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Innovation Modes in the Swiss Service Sector

A Cluster Analysis Based on Firm-level Data *

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Summary

Innovative activities of firms differ in many respects such as intensity, orientation, use of external knowledge, etc.. In the service sector, to which this article is devoted, there is presumably even more diversity than in manufacturing. Therefore, using Swiss data we grouped similar firms into „innovation modes“ based on a cluster analysis of seventeen innovation indicators which capture also non-technological aspects. In a second step, the five clusters we could identify have been characterized by use of various groups of variables: a) innovation indicators (partly already used for clustering), b) the firms‘ position in knowledge networks, c) demand- and supply-side determinants of innovative activity, d) some general characteristics of firms (size, industry, etc.), and e) measures of firm performance. The characterization of the five clusters showed that these can be interpreted as specific innovation modes with an economically plausible interpretation.

To evaluate whether the widely used approach of ranking industries by innovation intensity is sensible (which requires a sufficient degree of homogeneity of industries with regard to this criterion), or whether a purely classificatory approach in accordance with the evoulutionary view of technical change (which stresses the heterogeneity of firms) is more adequate, we investigated the relationship between innovation modes and a) their industry composition, and b) the (average) firm performance by cluster. This analysis showed that there is some concentration of innovation modes on specific industries but the overlap is far from perfect. In addition, exept in one case, economic performance does not significantly differ between innovation modes; however, there is strong evidence that variables related to innovativeness (human capital, etc.) exert a positive influence on firm performance. These ambiguous results can be interpreted as follows: On the one hand, in accordance with the heterogeneity hypothesis firms dispose of a certain degree of freedom in selecting an economically viable innovation strategy in similar economic and technological environments, but the room of manoevre is restricted by structural characteristics which are closely related to the hierarchy of industries in terms of innovation intensity, factor endowment, etc.. Therefore it still makes sense to rank industries according to their innovativeness, for example, in order to assess their competitiveness, growth potential, etc.; however, the measurement of innovation intensity must be based on a large set of indicators covering also non-technological aspects; only in this way one can take account of the diversity of innovation modes within an industry.

1. Introduction

The innovation process is a complex phenomenon characterized by several stages reaching from basic research up to the penetration of the market with new products. Therefore a whole series of indicators is needed to describe and measure a firm's innovative activities, each of them stressing specific aspects but also exhibiting measurement errors. Using the information contained in such a system of indicators we developed in earlier work a composite measure of innovation intensity and used it for ranking firms and industries of the manufacturing as well as the service sector according to their innovativeness (Hollenstein, 1996; Arvanitis et al., 1998, ch. 3).

Implicitly, such a „ranking" assumes that an industry is a (more or less) homogeneous entity with respect to the innovativeness of its firms, an assumption which contradicts a basic hypothesis of the evolutionary view of technological change. In the latter framework, one would rather look for groups of firms characterized by similar innovation patterns which are conceptualized as unordered categories (innovation modes). Such a purely classificatory procedure allows for the (presumed) heterogeneity of an industry with respect to the innovation strategies pursued by its firms. This approach allows for the co-existence of different innovation modes which – at least for a certain time period – may turn out as equivalent in terms of economic performance. Which of these innovation strategies are sustainable in the longer run is decided in the course of a market-driven selection process whose outcome is not predictable (see, for example, Metcalfe, 1995).

We explored such a classificatory approach in an earlier study for the Swiss manufacturing sector using firm-level data (Arvanitis and Hollenstein, 1998). The analysis yielded five innovation modes which show quite strong similarities to those identified by other authors (Pavitt, 1984; Cesaratto and Mangano, 1993; Arundel et al., 1995). The specificities of our classification could be explained to a large extent by some structural charcacteristics of the Swiss economy. In the present paper we look for innovation patterns in service industries of the Swiss economy by using quite the same methodology as in our study on manufacturing which has been inspired by the work of Cesaratto and Mangano (1993).

Despite high and growing importance of the service sector empirical work related to services is still quite scarce in empirical economics in general and in innovation research in particular.[1] This unsatisfactory situation is partly due to conceptual problems („what makes service innovations different?"),[2] partly to a lack of data.[3] It is thus not surprising that, to our knowledge, there is only one study which is looking for innovation patterns in the service sector in a similar way as the present paper does (Evangelista, 2000).[4] By applying cluster analysis to data for nineteen service industries in Italy this author succeeds to identify four „patterns of innovation" with two of them showing some similarities to innovation types in manufacturing identified by Pavitt (1984) and the other authors mentioned above.

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1 It is very revealing that the „Handbook of the Economics of Innovation and Technological Change" published in 1995 (Stoneman (ed., 1995) does not treat the service sector at all. Metcalfe and Miles (eds., 2000) may serve as a survey on many aspects of innoation in services.

2 See, for example, Gallouj and Weinstein (1997) and several constributions in Metcalfe and Miles (eds., 2000) for a discussion of these matters.

3 Although the „Community Innovation Survey 1996" (CIS II) and similar surveys conducted in non-EU countries such as Canada and Switzerland cover now also the service sector there are still rather few econometric investigations pertaining to this part of the economy. To mention are, for example, a study for the Netherlands (Brouwer und Kleinknecht, 1998), some work at the European Center for Economic Research (ZEW), Mannheim, for Germany (e.g. Ebling und Janz, 1999), a few studies at „Statistics Canada" (e.g. Gellatly, 1999) as well as some analyses for Switzerland (Arvanitis et al., 1998; Donzé and Lenz, 1999; Arvanitis, 2000).

4 To mention is also an explorative taxonomy of service industries proposed by Antonelli et al. (2000) which is based on other criteria as those used in Evangelista (2000) and the present paper: tradability, productivity, network interaction, internal/external impact of innovations.

The aim of the present paper is twofold: Firstly, we want to contribute to a better understanding of the patterns of innovation in the service sector which covers a broad range of activities with very different kinds of innovations. Secondly, we shall explore the relative merits of the classification and the ranking approach as a means to analyze the innovation process; in this way, we hope to define the range of application of the two ways of looking at the matter.

The set-up of the paper is as follows: The procedure and the variables we use in searching for innovation modes as well as the variables to characterize such patterns are described in the next section. Section 3 gives some information on the data we used in this exercise. The empirical results of the search for innovation modes and their main characteristics are presented in section 4. In section 5 we are looking at the relationship between the innovation modes we identified and a) their structure by industry and b) the (average) economic performance of the clusters‘ firms; based on these results we are able to discuss whether (or to what extent) service industries are heterogeneous or homogeneous in terms of innovation modes. Finally, we summarize the main results and draw some conclusions.

2. Procedure

In contrasts to Evangelista (2000) who uses industry data the present analysis is looking for innovation modes based on firm-level information. In a first step of analysis we try to group firms into homogeneous categories, which can be interpreted as innovation modes, by use of cluster analysis. In order to group the firms we take consideration of their characteristics with respect to a large number of innovation indicators. Cluster analysis, however, is not directly applied to these variables. We started by synthesizing (and standardizing) the information contained in these measures by means of a (principal component) factor analysis into a small number of variables („principal components“).[5] The latter are used then in a (non-hierarchical) cluster analysis 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 from each other (large between-cluster variance).[6] In a second step the clusters identified are interpreted in terms of the innovation indicators used in the cluster analysis itself as well as a large number of additional variables which cover the firms‘ position in knowledge networks, the environment with respect to a number of supply- and demand-side determinants of innovative activity, some structural characteristics of firms such as size, age, industry, etc. and the firms‘ economic performance.

The identification of the clusters (innovation modes) in step 1 is based on the seventeen innovation indicators listed in table 1. They cover all stages of the innovation process, i.e. the input and the output side of the generation of innovations as well as the degree of novelty of newly introduced products and the cost aspect of new processes. On the input side, in addition to the classical aspects of research and development which for several service industries are of minor importance, we take account of the expenditures for IT (hardware as well as software) and the level and composition (innovative machinery, aquisition of external knowledge such as licences, trademarks, etc., human

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5 This procedure produces linear combinations of the original variables (principal components). The latter are standardized variables which are uncorrelated and contain the common information of the underlying variables. The choice of the number of principal components used in the next step of analysis (clustering) depends on statistical criteria (variance accounted for by the factors, root mean square off-diagonal residuals, etc.) as well as on the plausibility and interpretability of the resulting factor pattern in economic terms; see Manly (1986) for an introductory and Ost (1984)) for an in-depth treatment of this method.

6 This procedure involves partitioning of the sample with observations being allowed to move in and out of groups at different stages of the analysis. At the beginning some more or less arbitrary group centres („cluster seeds“) are chosen and individual observations allocated to the nearest one. An observation is then moved to another group if it is closer to that group’s centre than to the centre of the present group. This process during which close groups are merged and distant ones split is continued until stability is achieved with a predetermined number of clusters (Manly, 1986, p. 101); for a more detailed discussion of cluster analysis see, for example, Kaufmann and Pape (1984).

Table 1: Innovation Indicators Used in the 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 application (no/yes)	nominal	0, 1
• Licences granted to other firms (no/yes)	nominal	0, 1
3. Market-oriented measures		
• Sales share of new or highly improved services (%)	metric	0, 100
• Cost reduction generated by process innovations (no/yes)	nominal	0, 1

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).

capital investments, marketing outlays) of innovation-related follow-up investment. The output side of the innovation process is captured, firstly, by the firm’s assessments with respect to the technical as well as the economic significance of the innovations; in addition, we include a variable measuring the IT content of innovation output, again evaluated by the firms themselves; at last, we use two indicators representing the innovation output of a firm in terms of patents and licences granted. The market-oriented innovation indicators taken into account refer to the sales share of innovative products and to cost reductions induced by process innovations which also improve market position. The seventeen innovation variables used in cluster analysis cover as many aspects as possible of the not well-known phenomenon of service innovations. The measurement scales and the corresponding value ranges of these variables are shown in table 1. Most of them are qualitative in nature, i.e. either dichotomous (no/yes) or polychotomous with five response levels ranging from „very low“ (value 1) to „very high“ (value 5). In contrast to prejudices of many researchers the information content of such subjective measures is high as has been shown in some earlier econometric work where we explained

the innovativeness of firms measured both by quantitative indicators such as R&D intensity and variables reflecting firms' assessments using the same set of right-hand variables (Arvantis and Hollenstein, 1994, 1996).

Step 2 of the analysis is devoted to the description and interpretation of the clusters identified in step 1. To this end we refer to the variables listed in table 2:

- A first group of measures contains the innovation indicators we used in the clustering procedure as well as some additional indicators characterizing a firm's innovative activities. To mention are, firstly, quantitative measures of R&D and innovation expenditures as well as of cost reductions directly linked to process innovations; these variables are already included as qualitative measures in the clustering procedure. In addition, we take account of the relative importance of product and process innovations, or combinations of the two which in most instances indicate more complex innovations. The „degree of novelty" pertains to information indicating whether the innovation is „new for the industry" or just „new for the firm" (reflecting adoption) or whether it is a (more or less far-reaching) improvement of an already existing product/service (incremental innovation).
- A second group of variables deals with the knowledge network which the firms are part of. Under this heading we take account of the intensity of informal or institutionalized use of fourteen external knowledge sources: clients/customers, three categories of suppliers (material/components, equipment, software), competitors/firms of the same industry, firms of the same enterprise group, universities, other research institutions, consultancy firms, technology transfer institutions, patent disclosures, professional conferences/journals, fairs/exhibitions and computer-based networks. Moreover, we include variables representing R&D out-contracting as well as institutionalized R&D cooperations; for both types of arrangements it is distinguished between domestic and foreign relationships with different types of partners. There are good reasons to draw on such detailed information with respect to the use of external knowledge. First, the importance of cooperation and networking for the generation of innovations has grown significantly over time (see Haagedoorn, 1996; for Switzerland: Arvanitis et al., 1998, ch. 6); secondly, the structure of use of external knowledge is one of the most important features of the patterns of innovations identified in the studies mentioned in section 1.
- A third group of variables used in characterizing innovation modes represents the main factors determining innovative activity as identified in the literature:[7] on the demand side we take account of the medium-run demand perspectives as well as the intensity of price and non-price competition on the relevant product markets; on the supply side, we include a variable representing a firm's assessment of the potential for generating novelties in or around the fields of its activities as a proxy for innovation opportunities as well as a measure for the appropriability of knowledge which is important as an incentive to exploit such innovation potentials. Human capital is added to this third group of variables because a rich endowment of a firm in this respect is – among other things – a precondition to absorb efficiently knowledge from other sources (Cohen and Levinthal, 1989).
- The fourth group of variables refers to some structural characteristics of a firm such as industry, size, age and export orientation.
- At last, the description of the clusters pertains to some measures of a firm's economic performance, i.e. its level (measured by value added per employee) as well as its change over time (sales, employment).[8]

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7 Empirical estimates which give some insight into the relative weight of these variables in determining innovative activity in manufacturing are found in Arvanitis and Hollenstein (1994, 1996) for manufacturing, in Arvanitis (2000) for services; for a detailed survey of the empirical literature see Cohen (1995).

8 We do not dispose of information with respect to the *change* of value added.

Table 2: Indicators Used to Characterize Innovation Modes

	Measurement Scale	Value Range
1. Innovative activities		
• Innovation indicators as shown in table 1	see table 1	see table 1
• Other innovation indicators		
- Sales share of R&D (%)	metric	0, 100
- Sales share of innovation expenditures (%)	metric	0, 100
- Cost reduction generated by process innovations (%)	metric	>=0
- Degree of novelty (3 dummies: new for the industry, new for the firm, improvements)	nominal	0, 1
2. Knowledge networks		
• Use of 14 types of external knowledge sources (see text)	ordinal	1, 5
• Out-contracting of R&D		
- in Switzerland (no/yes)	nominal	0, 1
- abroad (no/yes)	nominal	0, 1
• R&D cooperation:		
- number of domestic partners (0-2 vs. 3 and more partners)	nominal	0, 1
- number of foreign partners (0-2 vs. 3 and more partners)	nominal	0, 1
3. Determinants of innovative activity		
• Demand side		
- medium-run demand perspectives on the product market	ordinal	1, 5
- intensitiy of price competition on the product market	ordinal	1, 5
- intensitiy of non-price competition on the product market	ordinal	1, 5
• Supply side		
- opportunities for innovation in the fields relevant for the firm's activities	ordinal	1, 5
- appropriability of knowledge	ordinal	1, 5
- employment share (%) of highly qualified labour (tertiary level)	metric	0, 100
4. Structural characteristics of the firm		
• Share of firms (%) by 9 industries (see appendix, table A1)	metric	0, 100
• Employment share (%) by 5 size classes (5-19, 20-49, 50-199, 200-499, 500+)	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		
• Value added per employee (1000 sFr.)	metric	> 0
• Share of firms (%) with increasing sales in the period 1996/98	metric	0, 100
• Share of firms (%) with increasing employment 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). We used the share of firms (%) with the value 4 or 5 to characterize the clusters in case of ordinal scales; similarily the share of firms (%) with value 1 (yes) is used in the case of nominal scales.

To evaluate the relative merits of ranking and classification we investigate the relationship between innovation modes and their structure by industry. If the clusters are composed of several industries or – a less restrictive condition – the industry composition of the clusters is similar to that of the service sector as a whole, the heterogeneity hypothesis is confirmed; in this case classification is a more sensible procedure than ranking. The same holds if the (average) economic performance of the firms of the various innovation modes does not significantly differ from each other.

3. Data

The data used in this study are from the Swiss Innovation Survey 1999 which in its core questions is comparable to the „Community Innovation Survey" (CIS II) conducted in most European countries. The survey was based on a (disproportionally) stratified random sample (28 industries and – within each industry – three firm size classes based on industry-specific employment thresholds with full coverage of the class of large firms). The firms were asked to fill in a questionnaire[9] about their innovative activities and a large set of other variables relevant to the description of the innovation process and the explanation of innovative activity and economic performance during the period 1996-1999.

The present analysis is confined to the subsample of services (2731 firms; nine industries). We received valid answers from 880 firms, i.e. 32.2% of the underlying sample. The response rates are not too different across industries and size classes with a few exceptions as can be seen from table A1 in the appendix. Nevertheless, 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 a serious selectivity bias with respect to the structure of the basic sample. By imputing missing values in case of item non-response[10] we could avoid a loss of observations which might have led to a biased sample. In sum, the data set may be considered as „representative" for the underlying sample. For obvious reasons the search for innovation modes is based on the subsample of innovative firms only, that is 54.7% of the respondents (481 observations); see table A1, which shows also the share of innovating firms by industry and firm size classes.

4. Innovation Modes: Identification and Characteristics

4.1 Identification

As mentioned in section 3, the innovation modes are identified in two steps, that is, firstly, a principal component factor analysis to standardize the underlying variables and to synthesize their information content in a number of uncorrelated variables (i.e. „principal components" or „factors"); secondly, a cluster analysis to group the firms into a predetermined number of clusters which may be interpreted as innovation modes if the procedure yields satisfactory results.

The preliminary step of factor analysis, whose results are shown in detail in table A2 of the appendix, leads to statistically satisfactory results. The five factors extracted in the analysis account for 56% of total variance. The factor solution is convincing in economic terms as can be seen from the factor pattern depicted in the table A1. The first factor accounts for 20% of total variance and gives high weights to innovation-related follow-up investments (level and various components such as training, marketing-related outlays, etc.). The second factor capturing 11% of the variance shows high loadings on R&D inputs and science-oriented innovation output (patents, licences granted). The third factor

9 There is a German, a French and an Italian version of the questionnaire which is available on request.

10 The method we used is „multiple imputation" (see Donzé, 1998, 2000).

explaining 10% of total variance refers to the technological and IT demension of service innovations. Whereas the first three factors do not differentiate between product and process innovations the last two components do with both stressing the economic side of innovation: The fourth one loads heavily on (product) market-orientation, the last one on cost reductions related to process innovations.

In the second step we performed a non-hierarchical cluster analysis of the five principal components identified in the first step. According to the usual statistical criteria (approximate expected overall R^2, cubic clustering criterion, etc.) groupings with four, five or six clusters were more or less of the same quality. In order to choose the number of clusters we took account of three criteria, that is a) the statistical properties in terms of the relationship of within-cluster as compared to between-cluster variance, b) the plausibility of the clusters in economic terms („how well can the clusters be interpreted as innovation modes"?), and c) the need to have a minimum number of firms within each cluster. According to criterion c) the version with six clusters was not attractive, whereas the solution with four clusters was inferior to that with five groups in terms of criteria a) and b). We thus ended up with a five cluster solution which is satisfactory in statistical terms (the approximate expected overall R^2 of 0.45 points to an acceptable fit of the data to the underlying clustering model) and yields a set of innovation modes which have a straightforward interpretation.[11]

4.2 The basic characteristics of the five innovation modes

The five innovation modes we identified are described in some detail in the appendix (see table A3) based on the variables listed in table 2. In the following we characterize the five categories in a summary way.

Mode 1: „Science-based, network-integrated high-tech firms"

This cluster consists of 21 firms which are endowed with an excellently qualified staff doing very much R&D within a highly favourable environment in terms of technological opportunities and market perspectives. Own R&D is supported by intensive use of science-related external knowledge sources as well as many institutionalized R&D cooperations (and research contracts) with domestic and foreign universities as main partners. The innovation output consists in many instances of products/processes which are new for the industry and are protected by patents (accompanied by granting of licences). The sales share of new products is high (partly due to a significant number of young firms) though sales have to be realized in a very competitive environment (primarily non-price competition). This cluster contains an above average share of export-oriented medium-sized and some very large firms heavily concentrated in IT-/R&D-services, business services (together 70% of firms) as well as banking/insurance/other financial services (15%). Somewhat astonishingly, labour productivity is distinctly below-average; however, growth performance is better in terms of sales (about average) and very strong with respect to employment.

Mode 2: „IT-oriented, outward-looking developers"

This cluster contains 19 firms, which – though innovation opportunities are not more than average – dispose of good preconditions to be highly innovative in view of very favourable market conditions and a highly qualified labour force. Based on high investments in development and IT (but not in research) they generate product and process innovation which are of high technical standard and, in many instances, new to the industry. The innovations, often patented and licensed to other firms, are technology-oriented and characterized by a high IT-content as well as a strong potential for cost reductions. The firms of this clusters are intensive users of manifold sources of external knowledge (suppliers of software and investment goods, universities, competitors and other firms of the same

11 As stressed in Kaufmann and Pape (1984) there is no such thing as a „natural" or „correct" classification; statistical criteria are just helpful to narrow down the range of possible solutions within which a satisfactory one has to be identified.

enterprise group). Among the more formal knowledge links out-contracting of R&D (at home as well as abroad) and the use of licenses are of higher importance than more far-reaching cooperations. Medium-sized and export-oriented firms are distinctly 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 represented overproportionally, whereas the opposite holds for retail trade, hotels/-restaurants and real estate which are characterized on average by a rather low innovation intensity. Value added per employee in this cluster is on average higher than in the others; growth of sales and employment, however, is lower than in services as a whole.

Mode 3: „Market-oriented, inward-looking incremental innovators“

Innovative activities of the 100 firms belonging to this cluster profit strongly from very favourable market perspectives whereas the supply-side conditions for the generation of novelties are just average. These firms generate product and process innovations with a high IT-content which are primarily incremental in nature (which is no surprise in view of the rather low innovation input). Nevertheless innovation output is of high value in economic and technological terms and is successfully brought to the market place in spite of strong competition. In general, networking is rather weak; only market-oriented knowledge sources (users, software suppliers) and easily accessible knowledge sources (fairs/exhibitions, computer-based networks) are of some importance. Compared to the sector average this cluster is made-up of a high proportion of (very) small firms with average export orientation. The firms are distributed across industries quite similar as services as a whole with some overrepresentation of business services and wholesale trade and only few firms in transport/telecommunication. Labour productivity of this innovation mode is high, whereas growth of sales and employment are not more than average.

Mode 4: „Cost-reducing, value chain-oriented process innovators“

This cluster with 232 firms is by far the largest one. In view of strong price competition and only average market growth it is no surprise that process innovations (and corresponding cost-reductions), which are predominantly incremental, are most prominent. Innovation input concentrates on IT- and innovation-related follow-up investments all components of which seem to be of high relevance (machinery, external knowledge, training, marketing). The technological and economic significance of innnovation output is high although, as mentioned, it is frequently based on further developments of already existing products/processes. The firms‘ own innovative activity strongly benefits from a wide (primarily informal) network which is spanned along the value chain: from suppliers (of software in particular) at the one end to users at the other, with strong links to different partners in-between (consultancy firms, competitors/firms of the same industry, fairs/exhibitions, computer-based networks, professional conferences). Institutionalized cooperation (R&D contracts, R&D cooperation) is only of average importance. Large firms are somewhat overrepresented, very small ones distinctly underrepresented in this cluster, and export orientation is rather low. In view of the large number of firms of this cluster it is not surprising that the industry structure is close to the sector average. The same holds for labour productivity but growth of sales and employment are much higher than in all other clusters with one exception (employment growth in cluster 1).

Mode 5: „Low-profile, inward-looking innovators“

The (process) innovations of the 109 firms belonging to this cluster seem to be quite marginal what is no surprise in view of the unfavourable demand- and supply-side factors determining innovative activity: weak demand perspectives, strong price competition, low appropriability and innovation opportunities and relatively poor human capital endowment. This cluster shows the weakest performance with respect to most of the variables we use to characterize the various innovation modes. The adoption of novelties generated elsewhere is the most important form of innovations. Correspon-

dingly, innovation input is mainly restricted to buying machinery/equipment. The use of external knowledge, which is distinctly below average for almost all sources, is concentrated on suppliers and competitors. This clusters comprises an overproportional share of small firms, most of them producing for domestic markets, and of firms belonging to industries like personal services, real estate, hotels/restaurants, retail trade and transport whose innovation intensity is low or only moderate. Not surprisingly, the (average) economic performance (level, growth) of the firms which belong to this cluster is low.

It follows from this characterization of the five clusters that our procedure led to a set of innovation modes which clearly differ from each other and are consistent and plausible in economic terms. This holds not only for the description of the five modes in terms of the seventeen innovation indicators underlying the cluster analysis (table 1) but also – and most importantly – in terms of the large number of „external criteria“ which are not used in the clustering process (see table 2).

5. Are Innovation Modes Equivalent in Economic Terms?

It is general practice to rank industries according to their innovativeness with the objective, for example, to assess their competitiveness or to predict their opportunities and risks in structural change (see, for example, EU, 1997). As mentioned in section 1 ranking is sensible if industries are sufficiently homogeneous with respect to innovation intensity. This assumption holds only if innovation modes, which are homogeneous groups by construction, and industries closely correspond. In addition, to make inference from innovation rankings by industry to competitiveness (and the like) requires – 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 we shall discuss the first of these conditions, whereas section 5.2 will be devoted to the second one.

5.1 Relationship between innovation modes and industries

Table 3 shows the industry composition of the five innovation modes (cols. 1 to 5) and the service sector as a whole (col. 6). Industries are ordered by decreasing innovation intensity the latter being measured by an indicator which aggregates the information contained in the seventeen innovation measures listed in table 1 by means of a factor analysis.[12] Although the five innovation modes are primarily regarded as unordered classes, they could also be ranked – at least by tendency – according to innovation intensity with mode 1 („science-based, network-integrated high-tech firms“) at the top and mode 5 („low-profile, inward-looking innovators“) at the bottom of the ladder.

A first look at table 3 shows that the firms of four out of five innovation modes (exception: mode 1) are distributed to many industries, a fact which contradicts the „homogeneity assumption“. However, at least three innovation modes are strongly concentrated on few industries. This holds most clearly for mode 1 („science-based, network-integrated high-tech firms“) containing mainly firms from the two most innovative industries. The industry composition of mode 2 („IT-oriented, outward-looking developers“) – though somewhat less pronounced – is also biased towards the most innovative industries. Just the opposite is true for mode 5 („low-profile, inward-looking innovators“) which, in comparison with the sector average, is mainly present in industries with low or intermediate innovation intensity. Less pronounced is the concentration of mode 3 („market-oriented, inward looking incremental innovators“), whereas the firms of mode 4 („cost-reducing, value chain-oriented process innovators“) are distributed across industries almos in the same way as as the service sector as a whole (what is not very surprising, however, in view of the fact that more than half of the firms of our

12 For details of the procedure see Hollenstein (1996)).

sample belong to this group). In sum, we find, on the one hand, a clear correspondence between industries and innovation modes, if ranked by innovation intensity;[13] on the other hand, four out of five innovation modes are distributed quite widely across industries.[14]

In concordance with the „heterogeneity hypothesis", firms seem to have a certain degree of freedom in choosing an innovation strategy within technologically and economically similar environments (proxied by industry). Given the positive correlation between industries and innovation modes, the ranking of industries by innovation intensity seems also to be a sensible procedure if innovativeness is appropriately measured and interpreted with caution.

Table 3: Industrial Structure by Innovation Mode

Industry	Innovation Mode					
	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	30.0	16.7	5.1	3.9	2.8	5.5
(Other) business services	40.0	16.7	23.2	18.3	15.7	19.6
Banking/insurance/financial services	15.0	22.1	16.2	17.0	15.7	16.4
Wholesale trade	5.0	22.1	24.2	22.5	15.7	20.5
Transport/telecommunication	5.0	5.6	5.1	10.9	17.6	11.0
Innovativeness below average	*5.0*	*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	5.0	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

If in a cluster the industry share of firms (%) is higher than the share of the industry total in the grand total (column 6) by more than 10% the corresponding cell is shaded. The innovation modes are: (1) „science-based, network-integrated high-tech firms", (2) „IT-oriented, outward-looking developers", (3) „market-oriented inward-looking incremental innovators", (4) „cost-reducing, value chain-oriented process innovators", (5) „low-profile, inward-looking innovators"; see description in the text and the table A3 in the appendix.

5.2 Innovation modes and economic performance

To assess the validity of the „homogeneity hypothesis" we have also to investigate whether there are significant differences between the innovation modes with respect to average firm performance. A negative result would support the „heterogeneity hypothesis" according to which there is – at least temporarily – more than one economically feasible innovation strategy. To evaluate the two conflicting propositions we consider labour productivity (value added per employee (full-time equivalents))

13 This finding is supported by a statistically significant value of Goodman-Kruskal γ which is an appropriate measure of association in case of ordinally scaled variables ($\gamma = 0.19$).

14 It cannot be excluded that the wide distribution by industry is to some extent the result of too much heterogeneity in the underlying industry classification.

as a measure of firm performance and sales and employment growth as indicators of the development of performance over time.

As can be seen from table 4 labour productivity differs strongly between the five innovation modes; it is nearly 70% higher in mode 2 (cluster with the highest productivity) than in mode 1 (cluster with the lowest productivity). We find also pronounced differences with respect to the growth of sales and employment respectively. These data seem to be at variance with the „heterogeneity hypothesis". However, this view of the matter is too simple because firm performance is determined not only by the variable „innovation mode" but also by several other factors such as those listed in the lower part of table 4. For example, it is obvious that a firm which uses intensively physical capital exhibits higher labour productivity than one producing in a more labour-intensive way. This example is clearly relevant in comparing average labour productivity of innovation mode 3 (high value added, high capital intensity) with that of mode 1 (low value added, low capital intensity).

Table 4: Economic Performance by Mode of Innovation

Indicator	Innovation Mode					Total
	1	2	3	4	5	
	Cluster means					
Performance indicators						
Value added per employee (1000 sFr.)	154	260	202	180	165	183
Share of firms (%) with increasing sales 1996/98	63	47	64	71	58	66
Share of firms (%) with increasing employment 1996/98	50	31	35	43	32	39
Factors determining firm performance						
Gross capital income per employee (1000 sFr.)	49	68	95	89	73	84
Employment share of highly qualified labour (%)	50	33	28	23	19	25
Share of R&D performing firms (%)	100	89	31	44	35	44

For each indicator the cell with the cluster mean is shaded if it is higher than the mean of the service sector as a whole (column 6) by more than 10%. The innovation modes are: (1) „science-based, network-integrated high-tech firms", (2) „IT-oriented, outward-looking developers", (3) „market-oriented inward-looking incremental innovators", (4) „cost-reducing, value chain-oriented process innovators", (5) „low-profile, inward-looking innovators"; see description in the text and the table A3 in the appencix.

To control for such differences with respect to the use of various input factors we performed a cross-section regression analysis of firm performance in a production-theoretic setting. More specifically, we estimated a production function with the following arguments: a) physical, human and knowledge capital measured by gross capital income per employee, the employment share of personnel holding tertiary level degrees and the share of firms with R&D activities respectively;[15] b) dummy variables for the five innovation modes; c) industry dummies (as variables to control for unspecified factors; personal services as reference group). In explaining sales and employment growth we used the same variables augmented by two dummies to control for changes of the firms' structure (selling-off, splitting or closure of parts of the firm and mergers respectively). The sales growth has been used as an

15 As an alternative measure of knowledge capital we used the employment share of R&D personnel.

additional variable in explaining employment change. The growth of sales and employment have been measured on an ordinal scale (with alternatively 2, 3 or 6 levels) or as a percentage change.

The estimation results may be summarized as follows:

- *Labour productivity*: We find a statistically significant impact (positive sign) on firm performance only in the case of innovation mode 2 („IT-oriented, outward-looking developers“). The other four modes are thus equivalent in terms of labour productivity, that is the partly high differences with respect to value added per employee as shown in table 4 are explained by other factors. According to the estimates, which are satisfactory in statistical terms, the inputs of physical and knowledge capital have a positive, statistically significant impact on labour productivity. We obtain significant (positive) signs also for the dummies of those industries whose innovation intensity is above-average (IT/R&D-services, business services, banking/insurance/other financial services, wholesale trade, transport/communications). We do not find, however, statistically significant results for human capital input what presumably is due to a positve correlation with knowledge capital as well as some industry dummy variables.
- *Sales growth*: There is no evidence for an impact of the five dummies measuring a firm's innovation mode on this performance variable. We find a positive, though not in all specifications statistically significant influence of physical capital intensity, whereas the human and knowledge capital variables yielded no significant results. The two dummies controlling for changes over time of the firms‘ boundaries showed the expected sign and were statistically significant. In addition, two industry dummies (wholesale trade, banking/insurance/other financial services), exerted a significant positive influence.
- *Employment growth*: The effects of particular interest are again those pertaining to the innovation modes: we find in all specifications a statistically significant, positive effect for mode 4 („cost-reducing, value chain-oriented process innovators“) and in some estimates also for mode 1 („science-based, network-integrated high-tech firms“). The most important variable in explaining employment change is, not surprisingly, the change of sales. Moreover, the two variables controlling for changes of the firms‘ structure show the right signs and were statistically significant. A positive impact is found for the industry dummy IT/R&D-services. The intensity of use of the various input factors is important, but the effects are not very stable across different specifications of the variable „employment growth“; in some cases the coefficients for physical and knowledge capital intensity were statistically significant, in others only the parameter for knowledge or that for human capital.

In sum, the estimates of the relationship between innovation mode and firm performance lead to the conclusion that – with one exception (mode 2) – a firm's labour productivity is independent of its innovation mode. The same holds (without exception) for the growth of sales, whereas we get a significant (positive) impact of innovation modes 1 and 4 on employment change. The differences between innovation modes with respect to the three performance measures are thus only in „extreme cases“ (shaded areas in the upper half of table 4) and even here only in three cases systematic in nature. These results are more or less in concordance with the „heterogeneity hypothesis“ stating that firms dispose of a certain freedom in choosing (economically viable) innovation strategies. On the other hand, an assessment has to take into account that the intensity of use of human and/or knowledge capital as well as the dummies for industries with above-average innovativeness (IT/R&D-services, business services, banking/insurance/other financial services, wholesale trade, transport/telecommunications) exert a statistically significant influence on productivity. In view of this result we conclude that the choice of an innovation strategy depends quite strongly on structural characteristics which are closely related to the hierarchy of industries in terms of innovation intensity.

6. Summary and Conclusions

By applying cluster analysis on a large set of innovation indicators (which capture also non-technical aspects of innovation which are much more important in services than in manufacturing) we identified five clusters. In a second step the latter were characterized by using five groups of variables: a) innovation indicators (partly already used for clustering), b) the firms‘ position in knowledge networks (use of external knowledge sources, R&D out-contracting and cooperative agreements), c) demand- and supply-side determinants of innovative activity (market perspectives, competitive environment, innovation opportunities, appropriability, human capital endowment), d) some general characteristics of firms such as size, export orientation, industry, etc., and e) measures of firm performance. The description of the five clusters showed that they can be interpreted as specific „modes of innovation“ which have an economically plausible interpretation:

- „science-based, network-integrated high-tech firms“,
- „IT-oriented, outward-looking developers“,
- „market-oriented inward-looking incremental innovators“,
- „cost-reducing, value chain-oriented process innovators“,
- „low-profile, inward-looking innovators“;

According to the evolutionary view of technical change such a classificatory procedure („innovation modes“) is preferable to an approach which is looking for a ranking of industries according to their 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 rather homogeneous in terms of the innovativeness of its firms. To evaluate the relative merits of the two approaches and the underlying assumptions we investigated in a first step the relationship between innovation modes and industries. We found that the firms of most innovation modes are distributed over several industries; on the other hand, compared to the service sector average, three out of five innovation modes are concentrated on specific industries, and we find a significant positive correspondence between innovation modes and industries ranked according to innovation intensity. In a second step we analyzed the relationship between innovation modes and firm performance as well as its change. We found that a firm’s labour productivity is independent of its innovation mode (except in one case) with a somewhat stronger relationship between innovation strategies and employment change, but no correlation with the growth of sales. On the other hand, there is strong evidence that variables related to innovativeness such as human and knowledge capital intensity as well as dummies for industries with an above-average innovation performance exert a positive influence on firm performance.

In view of these results neither the „classical“ ranking of industries according to their innovativeness nor the classification of firms into (unordered) categories representing innovation modes of equal „economic value“ captures the whole reality. This ambiguous result can be interpreted as follows: On the one hand, in accordance with the heterogeneity hypothesis, firms dispose of a certain degree of freedom in selecting an economically viable innovation strategy (innovation mode) even in similar economic and technological environments, but the room of manoevre is restricted by structural characteristics which are closely related to the hierarchy of industries in terms of innovation intensity, factor endowment, etc.. On the other hand, it still makes sense to rank industries according to their innovativeness, for example, in order to assess their competitiveness, growth potential, etc.; in this framework, however, the measurement of innovation intensity must be broadly based and cover also non-technological indicators; only in this way one can take account of the diversity of innovation modes within an industry. This aspect rarely gets the attention it deserves; most rankings are based just on a single indicator which is easy to collect, such as R&D or patent intensity; but these

indicators, as shown, are irrelevant for the innovative activities of three out of five innovation modes. The aggregate innovation measure we used to rank industries according to their innovation intensity in table 3 seems to be a useful instrument to take account of the heterogeneity aspect, because it contains the information of seventeen innovation indicators covering many different aspects of „innovativeness“ with only some of them technology-oriented.[16]

The interesting question whether there are similar innovation modes across countries is difficult to answer at this stage of research. Evangelista (2000), to our knowledge the only study which is more or less comparable to the present one (though based on industry-level data), identified four groups of clusters (nine clusters in total). Excluding his fourth one which covers just one industry (technical consultancy) we get the following picture: One of groups of clusters found for Italy („S&T-based“) is more or less identical to our first innovation mode („science-based, network-integrated high-tech firms“) and two others („interactive and IT-based“ and „technology users“ respectively) show some similarities to our clusters 4 and 5 („cost-reducing, value chain-oriented process innovators“ and „low-profile, inward-looking innovators“ respectively). However, there is no correspondence to our innovation modes 2 and 3.[17] Some of the differences are presumably the result of some shortcoming of the specific procedure used in the Italian case: Evangelista (2000, p. 211) explicitly dropped at a certain stage of his analysis the indicators referring to the market-orientation of innovations for “technical reasons“; if he would not have done so, this author presumably would have identified a cluster similar to our third one („market-oriented inward-looking incremental innovators“) also for the service sector of the Italian economy.

In sum, there is some (preliminary) evidence for similarities of innovation modes across countries. This hypothesis should be tested in further work using the same type of data and method of analysis for several countries. In view of the harmonization of innovation surveys in Europe such a research strategy seems feasible. In this way, differences which are the result of specific methods of analysis could be excluded; it should thus become possible to identify common as well as nation-specific modes of innovation. From the few studies looking at innovation patterns in manufacturing mentioned in section 1 we know that innovation modes are quite similar across countries with some important exceptions. In the Swiss case, for example, there is no „scale-intensive mode of innovation“ as identified for Britain, Italy and the large European firms, a result which is not surprising in view of the small size of the Swiss economy and the overrepresentation of small firms in comparison with other countries. Therefore, although the common elements of innovation patterns seem to dominate, the country-specific identification of innovation modes can also contribute to characterize „National Innovation Systems“.

At this stage of research, one should be cautious in drawing policy conclusions. It may be just stated that in assessing or shaping policy measures one should take account of the variety of innovation patterns because firms belonging to specific innovation modes may have different needs with respect to public policy. „Cost-reducing, value chain-oriented process innovators“ and „IT-oriented, outward-looking developers“ presumably would profit most from programmes facilitating the diffusion of IT and measures to enlarge and improve the supply of IT-professionals; „science-based, network-integrated high-tech firms“ 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. If it is true that the overlap between industry structure and innovation modes is only partial and economic performance differences across innovation modes are rather small, it may be advisable not to direct

16 The same argument is put forward by Baldwin and Gellatly (1998) who constructed an overall index of innovativeness which also takes account of non-technological indicators.

17 Our second cluster shows some elements of the Italian „S&T-based“ group as well as some characteristics covered by the „interactive and IT-based“ category; compare the description of Evangelista (2000, pp. 211-13) with ours in section 4.2.

policy measures towards specific sectors (as „classical“ industrial policy would do) or types of firms (e.g. highly R&D-intensive ones); it would rather be sensible to formulate a policy (package) which takes into account the variety of needs and uses thus different types of policy instruments.

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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	102	21.2	49.3
Retail trade	516	18.9	132	15.0	25.6	64	13.3	48.5
Hotels, restaurants	403	14.8	84	9.6	20.8	51	10.6	60.7
Transport/communication	378	13.8	133	15.1	35.2	53	11.0	38.1
Banking/insurance	266	9.7	99	11.2	37.2	78	16.2	78.8
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	93	19.3	60.0
Personal services	50	1.8	20	2.3	32.2	9	1.9	45.0
Total	2731	100	880	100	32.2	481	100	54.7
Firm size (number of employees)								
Small	1487	54.4	465	52.8	31.3	221	46.0	47.5
Medium	1021	37.4	330	37.5	32.3	196	40.7	59.4
Large	223	8.2	85	9.7	38.1	64	13.3	75.3
Total	2731	100	880	100	32.2	481	100	54.7

Column 5 shows the response rate by industry and size class, column 8 the share of innovating firms. Underrepresented industries/size classes are brightly coloured, whereas overrepresented ones are darkly shaded; criterion: deviation of more than 15% of the total.

A.2. Results of the Factor Analysis with Innovation Indicators

The factor analysis with the innovation variables listed in table 1 led to satisfactory results as can be seen a) from the factor pattern which seems sensible in economic terms (see upper part of table A2 and main text, section 4.1), and b) from the statistical information presented in the lower part of table A2: According to Kaiser's MSA the original variables are quite strongly correlated; hence, a basic requirement for a factor analysis to be sensible is fulfilled. Moreover, the RMSE of the residual is low enough, and the variance accounted for by the first five principal components is sufficiently high.

Table A2: Factor Analysis with the Innovation Indicators Used in Cluster Analysis

Innovation indicator	Rotated Factor Pattern (Factor loadings)				
Follow-up investments: total	.77				
Follow-up investments: training	.75				
Follow-up investments: machinery and equipment	.67				
Follow-up investments: market introduction of innovations	.66				
Follow-up investments: acquisition of external knowledge	.54				
Development expenditures		.74			
Patent application		.73			
Research expenditures		.68			
Granting of licences		.61			
IT-content of innovations			.80		
IT expenditures (hardware, software)			.68		
Significance of product innovations in technical terms			.57		
Significance of process innovations in technical terms			.57		
Sales share of new or highly improved products				.76	
Significance of product innovations in economic terms				.73	
Cost reduction related to process innovations					.78
Significance of process innovations in economic terms					.59
Number of observations					475
Kaiser's overall measure of sampling adequacy (MSA)					.720
Variance accounted for by the first five components					.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

For the definition of the innovation indicators see table 1. Only factor loadings above 0.5 are shown. We used equamax as rotation method.

Table A3: Description of the Five Innovation Modes Identified for the Service Sector	
Mode 1: „Science-based, network-integrated high-tech firms“ *(4.4% of firms, 18.1 % of employment)*	
Innovation activities and innovativeness	Extraordinarily high innovation performance, in particular combined product/-process innovations: Based on very high R&D expenditures (also at foreign locations) these firms generate basic novelties often protected by patents (with much granting of licences); the innovations, which in many cases are „new for the industry“, are successfully introduced in the market
Knowledge network	Intensive use of (primarily) science-related external knowledge sources (universities, other research centres, patent disclosures, licences, journals); high importance of institutionalized relationships with domestic and foreign partners (R&D cooperations and contracts) which are very effective in terms of the generation of publications, patents, prototypes, new products
Innovation determinants	
- demand side	Very good market perspectives in a highly competitive environment (in particular with respect to non-price competition)
- supply side	Very high innovation opportunities, which are realized by an excellently qualified labour force (very high share of academics) and high appropriability of knowledge
Firm characteristics	
- Industry	Pronounced concentration on the most innovative industries (IT-/R&D services, business services)
- Size, age, export orientation	Besides some very large enterprises primarily medium-sized firms (with a considerable share of rather young ones) with very strong export orientation
Firm performance	Low labour productivity (combinded with very low physical capital intensity); average growth of sales, very strong employment growth
Mode 2: „IT-oriented, outward-looking developers“ *(4.0% of firms, 1.7% of employment)*	
Innovation activities and innovativeness	High innovation performance (products, processes, combind innovations): Based on high investments in development (but not research) and IT (also at foreign locations) these firms generate innovations which in many cases are industry novelties protected by patents and licensed to other firms. The innovations are technology-oriented and characterized by a high IT-content and a large cost-reducing potential, whereas the sales share of new products is low
Knowledge network	Intensive use of manifold sources of external knowledge (universities, suppliers of software and investment goods, licences, competitors, firms of the same group); institutionalized knowledge relationships (at home as well as abroad) take primarily the form of R&D out-contracting, in second instance also R&D cooperations (with a high output of patents and new processes)
Innovation determinants	
- demand side	Favourable market perspectives in a highly competitive environment (in particular with respect to non-price competition)
- supply side	Average innovation opportunities of which the firms can make use in view of rather good knowledge protection and highly qualified labour
Firm characteristics	
- Industry	Some concentration on IT-/R&D services, banking/insurance/other financial services, wheras retail trade and hotels/restaurants are represented less than in the service sector as a whole
- Size, age, export orientation	Primarily highly export-oriented, medium-sized firms (with a non-negligible share of rather young firms)
Firm performance	Very high labour productivity (combined with low physical capital intensity), but only weak growth of sales and employment

(continued on next page)

Table A3 (continued)

Mode 3: „Market-oriented, inward-looking incremental innovators“ (20.8% of firms, 9.1 % of employment)	
Innovation activities and innovativeness	Average innovation performance for new product as well as processes These firms generate and introduce successfully innovations which are primarily developments of already existing products/processes although the own innovation inputs (R&D as well as innovation-related follow-up investments) are rather low. Nevertheless, these incremental innovations, which contain much IT-elements, are of high value in technological and economic terms
Knowledge network	These firms are only loosely embedded in knowledge networks. Among the external knowledge sources only some easily accessible ones (fairs, compter-based networks) and some market-oriented sources (suppliers of software, users) are of some importance. The institutionalized knowledge transfer through cooperations and R&D out-contracting is weak
Innovation determinants	
- demand side	Very bright demand perspectives in a highly competitive market environment (in particular with respect to non-price competition)
- supply side	Innovation opportunities, appropriability and human capital endowment are about average
Firm characteristics	
- Industry	The firms are distributed across industries in a way quite similar to that of the service sector as a whole; there is some overrepresentation of wholesale trade and business services whereas transport/communication is underrepresented
- Size, age, export orientation	High proportion of (very) small firms (some of them rather young) with average export orientation
Firm performance	Labour productivity is somewhat higher than in total services (combined with a very high physical capital intensity); average growth of sales with only weak employment growth
Mode 4: „Cost-reducing, value chain-oriented process innovators“ (48.1% of firms, 62.9% of employment)	
Innovation activities and innovativeness	High innovation performance concentrated on new processes These firms generate strongly cost-reducing process innovations, which are primarily developments of existing processes, based on high innovation-related investments in machinery, training and marketing
Knowledge network	These firms are intensly connected to many types of external knowledge sources which form an (informal) network along the value chain: from suppliers (primarily of software) to users with many partners in-between (consultancy firms, competitors, fairs/exhibitions, computer-based networks, professional conferences). The institutionalized knowledge transfer through cooperations and R&D out-contracting is of average importance leading, not surprisingly, to new processes
Innovation determinants	
- demand side	Slightly above average demand perspectives combined with strong price competition
- supply side	Innovation opportunites are better than on average; the use of them, however, is hampered by weak appropriability and below-average skill endowment
Firm characteristics	
- Industry	Industrial structure is almost identical to that of the the service sector as a whole
- Size, age, export orientation	Large firms are somewhat overrepresented. Export orientation is rather low
Firm performance	Labour productivity is about average (with physical capital somewhat above-average); growth of employment, and even more, of sales is very strong

(continued on next page)

Table A3 (continued)

Mode 5: „Low-profile, inward-looking innovators“ (22.7% of firms, 8.2% of employment*)*	
Innovation activities and innovativeness	Very weak innovation performance (primarily process innovations): The innovations, primarily „new to the firm“ only, are of quite marginal significance with respect to innovation inputs (buying machinery only), the output in terms of its technological and economic content as well as the impact on sales and costs
Knowledge network	External knowledge is quite unimportant for these firms; only suppliers and competitors play a certain role as sources of know-how
Innovation determinants	
- demand side	Demand perspectives are weak, whereas the intensity of price competition is very high
- supply side	Innovation opportunities, appropriability and human capital endowment are all below average
Firm characteristics	
- Industry	Industries with (rather) low innovation intensity like real estate, personal services, retail trade and transport/communication are overrepresented, whereas firms producing business services and – even more – IT-/R&D services are rare
- Size, age, export orientation	The share of small firms is high; firms serve primarily domestic markets
Firm performance	Labour productivity is low (with physical capital intensity also below average), the increase of sales is somewhat lower than average and that of employment is very weak