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Are Firm Innovativeness and Firm Age Relevant for the Supply of Vocational Training? – A Study Based on Swiss Micro Data*

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Abstract

In this study we investigated the determinants (a) of the propensity of Swiss firms to train apprentices and (b) of the intensity of apprentice training as measured by the employment share of apprentices. Innovation, firm age and competition conditions on the product market are possible determining factors that are especially emphasized in this investigation. In a further step, we analyzed the impact of apprentice training on labour productivity when apprentice training is considered as an additional production factor in the framework of a production function. We found that the skill composition of the employment, innovation activities, firm age, labour costs, capital intensity, and competitive pressures all play a positive or negative role, even if not at the same extent, in determining the propensity and/or intensity of apprentice training. A further finding was that training propensity and/or training intensity correlate negatively with labour productivity.

Key words: start-ups; training; innovation; firm age

JEL classification: J24; O30

1. Introduction

Within contemporary advanced economies "apprenticeship typically denotes employer-sponsored programmes which integrate part-time schooling with part-time training and work experience [in a firm]… within an externally defined curriculum which contains mandatory part-time schooling and leads to a nationally recognized vocational qualification and takes at least two years to complete" (Ryan 1998, p. 290). This is exactly the definition of apprenticeship as it is exercised also in Switzerland.

Firm-funded training of apprentices covering a wide spectrum of skills from construction to information technologies and banking is the most important source of "middle-level" human capital for the Swiss economy. The employees with such "middle-level" vocational education build the largest group among employed persons. Moreover, having such a (nationally organized) vocational qualification is a precondition for the acquisition of every other type of higher tertiary-level education (with the exception of academic education). Thus, it is quite reasonable that both economists and economic policy-makers are greatly interested in better understanding the factors influencing positively or negatively the willingness of private enterprises to offer apprenticeships. Of particular interest is the training behaviour of technologically advanced enterprises. There is long-term empirical evidence that both the number and the employment share of high-skilled (or high-educated) workers have grown over time in many OECD countries. Most observers think that this effect is attributable primarily to skill-based technical change. Thus, technical change is expected to further shift labour demand in favour of high-qualified persons. In this context, it is important for policy-makers to know if the supply of apprenticeships, thus the supply of middle-educated persons, would be adequate also under the new technological conditions. In many cases new technologies and new products are introduced by young firms that just entered the market. Therefore, it is also relevant to have information on the training behaviour of such newly-founded firms. Finally, due to the increasing openness of world markets, firms are operating under the conditions of intense (international) competition. As a consequence, it might be of interest to know how product market competition is influencing training behaviour (see, e.g., Gersbach and Schmutzler 2006).

This study investigates the determinants (a) of the propensity of Swiss firms to train apprentices and (b) of the intensity of apprentice training as measured by the employment share of apprentices. Innovation, firm age and competition conditions on the product market are possible determining factors that are especially emphasized in this investigation. In a further step, we analyze the impact of apprentice training on labour productivity when apprentice training is considered as an additional production factor in the framework of a microeconomic production function.

The data used in this study were collected in the course of four surveys among Swiss enterprises in the years 1996, 1999, 2002 and 2005 using a questionnaire which included besides questions on some basic firm characteristics (sales, exports, employment, investment and employees' vocational education) also several innovation indicators.

New elements of the analysis that distinguish it from already done work on this subject, especially in Switzerland,[1] are: (a) the focus on the role of innovation and firm age for apprentice training; (b) the consideration of effects of competition on the product market; (c) the separate investigation of three sectors of the economy (manufacturing; services; construction); (d) the wide spectrum of determinants of training propensity (and intensity) that are taken into consideration; (e) the use of a panel of firms covering a period of about ten years (1995-2004).

The paper is organized as follows. Section 2 discusses the conceptual framework of the study. In section 3 the data are presented; this section contains also a description of the main facts with respect to the training propensity and training intensity of the firms in our sample. In section 4 we present the specification of the training propensity (intensity) equation and the labour productivity equation respectively. The results of the econometric estimations are presented in section 5. Section 6 contains a comparison with results of similar studies. Finally, section 7 concludes with a summary of the main results.

2. Incentives and disincentives related to the decision to train apprentices

Starting point of our conceptual framework is the human capital approach introduced by Becker (1964) according to which the acquisition of vocational education can be considered as an investment in human capital that enables the capital owner to achieve a higher individual performance in the future, e.g. higher productivity. Both employees and employers can have incentives for such investment, if the difference of the *expected benefits* (e.g., productivity gains for the enterprises, labour income increases for the employees) and the *expected costs* (e.g., training costs) is positive. We concentrate here on firms' incentives and motives to invest in human capital by offering training, especially training for apprenticeships.[2] Vocational training contains general skills that satisfy the firms' requirements at industry, sector or even country, but also a portion of firm-specific skills that are not transferable to other firms (or are transferable at a high cost). According to the original human capital approach, employers have an interest to pay only for an investment in firm-specific skills but not for general skills that have to be financed either by the employees or the state. However, in practice we can observe that firms bear a significant fraction of the costs of training, even if this training contains general skills. The investment hypothesis has been further elaborated and refined by Acemoglu and Pischke 1998, 1999). According to this new approach, it can be more profitable for a firm to use skilled

[1] For a survey of relevant literature see Wolter (2008) and Frick and Wirz (Eds.) (2006).

[2] We refrain here from discussing other motives of training (production motive; reputation motive) that are not taken into consideration in the empirical part of the study (see, e.g., Niederalt 2004 and Mohrenweiser and Backes-Gellner 2006 for a discussion of the literature dealing with the relevance of different motives).

employees that have been trained by the firm than unskilled employees, even if the training is not firm-specific. The main reason for this conclusion is the existence of labour markets imperfections due to asymmetric information with respect to the productivity of external employees, search costs, labour market institution such as unions and minimum wages, etc.[3] Put in a more abstract way, the main argument should be that the expected benefits and costs of training for a firm are primarily determined by all factors that influence the future demand for skilled labour.[4]

We hypothesize that a series of factors that would influence *positively* the expected demand for skilled labour would be also important for a firm's decision to train apprentices. In accordance with literature, we identified a series of such factors that we comprise in five groups (see, e.g., Franz et al. 2000 and Niederalt 2000 for a similar approach): human resources; physical capital; innovation and technology; firm activity level; and market conditions. A further group of determinants that would influence *negatively* the expected demand for skilled labour refers to cost aspects.

Human resources. A firm's demand for apprentices depends among other things on the demand for employees with different levels of vocational education. The relationship between the demand for apprentices and the demand for other categories could be substitutive or complementary. We expect a complementary relationship between apprentices and middle-educated employees (upper secondary education level; 'Berufslehre') and a substitutive relationship between apprentices and low-educated employees (vocational education without a formal degree; no vocational education). It is more difficult to disentangle the relationship of apprentices to high-qualified employees (tertiary-level education). Given that middle-educated and high-educated are mostly positively correlated, we expect a positive relationship of apprentices to high-qualified employees.

Innovation and technology. There is long-term empirical evidence that both the number and the employment share of high-skilled (or high-educated) workers have grown over time in many OECD countries. While many factors have contributed to this increase most authors think that this effect is attributable primarily to skill-based technical change. One of the most popular explanations which have been offered by the economic literature is based on the so-called „skill-biased technological change“ hypothesis, according to which the reason for the up-skilling of labour force is the non-neutrality of technological change, which favours the use of skilled labour more than the use of other labour inputs. Due to the complementarity of skills (education) and technology, an acceleration of the rate of technological change would cause an increase of the

[3] In a recent paper Kessler and Lülfesmann (2006) show that when general and specific skills are complementary to each other employers may be willing to sponsor general training even in competitive labour markets.
[4] This indirect approach differs from that used in an important branch of empirical literature that investigates the direct the net cost and gains of training apprentices, see, e.g. Schweri et al. (2003) for Switzerland and Beicht et al. (2004) for Germany.

demand for skilled labour.[5] The reason for the most recent acceleration of technological change is assumed to be the diffusion of Information and Communication Technologies (ICT) which seem to have given new impetus to the substitution process of low-skilled by high-skilled employees (see Bresnahan et al. 2002). Empirical evidence for Switzerland shows that technological changes (e.g., the use of ICT) shift skill requirements in favour of high-qualified (tertiary-level education) employees and appear to be neutral with respect to middle-educated employees (upper secondary education level; 'Berufslehre'), which is the most numerous category of employees in the Swiss economy (see Arvanitis 2005). The demand for apprentices is closely related to the demand for middle-educated employees, therefore the expected effect of innovation and technology on the training propensity of Swiss firms is not a priori clear.

Physical capital. The theoretically expected impact of physical capital on training propensity is also ambiguous. It depends on the relationship between capital and the different employee categories. We would expect that in many cases a complementary relationship exists between capital and the high-qualified (tertiary-level education) employees. Symmetrically, a substitutive relationship could be probable between capital and low-qualified employees. It is not clear a priori how capital and the share of middle-educated employees – the employee category that interests mostly in this study – are related to each other.

Firm activity level. The demand for any category of employees is dependent on the expected level of firm activity as measured, e.g., by the expected product demand or by sales. The extent of this dependence is related to the relative importance of a certain category of employees in a firm's skill mix. In general, we expect positive effects of the variables measuring firm activity.

Market conditions. In a recent paper Gersbach and Schmutzler (2006) postulate and derive theoretically two hypotheses about the market conditions under which industry-specific training is likely to occur: (a) concentration is high or competitive intensity is low, and (b) product differentiation is sufficiently strong. We consider the intensity of price competition (as measured in this study; see table 7) as a proxy for 'competitive intensity' in the above theoretical context and the intensity of non-price competition (as measured in this study; see table 5) as a proxy for 'product differentiation'. Thus, according to hypothesis (a) intensive price competition would exercise a *negative* influence on training propensity. On the contrary, according to hypothesis (b) intensive non-price competition would have a *positive* effect on training propensity.

Competitive pressure could enhance a firm's performance both in terms of productivity and product quality as well as its innovativeness and the pace of technological change ("free competition effect"; see, e.g., Geroski 1995). Contrary to this positive competition effect, the older literature assumed that intensive competition could hamper innovation activity ("Schumpeterian effect"). In the game-theoretic literature the impact of market structure (as a

[5] For recent surveys of the theoretical and empirical literature on skill-biased technical change see Sanders and ter Weel (2000) and Acemoglu (2002).

proxy for product market competition) upon the schedule of innovation is shown to depend critically on the difference of profit rates preceding and following the innovation (see e.g. Reinganum 1981). This dependence being quite complicated, most studies do not come to theoretical unambiguous results with respect to the effects of market concentration on innovation. Recently, Aghion et al. (2005) developed a model that predicts an inverted-U relationship between product market competition and innovation. The authors found strong evidence for this model using U.K. panel data. There is also some evidence for Switzerland for a positive correlation between the intensity of non-price competition and innovation (Arvanitis and von Arx 2004).

Given the ambiguity of the effect of market concentration on innovation and via innovation on the demand for qualified personnel as well as hypothesis (a) of Gersbach and Schmutzler above, we would expect an *insignificant* (or even a *negative*) effect of intense price competition on the training propensity. On the other hand, we expect that intensive non-price competition would *positively* influence not only innovation but also directly the propensity to train apprentices according to hypothesis (b) of Gersbach and Schmutzler.

What about *expected costs*? Costs (e.g., training costs, recruitment costs, and learning by doing of newly-hired employees) depend mostly on the requirements of technology used, the labour market situation, and the existing institutional framework with respect to training of apprentices. We expect a large portion of these costs to be industry-specific, sector-specific or even region-specific. For example, in the Swiss apprenticeship system duration of training, formal requirements for trainers, performance requirements for apprentices, and (partly) apprentices' wages are determined either by the state and/or the employers' associations at industry or sector level.

Further, we expect that the propensity to train apprentices would increase with increasing *firm size*. Larger firms have more resources than small ones, thus a larger potential for investing in education and vocational training. Moreover, if economies of scale exist, e.g., with respect to the facilities of vocational education, larger firms would have a comparative advantage vis-à-vis smaller ones, e.g., regarding training costs.

We are especially interested in understanding the relationship between *firm age* and training propensity. A general characteristic of an average young firm that distinguishes it from the average established firm is the considerably smaller size of the young enterprise. Thus, young firms would be expected to have generally a lower training propensity than established firms. An additional reason for newly-founded firms to be reluctant with respect to training activities would be that due to the more urgent problems of positioning the firm in the market little attention is paid to training, especially when the firm founder is also the apprentice trainer. On the whole, we expect a positive relationship between firm age and the training propensity (see also, e.g. Niederalt 2004).

To our knowledge there is no specific theory for explaining the training intensity as contrasted to training propensity. Thus, we use here the same theoretical arguments for the determinants of training intensity. Nevertheless, there are a priori reasons to expect that the pattern of explanation would not be identical. For example, the decision to offer apprenticeships is related to fix costs, while the number of apprentices that are employed, provided that the training infrastructure already exists, implies variable costs. Therefore, even if we use the same specification for both the training propensity and the training intensity we expect that differences may arise (see also Franz et al. 2000 and Niederalt 2004).

3. Descriptive Results

3.1 Description of the data

The data used in this study were collected in the course of four surveys among Swiss enterprises in the years 1996, 1999, 2002 and 2005 using a questionnaire which included besides questions on some basic firm characteristics (sales, exports, employment, investment and employees' vocational education) also several innovation indicators quite similar to those in the Innovation Surveys of the European Community (CIS). The survey was based on a (with respect to firm size) disproportionately stratified random sample of firms with at least 5 employees covering the manufacturing sector, the construction sector and commercial service industries as well as firm size classes (on the whole 28 industries and within each industry three industry-specific firm size classes with full coverage of the class of large firms). Answers were received from 33.0% (1996), 33.8% (1999), 39.6% (2002) and 38.7% (2005) respectively of the firms in the underlying sample. The response rates do not vary much across industries and size classes with a few exceptions. The final data set includes 9306 enterprises from all fields of activity and size classes and may be considered as representative of the underlying industries (see table A.1 in the appendix for the structure of the used data set by industry, firm size, and year respectively).

Further, we used the multiple imputations technique by Rubin (1987) to substitute for missing values in the variables due to item non-response (see Donzé 2001 for a detailed report on the procedure used). The estimations were based on the mean of five imputed values for every missing value of a certain variable. However, for some important variables such imputations were not possible. Moreover, for construction and service firms the information on the shares of innovative products in the years 1996 and 1999 was not comparable with that for the other two cross-sections and had to be removed from the panel. The data set used in the econometric estimations contained 7967 observations.

3.2 Training propensity and training intensity in the Swiss business sector 1995-2004

In table 1, column 1 we present data on the vocational training propensity and the intensity of vocational training of the firms in our sample by sector and industry.[6] Further, we distinguish a high-tech and a low-tech sub-sector in manufacturing and a modern (knowledge-intensive) and a traditional sub-sector in services, thus taking into account the differences among industries with respect to innovativeness.

At the sector level construction firms show the highest propensity to vocational training: 78.9% of them reported having apprentices all over the period of observation. The respective figures for manufacturing and service were 66.8% and 63.8% respectively. Thus the difference between manufacturing and service sector is small; also the differences between the sub-sectors are negligible. Printing, energy and wood processing are the (low-tech) manufacturing industries with the highest shares of firms having apprentices (76%-81%). Paper (also a low-tech industry) and machinery, electrical machinery and vehicles (all three of them high-tech industries) come next with shares of 71%-72%. Such innovative industries as chemicals, plastics and electronics/instruments show a rather low train propensity. Among service industries we find an above-average frequency of firms having apprentices in retail trade (traditional services) and bank/insurance (knowledge-intensive services). On the contrary, computer services, an increasingly important industry, show a very low frequency of firms training apprentices.

The picture becomes somewhat different if we take a look at the employment share of apprentices (training intensity referring to the firms with apprentices; table 1, column 2). The average share of apprentices in the construction and the service sector is of the same magnitude, namely about 11%. The respective figure for manufacturing is only 7%. Again there are no discernible differences between the sub-sectors in the manufacturing and the service sector. In manufacturing wood processing, printing and energy in the low-tech subs-sector, vehicles and machinery in the high-tech sub-sector show the highest shares of apprentices. Wholesale and retail trade and personal services in the traditional sub-sector have above-average shares of apprentices, the same holds true for business services in the knowledge-intensive sub-sector. On the contrary, the finance sector (banking/insurance) shows a below-average share, although the share of firms having apprentices is above-average.

[6] It is important to mention here that leaving out the very small firms with less than 5 employees leads to a quite different picture with respect to training propensity and training intensity as when the entire population of enterprises is observed. Müller and Schweri (2006, p. 39) calculated a training propensity of 15.5% (1995), 17.8% (1998), and 17.6% (2001) respectively based on data for the entire population. The respective figures in our data are 60.6% (1995), 66.9% (1998), and 67.4% respectively. The figures for the employment share of apprentices in Müller and Schweri (2006) are 25.0% (1995), 26.6% (1998), and 26.3% (2001), while the corresponding figures in our sample are 8.7% (1995), 8.8% (1998), and 8.5% (2001) respectively. This comparison shows that if the entire population is taken into consideration the statistical picture is dominated by the very large number of micro firms that mostly build a particular segment of the firm population with a low innovation propensity.

The percentage of firms having apprentices grows with increasing firm size (measured by the number of employees in full-time equivalents), but the employment share seems to decrease with increasing firm size until the threshold of 200-499 employees, after that remaining almost constant (table 2).

Table 3 contains some information on the training propensity and the training intensity by firm age (table 5). Very young firms (firm age of 0 to 5 years) seem to have a higher propensity than firms with a firm age of 6-10 years and 11-20 years respectively (column 2). Older firms (more than 20 years) show a higher propensity than very young firms. The relationship between firm age and training propensity seems to be non-linear. Also with respect to training intensity no clear-cut pattern is perceptible (column 3).

4. Model specification

4.1 Specification of the training propensity / training intensity model

Dependent variables

We use two dependent variables for the models of training propensity and training intensity: (a) firms reporting that they have apprentices yes/no (TRP); (b) the number of apprentices as a share of total employment (only for firms having apprentices; TRIN) (see table 4).[7]

Independent variables

In section 2 we discussed potential determinants of apprentice training. In this section we specify variables for these determinants (see table 4 for details).[8]

Human resources. We used four dummy variables for the following four categories of employees with different education level: employees with university education yes/no (LHQUAL1); employees with other tertiary-level education (including graduates of universities of applied sciences) (LHQUAL2); employees with upper secondary education ('Berufslehre') (LMQUAL); and employees (with vocational education without a formal degree; no vocational education) (LLQUAL). We used these variables as proxies for the expected demand for the respective employee categories. We expect a positive effect for the high-educated and the middle-qualified employees (upper secondary education-level) and a negative effect for the low-qualified employees.

[7] Estimations based on a dependent variable for training intensity *including firms without apprentices* (i.e. zero intensity) in an earlier version of this paper showed that the results are dominated by the pattern of behaviour found for the training propensity. For this reason we refrain here from presenting estimates for this version of the intensity variable.

[8] For similar specifications of the propensity to train apprentices in studies based on German or Austrian firm data, see, e.g., Neubäumer and Bellmann (1999); Franz et al. (2000); Stöger and Winter-Ebmer (2001); Beckmann, M. (2002a); and Niederalt (2004).

Innovation. We used the following seven indicators to measure innovation: two variables for innovation *input* ('R&D activities yes/no' (R&D) and 'R&D expenditure/sales' (LRDS)); three indicators for innovation *output* ('product innovations yes/no' (INNOPD); 'process innovations yes/no' (INNOPC); and 'patent applications yes/no' (PAT)); and two *market-oriented* indicators ('sales share of new products (LNEWS) and 'sales share of considerably modified already) existing products' (LIMPS)). The use of several alternative indicators that cover various aspects of the innovation process helps to test the robustness of the effects of innovation on training. The sign of the innovation effect is not a priori clear.

Firm activity level. We used a measure for the development of a firm's specific product demand (mean of past and expected development; variable D) to proxy the effect of firm activity level. We expect a positive effect of this variable.

Physical capital. Due to lack of data for capital stocks we use a flow variable (capital income per employee; variable LC) as a proxy for physical capital. We have no a priori expectations for the capital effect.

Market conditions. The competition pressure is measured directly by the two variables 'intensity of price competition' (IPC) and 'intensity of non-price competition (INP). A third variable measures the effect of market structure; 'number of principal competitors on the (worldwide) product market' (CONC)). We expect a positive effect for INPC and a negative effect for IPC. For CONC we expect also a negative effect.

Costs. We use the labour costs per employee (LLCL) as a proxy for costs in general that are related with recruitment and training of employees. Labour costs are negatively correlated – even if not at the same extent – with the demand for any category of employees. Thus, we expect a negative effect of this variable.

Firm age is a further variable that is included in our model. We expect a positive effect for the variable 'number of years since foundation' (LAGE).

Finally, the model contains a dummy variable for foreign firms (FOREIGN): We expect that foreign firms being less accustomed to the Swiss institutional environment than domestic firms would show a lower training propensity than domestic firms. We also use extensive control variables for time (if necessary), firm size, and industry.

A formal expression of the training propensity equation is as follows:

$$TRP = \alpha_0 + \alpha_1\, LLCL + \alpha_2\, LHQUAL1 + \alpha_3\, LHQUAL2 + \alpha_4\, LMQUAL + \alpha_5\, LLQUAL + \alpha_6\, LC + \alpha_7\, INNOV + \alpha_8\, LAGE + \alpha_9 FOREIGN + \alpha_{10}\, D + \alpha_{11}\, IPC + \alpha_{12}\, INPC + \alpha_{13}\, CONC(>50) + \alpha_{14}\, CONC(16\text{-}50) + \alpha_{15}\, CONC(11\text{-}15) + \alpha_{16}\, CONC(6\text{-}10) + control\ variables + u \qquad (1)$$

(where INNOV: alternatively INNOPD; INNOPC; R&D; PAT: LRDS; LNEWS; LIMPS). The same expression is used also for the training intensity equation (TRIN), whereas in this case the variable LC is dropped (see section 5).

4.2 Specification of the productivity model

Further, we constructed a variable for average labour productivity, defined as value added per employee (number of employees measure in full-time equivalents).

The labour productivity equation contains proxies of the intensity of human capital (variable LHQUAL; natural logarithm of the share of employees with tertiary-level education), physical capital intensity (variable LC; natural logarithm of capital income per employee) and knowledge capital intensity approximated by R&D expenditures (variable LRDL; natural logarithm of R&D expenditures per employee) (see table 4). Further, we control for firm being a foreign one or not (dummy variable FOREIGN), firm size, industry affiliation and time (if necessary). We expect positive effects for the resource endowment variables LC, LHQUAL and LRDL. The signs for the variable FOREIGN as well as for the firm size dummies are not a priori clear. We insert as additional right-hand variables (a) the training propensity (variable TRP) and (b) the training intensity variable (variable TRIN). We have no a priori expectations with respect to the sign of these variables. A formal expression of the productivity equation is as follows:

$$LQL = \beta_0 + \beta_1\, LC + \beta_2\, LHQUAL + \beta_3\, LRDL + \beta_4\, FOREIGN + \beta_5\, (TRP;\, TRIN) + control\ variables + u \qquad (2)$$

5. Econometric results

5.1 Estimates of the equation of training propensity

We estimated a probit model (binary dependent variable TRP) separately for the manufacturing sector, the service sector, and the construction sector (a) with pooled data of all four waves and time dummies for the years 1998, 2000 an 2004 respectively; and (b) with random effects to take into consideration firm heterogeneity effects (table 5).[9] We present first the results for manufacturing, then we compare them with those for the other two sectors of the economy.

Human resources. We obtained statistically significant (at the usual test levels) positive coefficients for the share of employees with tertiary-level education other than university (LHQUA2) and the share of middle-educated employees (LMQUAL), but significantly negative coefficients for the variables for employees with academic education as wells as the low-educated employees (LLQUAL). Similar effects for LHQUA2 and LLQUAL were found also in the other

[9] Fix effects models could not be estimated because for most firms the variable TRP takes the same value (0 or 1) in all four periods.

two sectors. A negative effect for LHQUAL1 was found also for the construction sector but not for the service sector. A positive coefficient for LMQUAL was also found in the service sector but not in construction.

In sum, the higher a firm's employment share of high-educated (without academics) and/or the higher the share of middle-educated (with the exception of construction), the higher is the training propensity. On the contrary, the higher a firm's employment share of low-educated employees, the lower is the likelihood of offering apprenticeships. Firms with a high share of academics seem to be less inclined to apprentice training than firms with a low share of academics. Nevertheless, the strong positive effect for LHQUAL2 is a clear hint that apprentice training remains a relevant channel for human capital formation even if labour demand is shifting toward high-educated employees.

Innovation. Table 6 shows the results for each sector and for all seven alternatively used innovation indicators. We found only positive significant effects, but only for 4 estimates out of 14 estimates in manufacturing, for 1 out of 14 in the service sector and for 2 out of 14 in construction. Thus, when there is any statistically significant effect of innovation on training propensity, it is positive and is found primarily in manufacturing. Particularly the effect of R&D intensity in manufacturing firms appears to be robust.

Firm age. We found a positive effect for firm age (LAGE), an effect with particular importance for this study. Thus, younger firms seem to be less inclined to train apprentices than older ones. This effect was observed in the manufacturing as well as in the service sector but not in construction. For firms in the construction sector, which is the most apprentice-intensive sector of the Swiss economy, firm age is not a hindrance for employing apprentices that are cheap workers that can become productive in short time, at least in some occupations and whose training does not absorb much management resources.

Firm activity level. Rather unexpectedly, the variable for demand development shows no effect in the estimates for manufacturing and services (and a weak negative effect in one of the estimates for construction). Given the volatility of macroeconomic conditions in the reference period 1995-2004, this result could be interpreted as a hint that the training propensity is a kind of structural characteristic of a firm, thus independent of demand conditions.

Market conditions. The results for the variable CONC show some weak evidence for the free competition effect, contrary to hypothesis (a) of Gersbach and Schmutzler (2006), at least for some types of markets. In manufacturing and partially in the service sector this is the case for firms operating in markets with more than 50 competitors versus firms operating in markets with less than 5 competitors; in construction this effect is found for firms in markets with 11-15 competitors versus firms in markets with less than 5 competitors. Thus, to some extent firms operating in less concentrated markets are more likely to have apprentices than those in more concentrated markets. But the relationship between concentration and training propensity is not monotonically increasing: for example, in manufacturing no effect is found for firms operating in markets with 16-50, 11-15 or 6-10 competitors. Otherwise, competitive pressures as measured directly by the variables IPC and INPC do not seem to be of relevance for the likelihood of offering apprenticeships. On the whole, the market conditions in the product market do not appear to exercise a strong influence on the training propensity.

Costs. We found a significant negative coefficient for the cost variable LLCL for the manufacturing and the service sector but not for construction. Firms with high labour costs per employee seem to be less inclined to offer apprenticeships than firms with low labour costs (with the exception of the construction firms).

Physical capital. The general tendency is of a negative effect of the variable LC on training propensity. For manufacturing and construction this effect is not very robust. It is at strongest in the service sector. Thus, especially in the service sector firms having high capital intensity are less inclined to train apprentices than firms with low capital intensity.

Firm size. In manufacturing up to the threshold of 500 employees there is a clear positive relation between firm size and training propensity. For the coefficients for the four lower firm size classes we found based on two-tailed t-tests not presented here that the coefficient of a higher size class is significantly larger that that of a lower class. No difference is discernible among the three upper firm size classes (200-499 employees; 5000-999 employees; and 2000 and more employees). The same effect was found in the service sector only up to the threshold of 200 employees, in construction only up to 50 employees. Therefore, the size-dependence of the training propensity is limited up to a certain size class, which is at lowest in the construction sector.

Other control variables. As expected, firms in foreign ownership show a low propensity to offer apprenticeships than domestic ones.

5.2 Estimates of the equation of training intensity

5.2.1 Testing for selectivity bias

In a first step we tested for the existence of selectivity biases that could merge if the training intensity (as measured by the employment share of apprentices) would significantly correlate with the probability that apprentice training is undertaken. To this end, we estimated a Heckman selection model separately for each sector with a selection equation for TRP specified as in table 5 (but without the variable LLQUAL)[10] and an intensity equation for TRIN specified as in table 7. The additional identifying variable in the selection equation is the variable LC, which is

[10] We had to drop the variable LLQUAL form the intensity equation because of the strong multicollinearity to the other three qualification variables.

significant in the TRP equation but does not correlate significantly with TRIN. We found no evidence for a selectivity bias (see table A.2 in the appendix), so we estimated three models for the manufacturing and the service sector: (a) a pooled OLS model with time dummy variables; (b) a GLS model with random effects; and (c) a GLS model with fixed effects to take into consideration firm heterogeneity effects (see table 10). For the construction sector the fixed effects model was not econometrically feasible, so we estimated a pooled and a random effects model.

5.2.2 Determinants of training intensity

We present first the results for manufacturing, then we compare them with those for the other two sectors of the economy and also with those for training propensity in table 5.

Human resources. The results for manufacturing show that there is no significant relation between the training intensity and the firms' endowment with high-qualified (LHQUAL1; LHQUAL2). Given the decision to train apprentices, the number of apprentices (as a share of total employment) does not depend on the shares of the two upper employee categories.

Contrary to the findings for training propensity, we found a negative effect for the middle-educated employees (variable LMQUAL). This result could be interpreted as indicating a substitutive relationship between employees with completed vocational education and apprentices. The higher the share of employees with upper secondary-level education, the lower is the share of apprentices.

There is evidence for a negative effect of LHQUAL2, otherwise the pattern for the human resources variables in the service sector is the same as in manufacturing. Thus, for these two sectors there are considerable differences between the estimates for training propensity and training intensity with respect to the role of the two upper categories of qualified employees. This is not the case for construction, where the results for these two categories but also for the category of middle-educated were qualitatively similar to those in the propensity estimates.

Innovation. Table 8 shows the results for each sector for all seven alternatively used innovation indicators. We found positive significant effects only for 5 out of 21 estimates in manufacturing. The result for product innovation (variable INNOPD) appears to be particularly robust. For the other two sectors, the effect of the innovation variables on training intensity tends to be negative (9 estimates out of 21 in the service sector; 7 out of 14 estimates in construction). Thus, for the services and construction we found some evidence for negative effects of innovation on training intensity that are opposite to the (rather weak) evidence for positive effects on training propensity.

Firm age. Firm age is much less relevant for training intensity than for training propensity. We found positive effects in one of estimates for manufacturing and in an estimate for services.

Firm activity level. There is some weak evidence for a rather unexpected negative effect of the demand variable for the manufacturing and the service firms but not for the construction enterprises.

Market conditions. The effects of the variable CONC are weak also in the estimates for the training propensity. The effects of the variables for competitive pressures (IPC; INPC) are also in the estimates for training intensity very weak, if at all existing. However, both the (weak) negative effect of the variable IPC in the service sector and the more robust positive coefficient of the variable INPC in construction are in accordance with the theoretical expectations in Gersbach and Schmutzler (2006).

Costs. The cost variable shows the expected negative sign in the estimates for all three sectors.

Firm size. An intuitively expected outcome would be that the larger the firm the lower is the employment share of apprentices. This is the case in the manufacturing sector und in the service sector up to the threshold of 200 employees for the pooled and the random effects estimates. Above this threshold the differences between the coefficients of the dummy variables for the four upper size classes are not statistically significant. For construction we could not find a clear-cut relationship between firm size and training intensity.

Other control variables. The negative effect for firms in foreign ownership that we found for training propensity disappears in the estimates for the training intensity.

5.3 Estimates of the productivity equation

We estimated two versions of the productivity model (dependent variable: natural logarithm of value added per employee; LQL) separately for each sector: (a) with training propensity (TRP) as an additional right-hand variable also taking into account the endogenous character of training propensity; and b) with training intensity (TRIN) as an additional right-hand variable also taking into account the endogenous character of this variable. For the estimates we applied three econometric procedures (as implemented in STATA): (a) a pooled two-stage least-squares estimator; (b) a two-stage least-squares fixed effects estimator; and (c) a two-stage least-squares random effects estimator.

As instrument variable equations for TPR and TRIN were used the equations for TRP and TRIN as specified in table 5 and table 7 respectively. The variable LAGE that correlates significantly with TPR for the manufacturing and the service sector but not with LQL served as identifying variable in the estimates for these two sectors. The variable LHQUAL2 that correlates significantly with the variable TRP for the construction variable but not with LQL served as identifying variable in the estimates for the construction sector. Accordingly, the variable LAGE served as instrument for TRIN in the estimates for the manufacturing sector; the variable D in the estimates for the service sector; and the variable INPC in the estimates for the construction sector.

The results are presented in table 9 (variable TRP) and table 10 (variable TRIN). We obtained throughout the expected positive effects for the variable for physical capital LC. Also the coefficients of the variable for human capital HQUAL are throughout positive, even if not statistically significant in all estimates. The variable for knowledge capital LRDL shows a statistically significant effect primarily in the manufacturing sector. Foreign firms in the manufacturing sector appear to be more productive than domestic firms.

The main result for this study is related to the effect of the two training variables TRP and TRIN respectively. In most estimates in table 9 and table 10 we found a statistically significant negative effect of the training variables.[11] An explanation for this result could be that firms that have already achieved a high productivity level, presumably by applying more advanced technology and/or having a better organization, assign a significantly lower priority to the task of training apprentices than firms with a low productivity.

6. Comparison with the results of recent empirical studies

We refer here only to studies from Germany, Austria and Switzerland that deal explicitly with apprenticeship training. On the whole, a close comparison with other studies is not possible due to differences either in the composition of the data with respect to industry affiliation or in model specification.

Determinants of apprentice training

Wolter and Schweri (2002) in a study for Swiss firms found a negative effect of net costs of training and a positive effect of firm size on training intensity. Mühlemann et al. (2005) investigated also for Swiss firms the determinants of both training propensity and training intensity and found a positive firm size effect for both dependent variables and a negative effect for firms being foreign (a result we also found in our investigation). Finally, Mühlemann and Wolter (2006) found also in a study on the training propensity of Swiss firms a positive effect of the number of skilled workers (as we also found), a negative effect of firms being foreign, further negative effects for firms having difficulties to find skilled workers and firms with a high percentage of young people with ‘college degree’. A further finding was that the number of young people per firm correlated positive with the training propensity.

Franz et al. (2000) in a study with a cross-section of German firms for 1996 (separate estimates for manufacturing and services) found a positive effect for the employment share of ‘qualified workers’ (‘Fachkräfte’) (corresponding to our group of ‘middle-educated’ employees), but no significant effect for the number of employees with education at the level of ‘Fachhochschule’

[11] In further estimates not presented here we used an alternative variable for the average labour productivity based on the number of employees without the apprentices and/or a lag of one period for the training variables. The results of these estimates were quite similar to those presented in table 9 and table 10.

(we found a positive effect for the share of employees with tertiary-level education other than university) and no significant effect for innovation performance. Also the variables for sales expectations (partly corresponding to our variable D) and the variables for expected shortage for qualified workers showed no effect. Finally, there was a positive correlation between firm size and training propensity, as in our case.

The results for training intensity showed the same effects for the other categories of employees as the estimates for training propensity. The findings with respect to innovation performance are rather contradictory: a negative effect of innovation expenditures for manufacturing, a positive effect for process innovation in the service industries. Also the results for the variables of sales expectations were contradictory: in this case a negative effect of positive sales expectations for manufacturing and a negative effect of negative sales expectations in the service sector were found. Finally, there were throughout positive effects for the variables for shortage of qualified workers.

Beckman (2002a) in study on training propensity and training intensity with German firm data for 2000 found a positive effect for firms applying 'new technologies' and having high investment expenditure but a negative effect for the share of qualified workers. There was no clear-cut pattern with respect to firm size. Further, there were negative effects for the rate of quits, the rate of recruitments and the share of fix-duration workers. On the contrary, unionization and subsidization seemed to have a positive influence both on the training propensity and the training intensity. In a further study Beckmann (2002b) investigated the determinants of training intensity. He found that firms using the '*newest* technologies' (but not those using '*new* technologies') were stronger inclined than other firms to offer apprenticeships. Further findings were (a) a (partly) negative effect of capital intensity (investment expenditure per employee), (b) a (partly) positive effect of the share of 'qualified workers', both of them similar to our findings, and (c) a (partly) positive effect for firms that have invested in production techniques and or ICT. He also included in his estimation equation further factors that were not considered in our model (unionization, subsidization, recruitment rate, and share of fix-duration workers). Finally a variable measuring the difference between the firms' effective wage rate and the minimum union wage rate was included in the model. There was a (partly) negative effect of this variable.

In a further study that is based on German firm data for the year 2000 Niederalt (2004) found – besides the usual positive firm size effect – that the propensity to train apprentices is positively correlated (a) with a variable measuring the technological level of the production equipment; (b) the share (of the sum) of middle-qualified and high-qualified employees; and (c) expected shortage of high-qualified employees; and negatively correlated with (a) the investment expenditures per employees; (b) the share of newly recruited high-qualified employees; (c) the share of newly recruited low-qualified employees; and (d) positive expected employment development. Further, it appeared to be of no relevance for the training propensity whether a firm was newly-founded or not. Finally, firms in foreign ownership showed a lower training propensity than domestic ones. The estimated model contained also further factors that were not considered in our study (share of employees with fix-term contracts; regional unemployment rate; etc.). With respect to the training intensity the study showed a positive effect for middle-qualified and high-qualified employees and negative effects for the share of newly recruited high-qualified employees as well as for firm size. The technology variable and the variable for the expected employment development showed no significant effects.

Demgenski and Icks (2002) offered some evidence based on German firm data for a positive correlation between firm age and training propensity and training intensity respectively. The study is based on data on start-up companies in business services in Germany that was collected in 2001. The sample used contains not only "green-field" start-ups, but newly-founded firms in general that were not older than 11 years in 2001. The authors conducted regression analysis for explaining the firms' training propensity. They found a positive effect with respect to expected higher skill-requirements, but a negative effect of the share of employees with tertiary-level education. No effect could be found for the expected development of employment and for advanced vocational training. As in most studies, there was a positive effect of firm size. With respect to founder characteristics, the qualification level of a company's manager does not seem to be of relevance for the probability to train apprentices. A further finding of the study is that venture start-ups show a higher training propensity than company takeovers.

Stöger and Winter-Ebner (2001) investigated the determinants of training propensity and training intensity in Austrian firms for three points of time (1983, 1990, and 1998). They found a positive effect for firm age and also for firm size both with respect to training propensity and training intensity. They included in their training equations also variables related to the age and gender structure of the employees.

Smits and Zwick (2004) in a study comparing German and Dutch firms analyzed the reasons of firms for not offering apprenticeships. These were (a) the preference of hiring experienced skilled employees, (b) the assessment that existing professions in the dual apprenticeship system are not compatible with the qualifications required, and (c) the assessment that training contents are outdated due to technological progress. Apprenticeships being too expensive or apprentices being too often absent form work due to school obligations were not reasons for not offering apprenticeships.

In sum, there are only few findings that can be considered as robust across the existing empirical studies. The most robust ones refer to the effects of firm size on training propensity (throughout positive) and training intensity (throughout negative) respectively.

Impact of apprentice training on economic performance

There are very few empirical studies that deal with this question.[12] Fougère and Schwerdt (2002) investigated the contribution of the number of apprentices to output value in production function framework based on data for German and French data in 1992/93. They estimated the production functions separately for three firm size classes (less than 20 employees; between 20 and 200 employees; more than 200 employees). Moreover, they estimated quartile regressions for every firm size class. They could not find a statistically significant contribution of the number of apprentices for 'small' and for 'large' firms for both countries when using the entire sample. For the 'middle-sized firms they found a negative effect for the German firms (as we also found for the Swiss firms) and once more an insignificant effect for the French firms. The regressions based on French data for the 1st, 2nd and 3rd quartile respectively showed positive effects, for the 4th one an insignificant effect. The respective regressions for the German firms showed a negative effect for the 1st quartile, a positive effect for the 4th quartile and insignificant effects for the 2nd and 3rd quartile respectively. On the whole, the contributions of apprentices to productivity are rather weak for both countries.

Zwick (2007) in a paper with German firm data studied the influence of the share of apprentice in German firms on the firm profits per employee and found no significant effect. In a new study, Mohrenweiser and Zwick (2008) showed that a negative effect of the share of apprentices n firms' profits can be found only in manufacturing occupations but not in trade, commercial, craft and construction occupations, for which this effect is positive.

7. Summary and conclusions

This study investigated the determinants (a) of the propensity of Swiss firms to train apprentices and (b) of the intensity of apprentice training as measured by the employment share of apprentices. Human resources, innovation activities, firm age, competition conditions on the product market, and firm size are possible determining factors that were especially emphasized in this investigation. In a further step, we analyzed the impact of apprentice training on labour productivity when apprentice training is considered as an additional production factor in the framework of a production function.

The detailed results can be summarized as follows:

Resource endowment. For training propensity we found in all three sectors a similar pattern: (a) positive effects for the share of employees with tertiary-level education (other than university); for the share of middle-educated employees (exception: no significant effect in the construction sector); and (b) negative effects for the highest (academics) (no significant effect for services) and the lowest educational category (no vocational education completed).

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[12] For productivity effects of firm-sponsored training in general (not specifically apprentice training) see, e.g., Dearden et al. (2006).

With respect to training intensity, the effect for the middle-educated employees becomes negative in the manufacturing and in the service sector, but remains positive for construction. The effects for the two categories of high-educated employees become (in the main tendency) insignificant in the manufacturing and the service sector; they remain the same as for training propensity in construction.

The physical capital intensity is negatively correlated with the training propensity (at strongest in the service sector).

Innovation. The differences between the sectors with respect to training propensity are small. When there is any statistically significant effect, it is positive and is found primarily in manufacturing. Particularly the effect of R&D intensity in manufacturing firms appears to be robust. For the training intensity we found positive significant effects only in some estimates for manufacturing. For the other two sectors the effect of innovation on training tends to be negative.

Firm activity level. Rather unexpectedly, with respect to the training propensity the variable for demand development shows either no effect (as in the estimates for manufacturing and services) or a weak negative effect (as in one of the estimates for construction). Also with respect to the training intensity is the demand variable either of no relevance or shows a weak negative effect. Given the volatility of macroeconomic conditions in the reference period 1995-2004, at least the result for the training propensity could be interpreted as a hint that the training propensity is a kind of structural characteristics of a firm, thus independent of demand conditions.

Market structure, competitive pressures. There is some weak evidence for the free competition effect with respect to training propensity at least for some types of markets. On the whole, the market conditions in the product market do not appear to exercise a discernible influence on the training propensity. This appears to be the case also with respect to the training intensity.

The *labour costs* per employee seem to be negatively correlated with the training propensity (with the exception of the construction sector for which no significant effect could be found) as well as with the training intensity.

Firm age and *firm size*. Younger firms seem to be less inclined to train apprentices than older ones. This effect was observed for training propensity in the manufacturing as well as in the service sector but not in construction. A weak positive effect could be found also for training intensity but it isn’t so robust. Firm size is positively correlated with training propensity and negatively correlated with training intensity.

Productivity effects. We found throughout a negative effect for training propensity as well as for training intensity. An explanation for this result could be that firms that have already achieved a high productivity level, presumably by applying more advanced technology and/or having a better organization, assign a significantly lower priority to the task of training apprentices than firms with a low productivity.

As a first important point of an overall assessment of the findings of the study, the strong positive effect for the share of employees with tertiary-level education (without academics) together with the even stronger positive effect for the share of the middle-educated employees for the manufacturing and the service sector on the training propensity can be interpreted as a clear hint that apprentice training remains a relevant channel for human capital formation even if labour demand is shifting toward higher educated employees. However, with respect to training intensity we found a negative relationship between the share of middle-educated employees and the share of apprentices for the service sector. This finding shows that even if firms with a high human capital endowment are stronger inclined to train apprentices than firms with a low human capital endowment, they also tend to train relatively less apprentices than the firms with low endowment that decided to offer training.

Further, this is a second important point, firms with a high capital intensity and high productivity are less inclined to train apprentices. Given high-productivity firms have decided to train apprentices, they tend to hire relatively less apprentices than firms with low productivity. There is some (rather weak) evidence for a positive effect of innovation activities both on the training propensity and the training intensity in manufacturing. But the service sector and the construction sector show either no effect (training propensity) or a negative effect (training intensity). Finally, a third important point is that younger firms seem to have a lower training propensity than older firms.

If the Swiss enterprise-based system of vocational education should keep its position as the most prominent channel of generating (basic) vocational knowledge, it is necessary that it is (or remains) strongly established in the high-productivity and high-growth part of the economy that also shows a high entry rate of new innovative firms. Thus, the three abovementioned points could be a relevant starting point for a policy discussion that goes beyond the aim of this paper.

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Table 1: Propensity of training and training intensity of Swiss enterprises 1995-2004 by sector and industry

Industry / sector	Percentage of enterprises having apprentices	Average employment share of apprentices (reference: enterprises with apprentices)
Food, beverage, tobacco	59.8	4.0
Textiles	58.2	4.5
Clothing, leather	50.0	4.8
Wood processing	76.0	12.0
Paper	71.4	4.4
Printing	81.0	8.8
Chemicals	58.0	6.2
Plastics, rubber	56.4	4.9
Glass, stone, clay	54.6	4.1
Metal	70.3	5.9
Metalworking	64.1	8.1
Machinery	71.1	8.6
Electrical machinery	72.5	6.9
Electronics, instruments	61.3	6.1
Watches	45.5	5.8
Vehicles	71.0	9.3
Other manufacturing	63.8	8.5
Energy	78.8	8.1
Manufacturing	66.8	7.2
- High-tech manufacturing	65.8	7.3
- Low-tech manufacturing	65.0	7.1
Construction	78.9	10.6
Wholesale trade	65.5	10.4
Retail trade	73.7	14.3
Hotels, catering	63.7	9.9
Transport, telecommunication	48.9	6.3
Banks, insurance	69.7	8.2
Real estate, leasing	50.8	6.6
Computer services	38.7	5.9
Business services	66.8	11.5
Personal services	46.6	19.1
Dienstleistungen	63.8	11.0
- Moderne DL	63.3	9.8
- Trad. DL	62.9	11.0
Total	65.6	8.9
N	9306	6110

High-tech manufacturing: chemicals, plastics, machinery, electrical machinery, electronics/ instruments, vehicles; low-tech industry: food/beverage/tobacoo, textiles, clothing/leather, paper, printing, glass/stone/clay, metal, metalworking, watches, other manufacturing, energy; knowledge-intensive services: banks/insurance, computer services, business services; traditional services: whole and retail trade, transportation/telecommunication; hotels/ catering, real estate/leasing, personal services.

Table 2: Propensity to training and training intensity of Swiss enterprises 1995-2004 by firm size

Firm size	Percentage of enterprises having apprentices	Average employment share of apprentices (reference: enterprises with apprentices)
5-19 employees	42.6	18.5
20-49 employees	60.1	10.1
50-99 employees	69.6	6.7
100-199 employees	83.5	5.4
200-499 employees	89.2	4.8
500-999 employees	92.0	5.5
> 1000 employees	94.0	4.9
Total	65.6	8.9
N	9306	6110

Table 3: Propensity to training and training intensity of Swiss enterprises 1995-2004 by firm age

Firm age	N	Percentage of enterprises having apprentices	Average employment share of apprentices (reference: enterprises with apprentices)
0-5 years	553	62.4	7.9
6-10 years	473	46.3	10.4
11-20 years	1062	48.2	11.4
> 20 years	7218	69.7	8.6
Total	9306	65.7	8.9

Table 4: Definition and measurement of model variables

Variable	Definition/measurement
Dependent variables	
TRP	Having at least one apprentice yes/no (training propensity)
TRIN	Employment share of apprentices; only firms having apprentices (training intensity)
LQL	Natural logarithm of value added per employee (number of employees measured in full-time equivalents)
Independent variables	
Training propensity/intensity model	
LLCL	Labour costs per employee
LHQUAL1	Natural logarithm of the share of employees with university degree (academics)
LHQUAL2	Natural logarithm of the share of employees with tertiary-level education (other than university education)
LMQUAL	Natural logarithm of the share of employees with a formal degree in vocational education ('middle' education; 'Berufslehre')
LLQUAL	Natural logarithm of the share of employees with vocational education a formal degree ('Anlehre') or without any vocational education ('low' education)
LC	Natural logarithm capital income per employee (capital income = value added minus labour costs)
LRDS	Natural logarithm of R&D expenditures divided by sales
LNEWS	Natural logarithm of sales share of *new* products
LIMPS	Natural logarithm of sales share of (already existing) considerably modified products
INNOPC	Introduction of process innovations yes/no
R&D	R&D activities yes/no
LAGE	Natural logarithm of firm age (number of years since foundation: year of survey minus founding year of the firm)
FOREIGN	Foreign firm yes/no
D	Mean of two five-level ordinal variables (level 1: ‘strong decrease’; 5; ‘strong increase’), the first one referring to the development of a firm’s specific product demand in the last three years, the second one in the next three years (reference year: survey year); transformation of this mean to a binary variable (value 1: values 4 to 5 of the original five-level variable; value 0: values 1 to 3 of the original variable)
IPC	Intensity of price competition; transformation of a five-level ordinal variable (level 1: 'very weak'; level 5: 'very strong') to a binary variable (value 1: levels 4 and 5 of the original five-level variable; value 0: levels 1, 2 and 3 of the original variable)
INPC	Intensity of non-price competition; original and transformed variables as for IPC
CONC	Dummies for four different market types: more than 50 competitors on the (worldwide) product market; 16 to 50 competitors; 11 to 15 competitors; 6 to 10 competitors; (reference group: up to 5 competitors)
Controls	
Firm size	Dummies for six firm size classes: 20 to 49 employees; 50 to 99 employees; 100-199 employees; 200 to 499 employees; 500 to 999 employees, 1000 and more employees (reference group: 5-19 employees)
Industry	Manufacturing: dummies for 17 2-digit industries (reference industry: food, beverage, tobacco; services: dummies for 8 2-digit industries (reference industry: retail trade)
Year	Three dummies for the three reference years for the quantitative variables (1998, 2001, 2004); reference year: 1995
Productivity model	
LRDL	Natural logarithm of R&D expenditures per employee

The ordinal variables refer to the 3-year periods 1994-1996, 1997-1999, 2000-2002 and 2003-2005 respectively; the quantitative variables refer to the years 1995, 1998, 2001 and 2004 respectively.

Table 5: Training propensity TRP by sector; pooled probit and probit random effects estimates 1995-2004

Explanatory variables	Manu-facturing		Services		Construction	
	TRP pooled probit	TRP random effect probit	TRP pooled probit	TRP random effect probit	TRP pooled probit	TRP random effect probit
Internal factors						
LLCL	-0.420***	-0.512***	-0.425***	-0.730***	-0.407	-0.482
	(0.090)	(0.178)	(0.101)	(0.219)	(0.265)	(0.424)
LHQUAL1	-0.131***	-0.162***	-0.028	-0.038	-0.302***	-0.358***
	(0.026)	(0.059)	(0.029)	(0.070)	(0.111)	(0.193)
LHQUAL2	0.058**	0.127**	0.091***	0.204***	0.297***	0.430***
	(0.024)	(0.051)	(0.028)	(0.063)	(0.067)	(0.131)
LMQUAL	0.201***	0.366***	0.147***	0.306***	0.107	0.144
	(0.041)	(0.089)	(0.038)	(0.086)	(0.108)	(0.194)
LLQUAL	-0.172***	-0.285***	-0.142***	-0.221***	-0.204***	-0.320**
	(0.026)	(0.054)	(0.026)	(0.058)	(0.061)	(0.129)
LC	-0.043*	-0.068	-0.094***	-0.172**	-0.056***	-0.072
	(0.023)	(0.049)	(0.035)	(0.072)	(0.074)	(0.139)
LIMPS	0.018*	0.009	0.017	0.028	0.051	0.083
	(0.009)	(0.019)	(0.015)	(0.031)	(0.048)	(0.082)
LAGE	0.192***	0.362***	0.234***	0.480***	0.043	0.006
	(0.029)	(0.065)	(0.037)	(0.090)	(0.084)	(0.156)
FOREIGN	-0.307***	-0.602**	-0.591***	-1.275***	-1.410***	-2.382***
	(0.068)	(0.167)	(0.093)	(0.255)	(0.327)	(0.712)
External factors						
D	-0.049	0.042	-0.020	-0.078	-0.395*	-0.231
	(0.057)	(0.111)	(0.079)	(0.166)	(0.238)	(0.418)
IPC	-0.006	-0.054	0.105	0.115	-0.024	-0.039
	(0.053)	(0.106)	(0.065)	(0.139)	(0.178)	(0.303)
INPC	0.013	0.021	-0.050	-0.134	0.036	0.016
	(0.048)	(0.094)	(0.066)	(0.137)	(0.167)	(0.297)
CONC						
> 50 main competitors	0.231***	0.389***	0.134*	0.206	0.146	0.416
	(0.069)	(0.145)	(0.081)	(0.177)	(0.210)	(0.387)
16-50 main competitors	0.111	0.174	-0.098	-0.199	0.108	0.404
	(0.077)	(0.156)	(0.105)	(0.225)	(0.244)	(0.430)
11-15 main competitirs	-0.083	-0.241	0.324	0.271	1.099***	1.393**
	(0.098)	(0.194)	(0.226)	(0.449)	(0.364)	(0.705)
6-10 main competitors	0.089	0.101	0.088	0.225	0.299	0.352
	(0.062)	(0.124)	(0.088)	(0.194)	(0.244)	(0.395)
Year						
1998	0.203***		0.160***		0.041	
	(0.068)		(0.124)		(0.213)	
2000	0.285***		0.174		0.045	
	(0.068)		(0.115)		(0.217)	
2004	0.209***		0.042		0.402*	
	(0.069)		(0.114)		(0.219)	
Controls						
Firm size						
20-49 employees	0.578***	1.260***	0.598***	1.329***	0.645***	1.025***
	(0.066)	(0.174)	(0.080)	(0.219)	(0.177)	(0.401)
50-99 employees	1.154***	2.452***	0.841***	1.866***	1.727***	2.997***

	(0.073)	(0.214)	(0.101)	(0.279)	(0.233)	(0.722)
100-199 employees	1.690***	3.581***	1.267***	2.705***	1.675***	2.909***
	(0.085)	(0.261)	(0.119)	(0.349)	(0.264)	(0.713)
200-499 employees	2.307***	4.815***	1.390***	3.042***	2.133***	3.698***
	(0.111)	(0.349)	(0.149)	(0.409)	(0.433)	(0.967)
500-999employees	2.428***	5.159***	1.695***	3.911***	1.395***	2.387***
	(0.192)	(0.514)	(0.230)	(0.698)	(0.511)	(1.043)
1000 and more employees	2.555***	4.878***	1.949***	4.270***		
	(0.258)	(0.559)	(0.263)	(0.723)		
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	4180	4180	2210	2210	617	617
Pseudo R2	0.260		0.216		0.312	
Wald chi2	1014***	300***	502***	120***	166***	38*
Rho		0.800***		0.812***		0.704

Notes: see table 4 for the variable definitions; ***, **, * denote statistical significance at the 1%, 5% and 10% test level respectively; manufacturing: 17 industry dummies; heteroscedasticity-robust standard errors (White procedure).

Table 6: Training propensity TRP by sector; alternative innovation variables; pooled probit and probit random effects estimates 1995-2004

Innovation variables	Manu-facturing		Services		Construction	
	TRP Pooled probit	TRP Random effects probit	TRP Pooled probit	TRP Random effects probit	TRP Pooled probit	TRP Random effects probit
INNOPD	0.031 (0.053)	-0.162 (0.109)	-0.002 (0.056)	-0.030 (0.110)	0.145 (0.148)	0.218 (0.275)
INNOPC	-0.046 (0.048)	-0.192 (0.120)	0.128** (0.057)	0.133 (0.110)	0.001 (0.150)	-0.169 (0.268)
R&D	0.062 (0.053)	-0.031 (0.109)	0.023 (0.065)	-0.043 (0.125)	-0.033 (0.179)	-0.358 (0.335)
PAT	0.122* (0.064)	0.054 (0.134)	-0.141 (0.133)	-0.170 (0.278)	-0.056 (0.338)	-0.439 (0.512)
LRDS	0.017** (0.008)	0.026* (0.016)	-0.001 (0.010)	-0.004 (0.020)	0.005 (0.033)	-0.015 (0.058)
LNEWS	0.007 (0.010)	0.002 (0.020)	0.018 (0.016)	0.038 (0.032)	0.102* (0.055)	0.174* (0.096)
LIMPS	0.017* (0.009)	0.009 (0.019)	0.017 (0.015)	0.028 (0.031)	0.051 (0.048)	0.083 (0.082)

Notes: see table 4 for the variable definitions; ***, **, * denote statistical significance at the 1%, 5% and 10% test level respectively; this table contains only the coefficients and the standard errors of the innovation variables.

Table 7: Training intensity TRIN by sector; pooled OLS; GLS fixed and random effects estimates 1995-2004

Explanatory variables	Manu Facturing			Services			Construction	
	TRIN Pooled OLS	TRIN random effects GLS	TRIN fixed effects GLS	TRIN Pooled OLS	TRIN random effects GLS	TRIN fixed effects GLS	TRIN pooled OLS	TRIN random effects GLS
Internal factors								
LLCL	-0.022***	-0.011***	0.005	-0.041***	-0.028***	-0.012	-0.044***	-0.029***
	(0.005)	(0.004)	(0.005)	(0.006)	(0.059)	(0.010)	(0.015)	(0.010)
LHQUAL1	0.001	-0.001	0.001	-0.003	-0.002	-0.001	-0.014**	-0.010*
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.004)	(0.006)	(0.005)
LHQUAL2	-0.001	-0.001	-0.001	0.000	-0.003*	-0.011***	0.008*	0.008**
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.005)	(0.004)
LMQUAL	0.000	-0.005***	-0.009***	-0.009**	-0.011***	-0.024***	0.018***	0.006
	(0.004)	(0.002)	(0.002)	(0.004)	(0.003)	(0.006)	(0.006)	(0.005)
LIMPS	7.9E-04*	5.1E-04	2.1E-04	-0.002**	-8.0E-04	6.1E-04	-0.001	1.0E-05
	(4.6E-04)	(3.8E-04)	(4.7E-04)	(0.001)	(8.0E-04)	(1.2E-03)	(0.002)	(1.8E-03)
LAGE	0.003**	0.002	-0.001	-0.002	0.000	0.011*	-0.008	-0.004
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.006)	(0.005)	(0.004)
FOREIGN	-0.004*	-0.003	0.003	-0.006	-0.005	-0.008	0.004	0.001
	(0.002)	(0.003)	(0.005)	(0.006)	(0.007)	(0.018)	(0.023)	(0.023)
External factors								
D	-0.002	-0.004*	-0.002	-0.012***	-0.005	0.005	0.017	0.013
	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.006)	(0.014)	(0.010)
IPC	-0.003	-0.002	-0.002	-0.008*	-0.004	0.002	0.005	0.008
	(0.003)	(0.002)	(0.003)	(0.004)	(0.003)	(0.006)	(0.009)	(0.007)
INPC	0.001	0.000	-0.001	0.005	0.004	0.002	0.022**	0.018**
	(0.002)	(0.002)	(0.002)	(0.004)	(0.003)	(0.005)	(0.010)	(0.007)
CONC								
> 50 main competitors	0.006*	0.002	0.001	0.007	0.009*	0.013*	0.000	0.007
	(0.003)	(0.003)	(0.004)	(0.005)	(0.005)	(0.008)	(0.014)	(0.010)
16-50 main competitors	0.001	0.002	0.003	0.000	0.004	0.009	-0.015	0.000
	(0.003)	(0.003)	(0.004)	(0.006)	(0.006)	(0.009)	(0.014)	(0.011)
11-15 main competitirs	0.004	0.000	-0.005	-0.008	0.002	0.020	-0.013	0.015
	(0.005)	(0.004)	,(0.004)	(0.014)	(0.011)	(0.014)	(0.021)	(0.014)

6-10 main competitors	-0.001	-0.003	-0.004	-0.005	-0.002	0.005	0.005	0.022**
	(0.003)	(0.002)	(0.003)	(0.005)	(0.005)	(0.007)	(0.015)	(0.011)
Year								
1998	0.007**			0.014			0.005	
	(0.003)			(0.009			(0.013)	
2000	0.005			0.007			0.005	
	(0.003)			(0.008)			(0.014)	
2004	0.008***			0.012			0.003	
	(0.003)			(0.008)			(0.013)	
Controls								
Firm size:								
20-49 employees	-0.081***	-0.066***	-0.024***	-0.074***	-0.070***	-0.047***	-0.078***	-0.070***
	(0.006)	(0.004)	(0.008)	(0.007)	(0.006)	(0.013)	(0.013)	(0.010)
50-99 employees	-0.103***	-0.091***	-0.042***	-0.099***	-0.100***	-0.074***	-0.110***	-0.096***
	(0.006)	(0.004)	(0.010)	(0.007)	(0.007)	(0.017)	(0.013)	(0.012)
100-199 employees	-0.110***	-0.099***	-0.048***	-0.116***	-0.113***	-0.076***	-0.091***	-0.093***
	(0.006)	(0.004)	(0.011)	(0.007)	(0.007)	(0.022)	(0.015)	(0.012)
200-499 employees	-0.109***	-0.100***	-0.051***	-0.119***	-0.122***	-0.117***	-0.118***	-0.107***
	(0.006)	(0.005)	(0.012)	(0.007)	(0.008)	(0.032)	(0.014)	(0.014)
500-999employees	-0.102***	-0.096***	-0.051***	-0.110***	-0.111***	-0.098**	-0.081***	-0.097***
	(0.007)	(0.006)	(0.014)	(0.009)	(0.011)	(0.039)	(0.021)	(0.028)
1000 and more employees	-0.107***	-0.095***	-0.042**	-0.117***	-0.118***	-0.101*	-0.100***	-0.101***
	(0.007)	(0.008)	(0.003)	(0.008)	(0.011)	(0.056)	(0.027)	(0.028)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2879	2789	2789	1529	1529	1529	539	539
R^2adj.	0.368	0.357		0.403			0.362	
F	30***		2***	23***		2***	11***	
SER	0.055			0.075			0.077	
R^2overall		0.357	0.076		0.359	0.242		0.327
Wald Chi2		899***			751***			177***
Rho		0.709	0.825		0.646	0.769		0.716

Notes: see table 4 for the variable definitions; ***, **, * denote statistical significance at the 1%, 5% and 10% test level respectively; heteroscedasticity-robust standard errors (White procedure); rho: share of variance that can be traced back to heterogeneity.

Table 8: Training intensity TRIN by sector; alternative innovation variables; pooled OLS; GLS fixed and random effects estimates 1995-2004

Innovation variables	Manu-facturing			Services			Constructi on	
	TRIN Pooled probit	TRIN Random effects probit	TRIN Fixed effects probit	TRIN Pooled probit	TRIN Random effects probit	TRIN Fixed effects probit	TRIN Pooled probit	TRIN Random effects probit
INNOPD	4.7E-03* (2.7E-03)	6.0E-03*** (2.0E-03)	5.8E-03** (2.9E-03)	-8.1E-03*** (3.2E-03)	-3.7E-03 (3.1E-03)	3.8E-03 (4.1E-3)	-1.1E-02* (0.6E-02)	-1.4E-02** (0.6E-02)
INNOPC	4.3E-03* (2.2E-03)	2.1E-04 (1.8E-04)	-2.5E-03 (2.5E-03)	-9.4E-03*** (3.2E-03)	-6.9E-03** (3.0E-03)	-4.4E-03 (3.9E-03)	-3.4E-03 (6.1E-03)	-1.0E-02** (0.5E-03)
R&D	7.8E-04 (2.7E-03)	1.4E04 (2.2E-03)	4.3E-04 (2.9E-03)	-9.7E-03*** (3.3E-03)	-6.6E-03** (3.4E-03)	-3.4E-03 (4.5E-03)	-1.3E-02* (0.7E-02)	-1.3E-02** (0.6E-02)
PAT	1.7E-03 (2.2E-03)	2.0E-03 (2.0E-03)	2.5E-03 (2.9E-03)	-1.5E-02*** (0.6E-02)	-9.0E-03 (7.9E-03)	3.0E-04 (1.0E-02)	-6.0E-03 (1.7E-02)	1.1E-02 (1.4E-02)
LRDS	4.8E-04 (4.3E-04)	1.8E-04 (3.1E-04)	3.1E-04 (4.1E-04)	-1.7E-03*** (0.5E-03)	-1.0E-03* (0.5E-03)	-1.8E-04 (7.3E-04)	-2.0E-03* (1.2E-03)	-2.0E-03* (1.2E-03)
LNEWS	5.3E-04 (4.9E-04)	4.7E-04 (4.1E-04)	4.1E-04 (5.0E-04)	-1.4E-03 (0.9E-03)	-3.1E-04 (8.2E-04)	1.9E-03 (1.2E-03)	1.8E-03 (2.1E-03)	1.0E-03 (1.8-E03)
LIMPS	7.9E-04* (4.6E-04)	5.1E-04 (3.8E-04)	2.1E-04 (4.7E-04)	-1.6E-03** (0.8E-03)	-8.0E-04 (8.0E-04)	6.1E-04 (1.2E-03)	-1.1E-03 (1.8E-03)	1.4E-03 (1.8E-03)

Notes: see table 4 for the variable definitions; ***, **, * denote statistical significance at the 1%, 5% and 10% test level respectively; this table contains only the coefficient+s and the standard errors of the innovation variables.

Table 9: Estimates of productivity equation by sector 1995-2004; TRP

Explanatory variables	Manu-facturing			Services			Construction		
	IV (2SLS) regression	LQL G2SLS random effects IV regression	LQL G2SLS fixed effects IV regression	IV (2SLS) regression	LQL G2SLS random effects IV regression	LQL G2SLS fixed effects IV regression	IV (2SLS) regression	LQL G2SLS random effects IV regression	LQL G2SLS fixed effects IV regression
LC	0.243***	0.257***	0.324***	0.423***	0.423***	0.392***	0.276***	0.262***	0.224***
	(0.080)	(0.005)	(0.062)	(0.012)	(0.007)	(0.021)	(0.015)	(0.012)	(0.018)
LHQUAL	0.025***	0.029***	0.008	0.028***	0.029***	0.023	0.028*	0.036***	0.037
	(0.006)	(0.005)	(0.008)	(0.006)	(0.005)	(0.023)	(0.014)	(0.013)	(0.024)
LRDL	0.020***	0.015***	0.003	0.009*	0.009*	-0.002	0.015	0.029*	0.026
	(0.006)	(0.003)	(0.003)	(0.005)	(0.005)	(0.017)	(0.016)	(0.015)	(0.023)
TRP	-0.445***	-0.399***	0.048	-0.426***	-0.424***	-1.291***	-0.454***	-0.535***	0.104
	(0.050)	(0.073)	(0.163)	(0.049)	(0.049)	(0.497)	(0.092)	(0.110)	(0.151)
FOREIGN	0.037*	0.042***	0.027	-0.026	-0.026	0.052	-0.092	-0.112	-0.130
	(0.020)	(0.017)	(0.023)	(0.023)	(0.022)	(0.126)	(0.059)	(0.071)	(0.128)
Controls									
Time dummies	yes			Yes			Yes		
Firm size dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3918	3918	3918	2198	2198	2198	622	622	622
R^2adj	0.401			0.677			0.433		
F	56***			147***			31***		
SER	0.315			0.294			0.260		
R^2 overall		0.460	0.438		0.692	0.303		0.425	0.348
Wald chi2		3694***	2.04E+07***		5339***	2.09E+06***		522***	2.49E06***
Rho		0.682	0.811		-	0.739		0.433	0.687

Notes: see table 4 for the variable definitions; ***, **, * denote statistical significance at the 1%, 5% and 10% test level respectively; heteroscedasticity-robust standard errors (White procedure); rho: share of variance that can be traced back to heterogeneity.

Table 10: Estimates of productivity equation by sector 1995-2004; TRIN

Explanatory variables	Manu-facturing			Services			Construction		
	IV (2SLS) regression	LQL G2SLS random effects IV regression	LQL G2SLS fixed effects IV regression	IV (2SLS) regression	LQL G2SLS random effects IV regression	LQL G2SLS fixed effects IV regression	IV (2SLS) regression	LQL G2SLS random effects IV regression	LQL G2SLS fixed effects IV regression
LC	0.193***	0.266***	0.319***	0.413***	0.428***	0.438***	0.261***	0.249***	0.217***
	(0.060)	(0.005)	(0.009)	(0.023)	(0.012)	(0.013)	(0.019)	(0.016)	(0.020)
LHQUAL	0.015	0.032***	0.008	0.015	0.004	-0.008	0.034	0.057***	0.049*
	(0.023)	(0.006)	(0.011)	(0.019)	(0.012)	(0.014)	(0.023)	(0.020)	(0.029)
LRDL	0.029**	0.011***	0.003	-0.014	-0.005	0.001	-0.002	0.006	0.029
	(0.013)	(0.003)	(0.005)	(0.010)	(0.008)	(0.009)	(0.017)	(0.020)	(0.023)
TRIN	-15.385***	-1.351*	4.194***	-8.360***	-5.697***	-1.768***	-3.657***	-4.292**	-0.951
	(3.162)	(0.758)	(1.046)	(1.207)	(0.740	(0.665)	(0.637)	(0.638)	(0.977)
FOREIGN	-0.015	0.054***	-0.001	-0.047	0.002	-0.029	0.002	-0.029	-0.081
	(0.042)	(0.019)	(0.037)	(0.048)	(0.050)	(0.079)	(0.074)	(0.106)	(0.184)
Controls									
Time dummies	Yes			Yes			Yes		
Firm size dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2598	2598	2598	1407	1407	1407	492	492	492
R^2adj	-			-			0.108		
F	7***			34***			21***		
SER	0.855			0.646			0.310		
R^2 overall		0.526	0.195		0.468	0.553		0.321	0.438
Wald chi2		626***	9.09E+06***		1585***	62E+06***		295***	2.09E+06***
Rho		0.928	0.862		0.890	0.791		0.597	0.636

Notes: see table 4 for the variable definitions; ***, **, * denote statistical significance at the 1%, 5% and 10% test level respectively; heteroscedasticity-robust standard errors (White procedure); rho: share of variance that can be traced back to heterogeneity.

APPENDIX:

Table A.1: Composition of data set used by industry, firm size and region

Industry / sector	N	Percentage of firms
Food, beverage, tobacco	363	3.9
Textiles	141	1.5
Clothing, leather	66	0.7
Wood processing	204	2.2
Paper	112	1.2
Printing	289	3.1
Chemicals	295	3.2
Plastics, rubber	225	2.4
Glass, stone, clay	205	2.2
Metal	111	1.2
Metalworking	668	7.2
Machinery	760	8.2
Electrical machinery	218	2.3
Electronics, instruments	473	5.1
Watches	167	1.8
Vehicles	93	1.0
Other manufacturing	199	2.1
Energy	132	1.4
Construction	925	9.9
Wholesale trade	796	8.6
Retail trade	590	6.3
Hotels, catering	377	4.1
Transport, telecommunication	477	5.1
Banks, insurance	406	4.4
Real estate, leasing	65	0.7
Computer services	199	2.1
Business services	659	7.1
Personal services	91	1.0
Firm size (number of employees)		
5-19 employees	2593	27.8
20.49 employees	2164	23.3
50-99 employees	1510	16.2
100-199 employees	1391	15.0
200-499 employees	1016	10.9
500-999 employees	348	3.7
>= 1000 employees	284	3.1
Year		
1996	1993	21.4
1999	2172	23.3
2002	2586	27.8
2005	2555	27.5
Total	9306	100

Table A.2: Results of probit model with sample selection (STATA procedure heckprob)

	Manu-facturing	Services	Construction
Rho	0.015	-0.027	-0.043
Std. Err.	(0.046)	(0.099)	(0.155)
LR test of indep. eqns. (rho = 0)			
Chi2	0.11	0.07	0.07
Prob > chi2	0.739	0.789	0.785

Table A.3: Descriptive statistics of model variables; by sector

Variable	Manu-facturing		Services		Construction	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
TRP	0.653	0.476	0.628	0.483	0.786	0.410
TRIN	0.072	0.071	0.106	0.097	0.106	0.092
LQL	11.810	0.412	11.913	0.537	11.645	0.368
LLCL	11.237	0.297	11.218	0.402	11.200	0.306
LHQUAL	-2.258	1.094	-2.247	1.401	-2.454	1.041
LHQUAL1	-3.834	1.033	-3.645	1.347	-4.296	0.672
LHQUAL2	-2.523	1.086	-2.602	1.318	-2.565	1.034
LMQUAL	-0.998	0.769	-0.969	0.982	-0.931	0.772
LLQUAL	-1.1598	1.290	-2.480	1.608	-1.827	1.472
LC	10.827	1.017	11.021	0.981	10.407	0.942
LRDS	-7.398	3.734	-9.915	3.011	-10.595	2.177
LRDL	2.020	2.108	0.732	1.617	0.289	0.907
LNEWS	0.741	2.514	-0.947	2.183	-1.672	1.591
LIMPS	0.730	2.627	-0.936	2.270	-1.646	1.669
INNOPD	0.654	0.476	0.420	0.494	0.240	0.427
INNOPC	0.556	0.497	0.394	0.489	0.275	0.447
R&D	0.597	0.490	0.270	0.444	0.179	0.384
PAT	0.265	0.441	0.042	0.198	0.047	0.212
LAGE	3.747	0.879	3.531	0.965	3.748	0.842
AGE (5-9 yeras)	0.039	0.195	0.070	0.255	0.034	0.180
AGE (10-19 years)	0.093	0.290	0.150	0.357	0.081	0.273
AGE (20 years and more)	0.813	0.390	0.712	0.453	0.834	0.373
FOREIGN	0.141	0.348	0.132	0.339	0.045	0.207
D	0.237	0.425	0.245	0.430	0.097	0.296
IPC	0.736	0.441	0.661	0.473	0.777	0.416
INPC	0.403	0.491	0.395	0.489	0.213	0.410
CONC (16-50 competitors	0.223	0.416	0.354	0.478	0.402	0.491
CONC (11-15 competitors)	0.136	0.343	0.126	0.332	0.208	0.406
CONC (6-10 competitors	0.067	0.249	0.039	0.193	0.067	0.250
CONC (up to 5 competitors)	0.300	0.458	0.218	0.413	0.196	0.397

Table A.4: Correlation matrix; manufacturing

	LWL	LHQUAL	LHQUAL1	LHQUAL2	LMQUAL	LLQUAL	LC	LRDS	LRDL	LNEWS	LIMPS	INNOPD	INNOPC	R&D	PAT	LAGE	FOREIGN	D	IPC	INPC	CONC(16-50)	CONC(11-15)	CONC(6-10)
LHQUAL	0.29																						
LHQUAL1	0.30	0.66																					
LHQUAL2	0.23	0.93	0.30																				
LMQUAL	0.11	-0.08	-0.07	-0.06																			
LLQUAL	-0.13	-0.26	-0.18	-0.26	-0.52																		
LC	0.10	0.06	0.08	0.03	0.01	0.03																	
LRDS	0.18	0.31	0.32	0.24	-0.10	0.00	0.05																
LRDL	0.26	0.36	0.37	0.28	-0.07	-0.06	0.10	0.94															
LNEWS	0.09	0.21	0.18	0.17	-0.09	0.08	0.05	0.56	0.50														
LIMPS	0.06	0.22	0.15	0.19	-0.07	0.05	0.05	0.52	0.46	0.61													
INNOPD	0.13	0.22	0.21	0.17	-0.09	0.04	0.05	0.64	0.56	0.63	0.60												
INNOPC	0.06	0.10	0.13	0.06	-0.04	0.04	0.02	0.37	0.30	0.41	0.42	0.36											
R&D	0.14	0.25	0.26	0.19	-0.12	0.07	0.06	0.89	0.75	0.58	0.55	0.68	0.41										
PAT	0.16	0.22	0.26	0.17	-0.04	0.04	0.03	0.45	0.46	0.32	0.30	0.37	0.20	0.41									
LAGE	0.04	-0.04	-0.03	-0.05	-0.01	0.14	0.03	-0.01	-0.03	0.03	0.00	0.03	0.04	0.03	0.06								
FOREIGN	0.14	0.13	0.13	0.11	-0.01	0.00	0.08	0.10	0.13	0.09	0.06	0.09	0.00	0.08	0.09	-0.07							
D	0.08	0.13	0.16	0.10	0.00	-0.03	0.09	0.19	0.21	0.14	0.13	0.14	0.12	0.17	0.12	-0.08	0.05						
IPC	0.03	0.00	-0.03	0.00	-0.05	0.10	-0.04	0.02	0.01	0.02	0.03	0.02	0.02	0.03	0.04	0.07	0.00	-0.10					
INPC	0.02	0.07	0.06	0.06	0.01	-0.05	0.03	0.13	0.13	0.10	0.10	0.10	0.08	0.11	0.08	-0.10	0.06	0.10	-0.06				
CONC(16-50)	-0.12	-0.10	-0.14	-0.07	0.06	-0.07	-0.06	-0.17	-0.08	-0.16	-0.10	-0.16	-0.02	-0.16	-0.17	-0.04	-0.12	-0.06	0.09	0.01			
CONC(11-15)	-0.03	-0.06	-0.04	-0.05	-0.02	0.06	-0.03	-0.07	-0.07	-0.02	-0.01	-0.02	-0.02	-0.05	-0.04	0.03	-0.01	-0.08	0.01	-0.03	-0.20		
CONC(6-10)	-0.05	-0.05	-0.03	-0.05	0.01	0.04	-0.03	0.00	-0.01	-0.04	0.01	-0.04	0.01	0.01	0.02	0.05	-0.02	0.00	0.00	0.02	-0.14	-0.10	
CONC(<5)	0.03	0.06	0.05	0.05	-0.07	0.06	0.03	0.07	0.09	0.09	0.07	0.10	0.03	0.10	0.07	0.04	0.07	0.05	0.00	0.03	-0.36	-0.03	-0.18

Table A.5: Correlation matrix; services

	LWL	LHQUAL	LHQUAL1	LHQUAL2	LMQUAL	LLQUAL	LC	LRDS	LRDL	LNEWS	LIMPS	INNOPD	INNOPC	R&D	PAT	LAGE	FOREIGN	D	IPC	INPC	CONC(16-50)	CONC(11-15)	CONC(6-10)
LHQUAL	0.34																						
LHQUAL1	0.31	0.64																					
LHQUAL2	0.30	0.89	0.32																				
LMQUAL	0.05	-0.33	-0.30	-0.27																			
LLQUAL	-0.26	-0.37	-0.34	-0.30	-0.16																		
LC	0.09	-0.03	-0.06	-0.02	0.11	-0.04																	
LRDS	0.18	0.25	0.27	0.20	-0.10	-0.09	-0.07																
LRDL	0.22	0.25	0.28	0.20	-0.10	-0.11	-0.01	0.94															
LNEWS	0.12	0.19	0.16	0.18	-0.04	-0.04	-0.02	0.46	0.40														
LIMPS	0.09	0.20	0.16	0.19	-0.04	-0.04	-0.02	0.49	0.41	0.76													
INNOPD	0.16	0.19	0.15	0.17	-0.03	-0.04	-0.02	0.53	0.46	0.74	0.70												
INNOPC	0.15	0.22	0.21	0.18	-0.04	-0.07	-0.01	0.45	0.39	0.58	0.58	0.53											
R&D	0.18	0.23	0.25	0.19	-0.06	-0.04	-0.04	0.90	0.77	0.50	0.54	0.57	0.51										
PAT	0.12	0.11	0.16	0.05	-0.04	-0.02	-0.04	0.29	0.28	0.20	0.13	0.21	0.13	0.25									
LAGE	0.12	0.02	-0.03	0.02	0.15	0.02	0.04	-0.02	-0.02	0.00	-0.02	0.01	0.02	0.00	-0.05								
FOREIGN	0.13	0.10	0.07	0.11	0.04	-0.01	0.09	-0.01	0.01	0.09	0.07	0.07	0.02	-0.01	0.01	-0.07							
D	0.11	0.05	0.01	0.05	0.06	-0.05	0.11	0.02	0.01	0.10	0.12	0.12	0.16	0.04	0.07	-0.01	0.04						
IPC	0.03	0.03	-0.02	0.07	0.07	0.03	0.02	0.03	0.02	0.08	0.09	0.09	0.12	0.06	-0.01	0.07	0.05	0.01					
INPC	0.04	0.02	0.00	0.04	0.04	-0.02	0.04	0.04	0.03	0.11	0.09	0.09	0.04	0.04	0.06	0.02	0.07	0.05	0.06				
CONC(16-50)	-0.07	0.03	0.07	0.02	-0.10	-0.01	-0.02	0.02	0.01	-0.02	-0.01	-0.05	-0.02	0.00	-0.03	-0.09	-0.05	-0.08	-0.01	0.01			
CONC(11-15)	-0.05	0.00	-0.03	0.01	0.05	0.00	-0.06	0.00	-0.02	0.00	0.03	0.01	-0.03	0.00	0.02	0.02	0.00	0.01	0.07	-0.01	-0.27		
CONC(6-10)	-0.04	-0.09	-0.08	-0.07	0.04	0.00	0.00	-0.06	-0.05	-0.11	-0.11	-0.12	-0.12	-0.75	-0.03	0.03	0.00	0.05	-0.04	0.17	-0.13	-0.07	
CONC(<5)	0.06	0.01	0.00	0.02	0.06	0.02	0.03	0.02	0.04	0.07	0.06	0.07	0.06	0.03	0.01	0.05	0.05	0.02	0.06	0.05	-0.41	-0.21	-0.10

Table A.6: Correlation matrix; construction

	LWL	LHQUAL	LHQUAL1	LHQUAL2	LMQUAL	LLQUAL	LC	LRDS	LRDL	LNEWS	LIMPS	INNOPD	INNOPC	R&D	PAT	LAGE	FOREIGN	D	IPC	INPC	CONC(16-50)	CONC(11-15)	CONC(6-10)
LHQUAL	0.12																						
LHQUAL1	0.10	0.32																					
LHQUAL2	0.08	0.96	0.09																				
LMQUAL	-0.08	-0.11	-0.20	-0.06																			
LLQUAL	0.20	-0.12	0.10	-0.16	-0.55																		
LC	-0.09	0.02	0.04	0.01	0.02	-0.06																	
LRDS	0.14	0.17	0.23	0.11	-0.07	0.09	0.01																
LRDL	0.14	0.17	0.22	0.11	-0.05	0.04	0.05	0.87															
LNEWS	0.13	0.15	0.10	0.12	-0.06	-0.04	-0.06	0.50	0.41														
LIMPS	0.13	0.16	0.09	0.13	0.00	-0.04	-0.06	0.50	0.44	0.80													
INNOPD	0.11	0.16	0.44	0.13	-0.04	-0.02	-0.03	0.57	0.44	0.60	0.60												
INNOPC	0.14	0.15	0.16	0.11	-0.03	0.02	-0.03	0.55	0.40	0.57	0.68	0.50											
R&D	0.15	0.16	0.25	0.10	-0.03	0.07	0.01	0.89	0.65	0.45	0.47	0.60	0.57										
PAT	0.15	0.13	0.11	0.08	0.00	-0.03	0.05	0.36	0.39	0.24	0.22	0.27	0.24	0.33									
LAGE	0.01	0.04	-0.11	0.07	0.05	0.06	-0.11	0.09	-0.05	0.00	0.01	-0.04	0.01	0.03	-0.20								
FOREIGN	0.07	0.05	0.17	0.02	0.09	-0.03	0.11	0.11	0.07	0.01	-0.03	0.02	0.08	0.14	0.24	-0.10							
D	-0.01	0.15	-0.03	0.12	-0.03	-0.04	-0.05	0.15	0.15	0.07	0.12	0.05	0.16	0.13	0.21	-0.05	0.01						
IPC	0.11	0.07	0.03	0.08	-0.10	0.09	-0.09	0.02	0.01	0.03	0.04	0.04	0.13	0.05	0.05	0.02	-0.02	0.06					
INPC	-0.04	0.04	0.03	0.05	0.04	-0.10	0.06	0.00	0.00	-0.01	-0.04	-0.02	-0.05	0.01	0.07	-0.17	0.02	-0.01	0.06				
CONC(16-50)	-0.03	0.05	0.08	0.04	-0.06	0.01	0.04	0.01	-0.02	-0.02	-0.03	0.06	-0.01	0.01	-0.08	-0.03	-0.12	-0.01	0.05	0.03			
CONC(11-15)	0.00	-0.07	-0.10	-0.05	-0.01	0.14	-0.17	0.00	-0.03	0.03	0.06	0.00	0.08	0.03	-0.09	0.17	-0.01	0.00	0.11	-0.09	-0.42		
CONC(6-10)	-0.05	-0.01	-0.04	-0.01	0.01	0.01	0.07	-0.12	-0.09	-0.16	-0.16	-0.16	-0.17	-0.13	-0.06	0.00	0.11	-0.05	-0.10	0.01	-0.26	-0.15	
CONC(<5)	0.02	-0.03	0.04	-0.04	0.01	-0.06	-0.15	-0.03	0.03	-0.02	-0.04	-0.05	-0.07	-0.04	0.16	-0.05	0.07	0.04	0.03	0.03	-0.40	-0.24	-0.15