model. More importantly, the five clusters can convincingly be interpreted as innovation modes, as will be shown in the next section.

3.2 Basic characteristics of the innovation modes

Step 2 characterises the five innovation modes, firstly, in terms of the innovation indicators used in clustering (see Table 1 above). Secondly, we implement the variables listed in Table 3, which pertain to the demand and supply variables determining innovation intensity, the knowledge networks of firms, the structural characteristics of firms and selected measures of performance.

Table 3

On the demand side, we take into account demand prospects, as well as the intensity of price and non-price competition in the relevant product markets. On the supply side, we include as a proxy for innovation opportunities, a variable which represents a firm’s assessment of its (overall) potential to generate novelties in (or around) its field of activity; moreover, we consider a measure of the appropriability of knowledge. A proxy for human capital is added to this group of variables, not only because firms that are well-endowed with highly skilled personnel are in a good position to absorb knowledge from other sources (Cohen and Levinthal, 1989), but also because this variable might prove to be particularly important in services (see Section 1).

Under the heading „position of the firm in knowledge networks”, we take into account the intensity of use of fourteen external sources of knowledge: customers; suppliers of components, of equipment and of software; competitors; firms in the same enterprise group; universities; other research institutions; consultancy firms; institutions of technology transfer; patent disclosures; professional conferences and journals; fairs and exhibitions; and computer-based networks. Moreover, we include variables representing R&D out-contracting, as well as institutionalised R&D co-operation; for both types of arrangements, we distinguish between domestic and foreign relationships. There are good reasons to draw on such detailed information pertaining to external knowledge relations. Firstly, the importance of co-operation and networking has, over time, become significantly more important to the generation of innovations (Haagedoorn, 1996; for Switzerland, see Arvanitis et al., 1998, 2001a). Secondly, the pattern of use of external knowledge is one of the most important features of the modes of innovations in manufacturing, as identified in the studies mentioned in Section 1.

Moreover, we also include several structural characteristics of firms, such as industry affiliation, size, age and export orientation. Finally, our description of clusters draws on two measures of firm performance: namely, nominal value added per employee and the development of nominal sales over time. [6]

The Tables 4a (indicators of innovation), 4b (factors determining innovation), 4c (the knowledge network) and 4d (the structural characteristics of firms) show the means of these variables for each of the five clusters, as well as for the service sector as a whole. The corresponding information regarding industry affiliation and performance is presented in Section 4 (Tables 5 and 6 respectively). In the summary that follows, we shortly characterise the five clusters in terms of these categories. For more detail, we ask the reader to study the corresponding tables**.**

Table 4a, 4b, 4c, 4d

Mode 1: „Science-based high-tech firms with full network integration"

This cluster consists of 21 firms (4.4% of the firms, 18.1% of employment), which are endowed with an excellently qualified staff, and are engaged intensively in R&D within a highly favourable environment in terms of innovation opportunities and market perspectives. Internal R&D is supported by an intensive use of science-related external sources of knowledge, as well as many institutionalised co-operative R&D projects (and research contracts), with domestic and foreign universities serving as the primary partners. Innovation output consists in many instances of products and processes which are new to the industry and are protected by patents (accompanied by the granting of licences). The sales share of new products is high. This cluster contains an above-average proportion of export-oriented, medium-sized firms, in addition to some very large firms, which are heavily concentrated in IT/R&D-services, business services (70% of the firms), as well as in banking, insurance and other financial services (15% of the firms). Nominal labour productivity is distinctly below-average; although sales growth is more favourable, i.e. about average.

Mode 2: „IT-oriented network-integrated developers"

This cluster contains 19 firms (4.0% of the firms, 1.7% of employment) whose innovative activities are supported by very favourable market perspectives and a highly qualified labour force. Based on high investments in development and IT (but not in research), the firms in this cluster generate product and process innovations which are of high technical standards and, in many instances, new to the industry. The innovations, often patented and licensed to other firms, are technology-oriented and characterised by a high IT-content and a great potential for cost reduction. These firms are intensive users of manifold sources of external knowledge (suppliers of software and investment goods, universities, competitors, firms in the same enterprise group). Among the more formal knowledge links, the out-contracting of R&D (at home, as well as abroad) and the use of licences are of higher

[6] In this study, we are not confronted with the well-known problem of measuring productivity in services, since we only take nominal productivity at a certain point in time (cross section-analysis) into consideration. Difficulties arise solely in the measurement of the change in real output over time, which requires adequate price deflators.

importance than more far-reaching R&D co-ooperation. Medium-sized and export-oriented firms are clearly more frequent in this cluster than in services as a whole. Compared to the sector average, IT/R&D-services as well as banking/insurance/other financial services are overrepresented, whereas the opposite is true for retail trade, hotels/restaurants and real estate, which are characterised, on average, by a rather low innovation intensity. Value added per employee is distinctly higher than in the other four categories of firms, whereas growth in sales is lower than in services as a whole.

Mode 3: „Market-oriented incremental innovators with weak external links"

The innovative activities of the 99 firms belonging to this cluster (20.9% of the firms, 9.1% of employment) are fostered by very favourable market prospects, whereas the supply-side conditions for the generation of novelties are just average. The firms in this cluster generate product and process innovations with high IT-content, which are primarily incremental in nature (this is not surprising in view of the rather low level of innovation input). Nevertheless, innovation output is of a high value in economic and technological terms, and is successfully brought into the market place (high sales share of innovative products). In general, networking is rather weak; only market-oriented sources of knowledge (users, software suppliers) and easily accessible knowledge sources (fairs/exhibitions, computer-based networks) are of any importance. Compared to the sector mean, this cluster consists of a high proportion of (very) small firms with an average export orientation. The firms are distributed across industries quite similarly to services as a whole, with a slight overrepresentation of business services and wholesale trade and only few firms in transport/telecommunication. In this innovation mode, labour productivity is high, whereas growth in sales is not above average.

Mode 4: „Cost-oriented process innovators with strong external links along the value chain"

This cluster of 229 firms is by far the largest (48.2% of firms, 62.9% of employment). In view of the strong price competition and only slightly above-average market growth, it is no surprise that (incremental) process innovations aimed at cost reductions are the most prominent feature of innovative activity in this cluster. Innovation input concentrates on IT-expenditures and innovation-related follow-up investments, whereby all components are highly relevant (machinery, external knowledge, training, marketing). The technological and economic significance of innovation output is high. The firms' own innovative activity strongly benefits from a wide (primarily informal) network that spans the entire value chain, from suppliers (in particular, of software) to users, with strong links to different partners between each end of the chain (consultancy firms, competitors, fairs and exhibitions, computer-based networks, conferences). Institutionalised co-operation (R&D contracts and R&D co-operation) is only of average importance. Large firms are somewhat overrepresented, very small ones distinctly underrepresented, and export orientation is rather low. In view of the large number of firms in this cluster, it is not surprising that the industry structure is close to the sector average. The same holds for labour productivity. Sales growth is, however, higher than in any other cluster.

Mode 5: „Low-profile innovators with hardly any external links"

The (process) innovations of the 107 firms belonging to this cluster (22.5% of firms, 8.2% of employment) appear to be quite marginal. This is not surprising in view of the unfavourable demand- and supply-side factors determining innovative activity: weak demand prospects, strong price competition, low appropriability and innovation opportunities, and relatively poor human capital endowment. This cluster performs most weakly with respect to the majority of variables used to characterise modes of innovation. The adoption of novelties generated elsewhere is the most important form of innovation. Correspondingly, innovation input consists primarily of machinery and equipment supplied by manufacturing firms. The use of external knowledge, which is below average for almost all sources, is concentrated (in relative terms) around suppliers and competitors. This cluster comprises an above-average share of small firms, which produce for domestic markets and belong to less innovative industries, such as personal services, real estate, hotels and restaurants, retail trade and transport. Not surprisingly, the economic performance of the firms in this cluster is weak.

We conclude that the five clusters differ in terms of the specific configurations of the variables we use to characterise innovative activities and the innovation-related environment. It is particularly important that this also holds true with respect to the „external criteria", that is those variables not implemented in the clustering process (i.e. the variables shown in Tables 4b-4d). Against this background, the five clusters can be safely interpreted as specific innovation modes.

4. Empirical Results II: Are Innovation Modes Equivalent in Economic Terms?

It is general practice to rank industries according to their innovativeness, in order to assess their competitiveness or to predict their opportunities and risks with respect to structural change (see e.g. European Commission, 1997). As mentioned in Section 1, sectoral ranking is sensible if industries are sufficiently homogeneous in terms of innovation intensity. This assumption holds only if innovation modes (which according to their construction are homogeneous groups) and industries closely correspond in terms of innovativeness. In addition, inferences regarding competitiveness (and the like), which are based on innovation rankings by industry, require, as a necessary though not sufficient condition, systematic differences between innovation modes in terms of economic performance. It is precisely this hypothesis, which is denied by advocates of the classificatory approach to innovation. In the following section, we shall discuss the first of these conditions, whereas Section 4.2 will be devoted to the second.

4.1 The relationship between innovation modes and industries

Table 5 shows the industrial composition of the five innovation modes and the service sector as a whole. Industries are ordered according to decreasing levels of innovation intensity, as measured by an indicator which aggregates the information contained in the seventeen innovation measures listed in Table 1 by means of a factor analysis; for details of the procedure, see Hollenstein (1996). Although the five innovation modes are primarily regarded as unordered classes, we can also rank them according to innovation intensity, with Mode 1 („Science-based high-tech firms with full network integration") at the top and Mode 5 („Low-profile innovators with hardly any external links") at the bottom of the ladder.

A first look at Table 5 reveals that the firms in four of the five innovation modes (the exception is Mode 1) are distributed across several industries, thereby contradicting the „homogeneity assumption". However, at least three innovation modes are quite strongly concentrated in a few industries. This holds most clearly for Mode 1 („Science-based high-tech firms with full network integration"), which primarily contains firms from the two most innovative industries. To a lesser extent, the industry composition of Mode 2 („IT-oriented network-integrated developers") is also biased towards the most innovative industries. The opposite is true for Mode 5 („Low-profile innovators with hardly any external links") which, in comparison to the sector average, is mainly present in industries with low or intermediate levels of innovation intensity. Concentration is less pronounced in Mode 3 („Market-oriented incremental innovators with weak external links"), whereas firms in Mode 4 („Cost-oriented process innovators with strong external links along the value chain") are distributed across industries in almost the same way as the service sector as a whole (which is not very surprising, since nearly half of the firms in our sample belong to this group).

Thus we find, on the one hand, a clear and positive correspondence between industries and innovation modes (when ranked according to innovation intensity). This result is supported by a statistically significant value of the Goodman-Kruskal γ, which is an appropriate measure of association in the case of ordinally-scaled variables. On the other hand, four out of five innovation modes are distributed quite widely across industries, which, however, might partly reflect the high sectoral aggregation (nine industries only). We conclude that the evidence does not clearly favour any one of the competing hypotheses (classification vs. ranking).

Table 5

4.2 Innovation modes and economic performance

To assess the validity of the „homogeneity hypothesis", we must also investigate whether there are significant differences between innovation modes with respect to average firm performance. A negative result would support the „heterogeneity hypothesis", according to which more than one innovation strategy is, at least temporarily, economically feasible. To evaluate the two conflicting propositions, we consider nominal labour productivity (value added per employee) as a measure of firm performance, and nominal sales growth as an indicator of change in performance over time.

As is illustrated by Table 6, levels of labour productivity vary strongly between the five innovation modes; it is 44% higher in Mode 2 (the cluster with the highest level of productivity) than in Mode 1 (the cluster with the lowest level of productivity). We also find substantial differences with respect to the growth of sales. These data seem to be at variance with the „heterogeneity hypothesis". However, this view of the matter is too simple, since firm performance is determined not only by the variable „innovation mode" but also (and probably to an even larger extent) by other factors, such as those listed in the lower part of Table 6. For example, it is obvious that a firm which intensively uses physical capital, exhibits (ceteris paribus) a higher level of labour productivity than one in which production is more labour intensive; neglecting the contributions of other determinants of productivity would clearly bias a comparison of the performance of Mode 3 (high value added per employee, high capital intensity) and Mode 1 (low value added per employee, low capital intensity), and so on.

Table 6

As a consequence, instead of comparing cluster means, we regress labour productivity at the firm level with the following independent variables: a) four dummies representing affiliation with Clusters 2, 3, 4 and 5 respectively (with Cluster 1 as the reference group), b) variables which control for physical capital intensity (gross capital income per employee), human capital intensity (the employment share of personnel holding tertiary level degrees), and knowledge capital (the employment share of R&D personnel), and c) industry dummies. Sales growth, as a measure of the development of firm performance over time, was used as a dependent variable in a regression containing not only the explanatory variables used in the labour productivity estimates, but also two dummies which control for changes of the firms' boundaries (the selling-off or closure of parts of the firm, as well as mergers and acquisitions).

The results of these estimates can be summarised as follows: In the case of labour productivity, only an affiliation with Cluster 2 („IT-oriented network-integrated developers") exerts a statistically significant (positive) impact. The other four modes cannot be distinguished from each other in terms of labour productivity. The productivity differences, as shown in Table 6, are mainly explained by variations in physical, as well as human and/or knowledge capital intensity (positive signs). In addition, we obtain statistically significant signs for some industry dummies, which are negative in the cases of two less innovative industries (retail trade, hotel and restaurants) and positive for the highly innovative banking and insurance industry.[7] When „sales growth" is the dependent variable, two of the dummies which measure affiliation with innovation modes exert a statistically significant influence: the sign of Mode 2 („IT-oriented network-integrated developers") is negative, that of Mode 4 („Cost-oriented process innovators with strong external links along the value chain") is positive. In addition, we find a significantly positive influence of knowledge capital intensity on sales growth, whereas the human and physical capital variables yield no statistically significant results.

In sum, these estimates of the relationship between performance and innovation mode (controlling for other important determinants of performance) reveal that labour productivity and sales growth differ with respect to innovation modes in only a few „extreme cases" (see Table 4). This result is more or less in line with the „heterogeneity hypothesis", which states that firms exercise a certain degree of freedom in choosing economically viable innovation strategies. However, an assessment of this conclusion should also take into consideration the fact that performance is additionally influenced by the intensity with which human and/or knowledge capital is used, as well as by several industry dummies systematically related to innovativeness. Therefore, we can conclude that the selection of an

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7 Dropping the industry dummies to avoid multicollinearity (as shown above, there is some correlation between industry affiliation and innovation mode) did not affect the results with respect to the cluster variables.

innovation strategy also depends quite strongly on structural characteristics that are closely related to the ranking of industries in terms of innovation intensity.

5. Do Innovations in Services Differ from those in Manufacturing?

As mentioned in the introductory section, many authors maintain that innovations in services differ significantly from those in manufacturing, whereas others postulate that such differences have been reduced in recent years due, for example, to the strong diffusion of IT in the service sector or the growing importance of customisation in manufacturing. What are the implications of the present analysis and a similar study pertaining to the Swiss manufacturing sector (Arvanitis and Hollenstein, 2001)?

Firstly, our results are in line with the proposition of lower R&D in services, as compared to manufacturing. Only innovation Modes 1 and 2 (less than 10% of firms) are strongly R&D-based (see Table 4a), whereas in Swiss manufacturing, the same holds true for three out of five clusters that cover more than 50% of firms. This result is confirmed by data from the OECD (2001), even if it is assumed that in service industries R&D is generally underestimated in official statistics (measurement problems; only partial coverage of the service sector).[8] Hence, a relatively low level of R&D remains an important characteristic of service innovations, although the share of this sector in total business R&D increased significantly during the nineties.

Secondly, it is argued that human resources play a particularly important role in the generation of service innovations. We observed that human capital input is high in three out of five innovation modes. Since the use of highly qualified manpower is almost as intensive as in manufacturing, we conclude that human resources indeed play a very important role in the innovation process within the service sector. However, this is not a peculiarity of service innovations.

Thirdly, some of the literature mentions the high information content of services and the widespread use of IT as an additional characteristic of service innovations. Our results confirm this proposition. However, the use of IT in services is not more intensive than in manufacturing, at least in Switzerland (Arvanitis et al., 2001b). Hence, IT is a characteristic of innovative activities in general, rather than a specific feature of service innovations.

Finally, the high relevance of non-technological innovation is often seen as the most distinct feature of innovation in services. The cluster-specific pattern of innovation found in this study allows a tentative assessment of the role played by this type of innovative activity. We therefore hypothesise that non-technological innovations are an important element of innovation patterns, when the following two conditions are fulfilled: a) high values of innovation variables which are related to non-technological factors (i.e. the economic significance of innovation, innovation-related outlays for

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[8] The problem of measurement of R&D in services is discussed in detail in Jankowski (2001) and in various papers of the OECD devoted to the revision of the Frascati Manual, is due to be completed at the end of 2002 (OECD, 2002). Even if this revision will lead to a (further) correction of the underestimation of R&D in services, manufacturing, on average, will certainly remain more R&D intensive than services.

training and marketing respectively, the sales share of innovative products, and human capital intensity), and b) low values of innovation variables closely related to technological factors. In contrast to this proposition, our results indicated that in three of the five innovation modes, both sets of innovation variables are either high (Clusters 1 and 2) or low (Cluster 5); these three clusters contain about one third of the firms. Cluster 4 shows no clear pattern with respect to the relative importance of technological and non-technological aspects of innovation (nearly 50% of the sample firms). Only in Cluster 3 (about 20% of the firms), did we find some confirmation of the hypothesis that non-technological factors are more important than technological ones. We thus tentatively conclude that innovations based primarily on non-technological factors play a dominant role in only some segments of the service sector. In contrast, in Swiss manufacturing, technological factors shape the pattern of all innovation modes we identified in earlier work (Arvanitis and Hollenstein, 2001)[9]. However, in most parts of the service sector, a strong technology base seems to be a prerequisite to good performance in innovation as well (which does not exclude the possibility that such firms also generate non-technological innovations). Recent survey data on the importance of organisational innovations[10] in the Swiss business sector, which are not covered by the data base used in this study, indicate that in this respect, there are only minor differences between manufacturing and services (Arvanitis et al., 2001b). This result is consistent with our assessment that the differences between manufacturing and services with respect to non-technological innovations are not very large.

All in all, we can conclude that innovations in services do differ from those in manufacturing. However, it seems that these are less accentuated than hypothesised by many authors. Therefore, we are rather inclined to support the hypothesis put forward by, among others, Coombs and Miles (2000), who postulate that differences between the two sectors have been blurred in recent years and are now one of degree rather than of substance.

6. Summary, Discussion, and Conclusions

By applying cluster analysis to a large set of innovation indicators (which, to some extent, also capture non-technological aspects of innovation), we identified five clusters. These were characterised by the use of several groups of variables: a) innovation indicators, b) demand- and supply-side determinants of innovative activity, c) the firms' position in knowledge networks, d) several structural characteristics of firms, and e) measures of firm performance.

In view of the distinct patterns exhibited by these variables, the clusters can be interpreted as specific „innovation modes“:

- „Science-based high-tech firms with full network integration“
- „IT-oriented network-integrated developers“

[9] This holds true although non-technological innovations (e.g. customisation of new products; fundamental organisational change) have become more important also in manufacturing.

[10] Change in the number of management layers, redistribution of competencies among hierarchical levels, introduction of team-based work, job-rotation programmes, etc.

- „Market-oriented incremental innovators with weak external links“
- „Cost-oriented process innovators with strong external links along the value chain“
- „Low-profile innovators with hardly any external links“

According to the evolutionary view of technical change, such a classificatory procedure („innovation modes“) is more appropriate than an approach which ranks industries according to innovativeness. Whereas the starting point of classification is the heterogeneity of firms with respect to innovation strategies, the ranking approach assumes that an industry is more or less homogeneous in terms of the innovativeness of its firms. In order to evaluate the relative merits of the two approaches, we investigated the sectoral distribution of innovation modes, as well as the differences across innovation modes with respect to economic performance. We found, firstly, that the firms in most innovation modes are distributed across several industries; however, taking the service sector average as our benchmark, three of five innovation modes are (heavily) concentrated in specific industries. Secondly, we found that economic performance is related to the affiliation with a specific innovation mode in only one or two of the five modes, depending on the performance measure used. However, there is strong evidence that in addition to cluster affiliation, variables related to innovativeness (such as human and knowledge capital intensity), as well as dummies for industries with an above-average (below-average) innovation performance, exert a positive (negative) influence on firm performance.

These results imply that neither the „classical“ ranking of industries according to innovativeness nor the classification of firms into unordered categories representing innovation modes of equal „economic value“ capture the whole reality. This ambiguous result can be interpreted as follows: In accordance with the heterogeneity hypothesis (classification approach), firms exercise a certain degree of freedom in selecting an economically viable innovation strategy, even in similar economic and technological environments; however, their room for manoeuvre is restricted by structural characteristics closely related to the hierarchy of industries in terms of innovation intensity (ranking approach).

Therefore, we conclude that the widespread practice of ranking industries according to their innovation intensity in order to assess, for example, their competitiveness, (still) makes sense. However, such a procedure requires broadly-based measures of innovation intensity (use of many and different types of indicators); otherwise the diversity of innovation modes within an industry cannot be adequately taken into account. This aspect rarely receives the attention it deserves. Most sectoral rankings are based on a single, easily available indicator (e.g. R&D or patent intensity). In services, however, these two indicators are hardly relevant in three of the five innovation modes we identified. The aggregate measure of innovation, which we developed in earlier work as a means of ranking industries according to innovation intensity, is a useful instrument for taking into account the heterogeneity aspect, since it contains information from a large number of indicators covering quite different (and also non-technological) aspects of „innovativeness“.

A comparison of our classification with the taxonomies characterised in Section 1 cannot be performed in a straightforward way, since there are important differences with respect to the level of aggregation (firm vs. industry), the method used (formal statistical procedures at the one extreme vs. (purely) conceptual work at the other) and the time dimension of the analysis (static vs. dynamic view).

Evangelista (2000), who also applied cluster analysis (although at the industry-level), basically identified three categories of industries; two of them („S&T-based“ and „Technology users“) are very similar to our Innovation Modes 1 and 5 („Science-based high-tech firms with full network integraton“, and „Low-profile innovators with hardly any external links“). His third category („Interactive and IT-based”) exhibits some similarities to our Innovation Modes 4 and 2 („Cost-oriented process innovators with strong external links along the value chain“ and „IT-oriented network-integrated developers“), although the correspondence is far from perfect. However, there is no cluster in Evangelista’s taxonomy which corresponds to our Mode 3 („Market-oriented incremental innovators with weak external links“). This result might reflect, to some extent, the specific procedure used in the Italian case where, at a certain stage in the analysis, market-oriented innovation indicators were dropped for technical reasons (Evangelista, 2000, p. 211). If this interpretation holds true, the two taxonomies would be quite similar. We also find similarities to the taxonomy proposed by Soete and Miozzo (1989). „Specialised producers/Science-based industries“ and „Supplier-dominated industries“ correspond strongly to our Innovation Modes 1 and 5. These two modes have thus been identified in all the studies compared up to this point. However, both „Network-based sectors“ proposed by the two authors can only be loosely related to our classification (subsector „information networks“ vs. our Mode 2, i.e. „IT-oriented network-integrated developers“).

A comparison with Gallouj (1999) is difficult, since he primarily strives to define a suitable analytical framework for developing a taxonomy of innovation trajectories. A basic difference between his and our work and the taxonomies mentioned so far, is the dynamic nature of his approach; it yields a multiplicity of innovation trajectories which evolve over time in terms of a changing mix of the basic elements constituting a trajectory. Nevertheless, it would be possible to develop a dynamic version of our approach. By using information from different waves of the Swiss innovation survey, we could pool cross-sectional and longitudinal data. In this way, we would be able to identify innovation modes based on a time-dependent database (panel); moreover, we could analyse to what extent firms are changing their innovation mode over time and whether there are typical patterns of transition from one innovation mode to another.

Another aspect stressed by many authors is the greater importance of non-technological innovations in services as compared to manufacturing. In this respect, we conclude that such a difference exists, although it seems to be one of degree rather than of substance. Against this background, it would be sensible to look for innovation modes using data covering both sectors. This would enable us to gain greater insight into the differences between innovation patterns prevailing in the two sectors.

Furthermore, it would be valuable to make cross-country comparisons of innovation modes based on the same type of data and method. This might be feasible, since the innovation surveys conducted in the EU member states (CIS) and other countries are (more or less) harmonised. Such work would enable the identification of the innovation modes that are common to most countries, as well as country-specific innovation patterns. The identification of country-specific features would contribute to the characterisation of „National Innovation Systems".

As far as policy conclusions are concerned, one must exert caution at this stage of the research. Nevertheless, the results do have some implications which should be considered by policy makers. Firstly, in assessing and shaping policy measures, one should take into account the variety of innovation patterns, since firms belonging to specific innovation modes have different needs with respect to public policy. For example, firms belonging to the innovation mode „IT-oriented network-integrated developers" would profit most from measures contributing to the enlargement and improvement of the supply of IT-professionals and from programmes facilitating the diffusion of IT. On the other hand, „Science-based high-tech firms with full network integration" may be supported, in the first place, by strengthening the production of (basic) scientific knowledge, as well as by measures to improve its transfer to the business sector. Considering the poor economic performance of „Low-profile innovators with hardly any external links", suitable measures for strengthening outside links could perhaps contribute to improving the innovativeness of this type of firm. Secondly, to the extent that innovation modes are country-specific, there are limitations to designing best policy practices at the international level.

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Table 1: Innovation Indicators Used in Cluster Analysis

Innovation Indicator	Measurement Scale	Value Range
1. Input-oriented measures		
Expenditures for		
- Research	ordinal	1, 5
- Development	ordinal	1, 5
- IT (hardware, software)	ordinal	1, 5
Follow-up investments		
- Total	ordinal	1, 5
- By type		
- Machinery and equipment	ordinal	1, 5
- Acquisition of external knowledge (licences, trademarks, etc.)	ordinal	1, 5
- Training	ordinal	1, 5
- Market introduction of innovations	ordinal	1, 5
2. Output-oriented measures		
Significance of the innovations in technical terms		
- Product	ordinal	1, 5
- Process	ordinal	1, 5
Significance of the innovations in economic terms		
- Product	ordinal	1, 5
- Process	ordinal	1, 5
IT-content of innovations	ordinal	1, 5
Patent applications (yes/no)	nominal	1, 0
Licences granted to other firms (yes/no)	nominal	1, 0
3. Market-oriented measures		
Sales share of new or highly improved services (%)	metric	0, 100
Cost reduction generated by process innovations (yes/no)	nominal	1, 0

Table 2: Factor Analysis of the Innovation Indicators Used in Cluster Analysis

Innovation indicator	Rotated Factor Pattern (equamax)				
Follow-up investments: total	.77	.09	.08	.09	.07
Follow-up investments: training	.75	-.03	.21	-.00	.05
Follow-up investments: machinery and equipment	.67	.01	-.02	.03	-.01
Follow-up investments: market introduction of innovations	.66	.13	-.01	.14	.17
Follow-up investments: acquisition of external knowledge	.54	.08	.30	-.09	-.20
Development expenditures	.19	.74	.08	.17	.01
Patent application	-.08	.73	-.02	.06	.07
Research expenditures	.14	.68	.10	.13	-.01
Granting of licences	-.02	.61	.14	-.09	-.02
IT-content of innovations	.06	-.07	.80	-.01	-.25
IT expenditures (hardware, software)	.46	.03	.68	.01	-.09
Significance of product innovations in technical terms	-.04	.15	.57	.18	.17
Significance of process innovations in technical terms	.03	-.01	.57	.13	.39
Sales share of new or highly improved products	-.02	.13	.01	.76	-.20
Significance of product innovations in economic terms	.07	-.06	.12	.73	.22
Cost reduction related to process innovations	.03	.06	-.08	-.11	.78
Significance of process innovations in economic terms	.07	-.05	.14	.47	.59
Number of observations					475
Kaiser’s overall measure of sampling adequacy (MSA)					.720
Variance accounted for by the first five factors					.557
Root mean square off-diagonal residuals (RMSE)					.079
Variance accounted for by each factor	3.32	1.94	1.68	1.46	1.06
Final communality estimate (total)					9.46

There are numerous methods to rotate a factor loading matrix in order to facilitate the interpretation of the factors. Common to them is the attempt to simplify the factor matrix. The equamax criterion is a combination of varimax and quartimax which seek to simplify the columns and rows respectively of the (unrotated) matrix of factor loadings; see, for example, Ost (1984).

Table 3: Indicators Used to Characterise Innovation Modes

	Measurement Scale	Value Range
1. Innovative activities		
Innovation indicators as shown in Table 1	see Table 1	see Table 1
2. Determinants of innovative activity		
Demand side		
- medium-run demand prospects in the product market	ordinal	1, 5
- intensity of price competition in the product market	ordinal	1, 5
- intensity of non-price competition in the product market	ordinal	1, 5
Supply side		
- opportunities for innovation in the fields relevant to the firm's activities	ordinal	1, 5
- appropriability of knowledge	ordinal	1, 5
- employment share (%) of highly qualified labour (tertiary level)	metric	0, 100
3. Knowledge networks		
Use of fourteen types of external knowledge sources (see text)	ordinal	1, 5
Out-contracting of R&D		
- in Switzerland (yes/no)	nominal	1, 0
- abroad (yes/no)	nominal	1, 0
R&D co-operation:		
- number of domestic partners (3 and more vs. 0-2 partners)	nominal	1, 0
- number of foreign partners (3 and more vs. 0-2 partners)	nominal	1, 0
4. Structural characteristics of the firm		
Industry affiliation: share of firms (%) in 9 industries (see appendix, Table A1)	metric	0, 100
Firm size: share of firms (%) by 5 size classes (5-19, 20-49, 50-199, 200-499, 500 and more employees)	metric	0, 100
Share of firms (%) by start-up year: 3 classes (up to1988, 1989/94, 1995/99)	metric	0, 100
Share of firms (%) by export to sales ratio: 3 classes (up to 1, 2-19, 20+)	metric	0, 100
5. Economic performance		
Nominal value added per employee in 1998 (1000 SFr.)	metric	> 0
Share of firms (%) with increasing nominal sales in the period 1996/98	metric	0, 100

The ordinally scaled variables reflect the firms‘ assessments on a five-point Likert scale; the response levels range from „very low“ (value 1) to „very high“ (value 5).

Table 4a: Innovative Activity by Cluster

Innovation Indicators	Cluster 1	2	3	4	5	Total
1. Input-oriented measures						
Expenditures for						
- Research	50	0	2	1	2	9
- Development	90	39	8	14	3	14
- IT (hardware, software)	30	56	32	55	20	42
Follow-up investments						
- Total	30	17	6	29	11	20
- By type						
- Machinery and equipment	30	17	5	30	21	23
- Acquisition of external knowledge	5	17	3	14	7	10
- Training	25	22	13	52	25	36
- Market introduction of innovations	50	28	9	43	16	30
2. Output-oriented measures						
Significance of the innovations in technical terms						
- Product	75	67	71	59	29	56
- Process	55	67	69	69	26	58
Significance of the innovations in economic terms						
- Product	65	17	76	60	27	55
- Process	55	44	70	70	19	57
IT-content of innovations	15	67	65	46	26	45
Patent application (% yes)	75	44	0	1	1	6
Licences granted (% yes)	45	61	5	3	1	7
3. Market-oriented measures						
Sales share of new or highly improved services (%)	28	9	29	13	10	16
Cost reduction generated by process innovations (yes/no)	35	50	23	49	12	35

If not otherwise specified, the table shows for each cluster and the total sample the percentage share of firms with scores 4 or 5 on a 5-point ordinal scale (for definition, see Table 1); for example, 50% of the firms in Cluster 1 spend (very) much on research.

Table 4b: Determinants of Innovation Performance by Cluster

Innovation Determinants	Cluster 1	2	3	4	5	Total
1. Demand side						
Demand prospects	75	67	70	65	46	62
Intensity of price competition	70	61	62	69	65	66
Intensity on non-price competition	50	50	53	61	50	56
2. Supply side						
Innovation opportunities	75	22	35	41	31	38
Appropriability of knowledge	35	17	9	7	2	8
Highly qualified labour (%)	24	13	10	7	7	9

If not otherwise specified, the table shows for each cluster and the total sample the percentage share of firms with scores of 4 or 5 on a 5-point ordinal scale (for definitions, see Table 3); for example, 75% of the firms in Cluster 1 have (very) good demand prospects in their product market.

Table 4c: Characteristics of the Firms' Knowledge Network by Cluster

Knowledge Sources / R&D Networks	Cluster 1	2	3	4	5	Total
1. Sources of external knowledge						
Users	35	44	38	51	32	43
Suppliers of materials/components	40	28	29	36	26	32
Suppliers of software	25	72	32	44	28	38
Suppliers of machinery/equipment	25	28	10	19	9	15
Competitors	20	44	30	47	39	41
Other firms in the same group	35	33	12	21	9	18
Universities	45	33	18	14	18	18
Other research institutions	40	0	9	7	5	8
Consultants	25	17	11	24	7	17
Technology transfer organisations	10	11	3	9	7	8
Patent documents	20	0	2	0	3	2
Fairs/exhibitions	25	22	26	27	13	23
Scientific/trade journals, conferences	55	39	34	44	36	41
Computer networks	20	33	33	34	26	32
2. Out-contracting of R&D						
At home (% yes)	60	50	11	20	13	19
Abroad (% yes)	40	17	4	6	2	7
3. R&D co-operation						
% with more than 2 domestic partners	45	19	10	10	13	14
% with more than 2 foreign partners	45	25	13	8	3	12

If not otherwise specified, the table shows for each cluster and the total sample the percentage share of firms with scores of 4 or 5 on a 5-point ordinal scale (for definition, see table 3); for example, in Cluster 1, users are a (very) important source of knowledge for 35% of firms.

Table 4d: Selected Structural Characteristics of Firms by Cluster

Structural Characteristics	Cluster 1	2	3	4	5	Total
1. Share of firms (%) by size class (number of employees)						
5-19	25	22	34	24	34	28
20-49	20	17	25	23	21	23
50-199	30	28	21	27	27	26
200-499	10	28	12	13	8	12
500+	15	5	8	13	10	11
2. Share of young firms (%)						
Start-up in 1989 or later	21	18	15	8	11	11
3. Share of firms by export/sales ratio (%)						
Up to 1	20	50	68	67	67	65
2-19	15	17	11	14	17	14
20+	65	33	21	19	16	21

Table 5: Industrial Structure by Innovation Mode

Industry	Innovation Mode (Cluster) 1	2	3	4	5	Total
	Distribution of firms by industry (%)					
Innovativeness above average	*95.0*	*83.2*	*73.8*	*72.6*	*67.5*	*73.0*
IT and R&D services	33.3	16.7	5.1	3.9	2.8	5.5
(Other) business services	38.3	16.7	23.2	18.3	15.7	19.6
Banking/insurance/financial services	14.3	22.1	16.2	17.0	15.7	16.4
Wholesale trade	4.7	22.1	24.2	22.5	15.7	20.5
Transport/telecommunication	4.7	5.6	5.1	10.9	17.6	11.0
Innovativeness below average	*4.7*	*16.8*	*26.2*	*27.4*	*32.5*	*27.0*
Retail trade	0.0	5.6	14.1	13.0	16.7	13.3
Hotels, restaurants	4.7	5.6	9.1	12.2	11.1	10.7
Real estate	0.0	0.0	1.0	0.9	1.9	1.1
Personal services	0.0	5.6	2.0	1.3	2.8	1.9
Total	100	100	100	100	100	100

The innovation modes are: (1) „Science-based high-tech firms with full network integration“, (2) „IT-oriented network-integrated developers“, (3) „Market-oriented incremental innovators with weak external links“, (4) „Cost-oriented process innovators with strong external links along the value chain“, (5) „Low-profile innovators with hardly any external links“; see description in the text.

Table 6: Economic Performance by Innovation Mode

Indicator	Innovation Mode (Cluster) 1	2	3	4	5	Total
	Cluster means					
Performance indicators						
Nominal value added per employee in 1998 (1000 SFr.)	153	221	196	171	172	178
Share of firms (%) with increasing nominal sales 1996/98	50	28	34	43	32	38
Factors determining firm performance (in addition to cluster affiliation)						
Gross capital income per employee (1000 SFr.)	56	67	87	86	72	81
Employment share of highly qualified labour (%)	50	32	27	22	19	24
Employment share of R&D personnel (%)	34	6	1	2	1	3

The innovation modes are: (1) „Science-based high-tech firms with full network integration“, (2) „IT-oriented network-integrated developers“, (3) „Market-oriented incremental innovators with weak external links“, (4) „Cost-oriented process innovators with strong external links along the value chain“, (5) „Low-profile innovators with hardly any external links“; see description in the text.

Appendix

Table A1: Structure of the Sample and the Final Data Set

	Sample		Respondents			Innovators		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	N	%	N	%	(3)/(1)	N	%	(6)/(3)
Industry								
Wholesale trade	596	21.8	207	23.5	34.7	101	21.2	48.8
Retail trade	516	18.9	132	15.0	25.6	63	13.3	47.7
Hotels, restaurants	403	14.8	84	9.6	20.8	50	10.6	59.5
Transport/communication	378	13.8	133	15.1	35.2	52	11.0	39.1
Banking/insurance	266	9.7	99	11.2	37.2	77	16.2	77.8
Real estate	38	1.4	14	1.6	36.8	5	1.1	35.7
IT and R&D services	100	3.7	36	4.1	36.0	26	5.4	72.2
Business services	384	14.1	155	17.6	40.4	92	19.3	59.4
Personal services	50	1.8	20	2.3	32.2	9	1.9	45.0
Total	2731	100	880	100	32.2	475	100	54.0
Firm size (number of employees)								
Small	1487	54.4	465	52.8	31.3	218	46.0	46.9
Medium	1021	37.4	330	37.5	32.3	194	40.7	58.8
Large	223	8.2	85	9.7	38.1	63	13.3	74.1
Total	2731	100	880	100	32.2	475	100	54.0

Column 5 shows the response rate by industry and size class, column 8 the share of innovating firms.