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Helsinki, November 2007

The Research Institute of the Finnish Economy

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ABSTRACT: We study how upgrading the skills of the personnel affects a firm's performance. Two different strategies are examined: 1) providing formal training and 2) strategic recruitment and separation policy. The use of register-based longitudinal employer-employee data supplemented with a survey on vocational training provides an opportunity to shed fresh light on the issue and allows us to address the usual econometric problems. We find that internally (but not externally) organized training stimulates subsequent growth of performance but only when combined with the implementation of new process or product technology. Hiring highly skilled workers is initially costly to firms but is productivity-enhancing in the long run.

Key words: *Productivity, profitability, training, education, hiring*

JEL code: J24, M5, O3, D2

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TIIVISTELMÄ: Tutkimuksessa tarkastelemme sitä, miten henkilöstön osaamisen parantaminen vaikuttaa yrityksen suoritukseen. Tutkimme kahta strategiaa: 1) työnantajan järjestämää henkilöstökoulutusta ja 2) strategista rekrytointi- ja irtisanomispolitiikkaa. Yhdistämällä rekisteripohjainen pitkittäinen työnantaja-työntekijäaineisto yrityksen henkilöstökoulutustiedusteluun olemme saaneet mahdollisuuden valottaa tutkimuskysymystä tuoreella tavalla. Tämän aineiston avulla voimme käsitellä myös tyypillisiä ekonometrisia ongelmia. Havaitsemme, että sisäisesti (muttei ulkoisesti) järjestetty henkilöstökoulutus kiihdyttää yrityksen suorituskyvyn kasvua, mutta vain niissä tilanteissa, joissa yritys on samaan aikaan ottanut käyttöönsä uuden valmistustekniikan tai alkanut valmistaa uutta tuotetta. Korkeasti koulutetun palkkaaminen on aluksi tappiollista, mutta parantaa yrityksen tuottavuutta pitkällä aikavälillä.

Avainsanat: *Tuottavuus, kannattavuus, henkilöstökoulutus, muodollinen koulutus, rekrytointi*

JEL koodi: J24, M5, O3, D2

CONTENTS

1. INTRODUCTION

Current economic growth is to an important degree driven by firms' past investments. In addition to building up their stock of productive tangible capital, firms continuously invest also in their intangible assets such as digitalized information obtained through purchase of software or by programming on their own. Innovative property accumulated by R&D efforts constitutes another crucial part of firms' intangibles. To improve their performance, however, firms also need to invest in their economic competencies, an important part of which is embodied in their personnel (e.g. Corrado, Hulten, and Sichel, 2006). When upgrading the skills of its personnel, the firm can resort to two inherently different but possibly complementary strategies: it can lean on strategic recruitment and separation policies or opt to train its current staff, or do both. Hiring skilled workers or training their workers may initially be costly but should, sooner or later, boost the firm's productivity and profitability.

Rapid technological change is likely to increase the importance of upgrading the skill level of the personnel. For instance, an increasing amount of evidence shows that the best productivity gains can be achieved when the adoption of an IT technology (an example of a radical process innovation in many firms over the past ten years) is complemented with skilled workers and some modern way of organizing work (Brynjolfsson and Hitt, 2000; Bresnahan, Brynjolfsson, and Hitt, 2002).[1] To obtain productivity (and profitability) gains from a radical process or product innovation, the firm might first need to upgrade the skills level of its personnel by hiring (university) educated workers and then augment further the skills of its personnel by providing more specific vocational training. Brynjolfsson and Hitt (2003) find that it takes five to seven years for firms to capture the productivity effects of IT investments fully. Arguably the corresponding lags in the case of educated new hires may be of comparable or even longer length.

The novelty of this paper is threefold. First, it contributes to the *training* literature by using broad register-based longitudinal employer–employee data which is linked to firm-level survey data on formal training. This unique data set has several advantages over the data typically used in analyses of the economic effects of employer-provided training. In particular, it allows us to examine both productivity effects, which are interesting especially from the standpoint of a nation, and profitability effects, which are among the ultimate interests of firms operating in a market economy. Doing so, our paper complements the extensive literature on individual-level wage effects of employer-provided training as well as the growing literature on firm-level productivity

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[1] For surveys of the productivity effects of ICT at the firm level, see e.g. Pilat (2004) and Draca et al. (2007).

effects of the employers' investments in training.[2] Additionally our research adds to the small and rather inconclusive literature that jointly estimates the wage and productivity effects of firm-provided training to analyze how the economic benefits of training are shared between the employer and the employee.[3] Most importantly, our paper contributes to correcting the compelling lack of firm-level evidence on the profitability benefits accruing from the employers' training investments.[4] Moreover, the existing studies suffer – more or less – from biased training estimates due to insufficient possibilities to solve the intrinsically difficult econometric problems of heterogeneity and endogeneity which arise when exploring wage, productivity and profitability effects of firm-provided training.[5] The longitudinal dimension of our data allows us to address successfully problems of firm and worker heterogeneity as well as training endogeneity.

Second, our paper contributes to the *labor turnover* literature in the sense that the employed empirical framework, which follows the approach proposed by Maliranta and Ilmakunnas (2005), allows us to analyze the joint impact on firm performance of training, hiring and separation behavior. Earlier studies typically include some measure of turnover but fail to distinguish between firm-specific recruitments and separations measured at the individual level.

Third, our work contributes to the *human resource management* literature in that the richness of our data allows us to also include measures indicating whether or not the firm has implemented new production or process technologies or undertaken major

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2 For reviews of the literature, see e.g. Bishop (1997) , Blundell et al. (1999), Bartel (2000), Asplund (2005), Bassanini et al. (2007) and Zwick (2005). A summary of the theoretical work on employer-provided training is provided in Leuven (2005).

3 Studies having simultaneously estimated wage and production functions at the *individual* level are Bartel (1995) and Barron et al. (1997) for the USA, Groot (1999) for the Netherlands and López-Acevedo (2003) for Mexico. Corresponding studies at the *firm* level have usually relied on cross-section data, hence focusing on training effects on wage and productivity levels rather than on growth. Among these studies are Barron et al. (1989), Holzer (1990) and Bishop (1994) for the USA, Alba-Ramirez (1994) for Spain, Turcotte and Rennison (2004) for Canada, López-Acevedo et al. (2005) for Mexico and Tan et al. (2007) for Russia. Only a few studies are based on firm-level panel data: Hempell (2003) uses information on over 1,200 German service companies, Tan and López-Acevedo (2003) explore a sample of several thousand larger manufacturing firms in Mexico, Dearden et al. (2005, Appendix B) analyze information on 119 UK firms and Ballot et al. (2006) use information on 101 French and 235 Swedish large manufacturing firms.

4 This knowledge gap is surprising in view of employer-provided formal training constituting a substantial part of spending in advanced countries (Corrado et al., 2006; Haskel and Marrano, 2007) thus implying substantial adoption costs associated with the creation of human capital specific to the use of new technology (Jovanovic, 1997). Indeed, few studies have extended the perspective on firm investments in training beyond their impact on wages and productivity. Among the exceptions are Almeida and Carneiro (2006), who calculate internal rates of return on employers' investments in formal training programs from estimations of production and cost functions using data on large manufacturing firms in Portugal, and Kazamaki Ottersten et al. (1999), who evaluate the indirect effects of training on long-term labor demand arising through cost savings and productivity gains by estimating a cost function using a panel of machine tool industry plants for Sweden.

5 Due to the lack of comprehensive high-quality firm-level panel data containing also training information, one line of studies has relied on data aggregated to the industry or the industry-by-region level (see Machin et al. (2003) and Dearden et al.(2006) for the UK, Conti (2005) for Italy and Kuckulenz (2007) for Germany).

organizational changes. While the HRM literature provides unambiguous support to the importance of this type of practices for firm performance, the role of training is mostly overlooked in this context or, if included, seldom interacted with HRM practices (see e.g. Black and Lynch, 2001, 2004). A recent exception is Lynch (2007), who addresses the question of a potentially important link between organizational change and investment in training and also stresses the importance of considering the timing by showing that organizational innovations are preceded by investments in information technology and human capital.

Our main findings are the following. First, internally (but not externally) organized firm-provided training stimulates subsequent growth of productivity and profitability but only when combined with the implementation of new process or product technology. Second, training investments should be measured in a way that properly takes into account the intensity of training (we use the number of firm-level training days per employee as our preferred measure). Last but not least, highly educated new hires have initially a strongly negative impact on productivity and profitability, but in the longer term they contribute markedly to productivity growth. Hence, this finding provides support for the so-called Nelson–Phelps hypothesis stating that highly educated workers are more like a factor of technical *change* and productivity *growth* in the firm and should not be seen narrowly as just another factor of production (Nelson and Phelps, 1966).

These key findings are robust with respect to a number of checks we have made. Our findings are also not plagued by the three biases commonly encountered in the training literature. Firm heterogeneity is dealt with by the inclusion of a rich set of explanatory variables and by direct focus on differences (i.e. growth rates), which eliminates time-invariant fixed firm effects (see Griliches and Mairesse, 1998). The worker heterogeneity problem is avoided by looking at profitability effects, that is, by contrasting productivity[6] against wage effects (see Hellerstein and Neumark, 2007). Finally, the use of a lag between the firm's human capital investments and the change in its performance should handle the simultaneity problem (e.g. Caroli and Van Reenen, 2001). Simultaneously, this approach accounts for that fact that, as in the case of information technology, positive productivity effects of human capital investment, especially in the form of highly educated new hires, can be expected to appear with a considerable lag.

The structure of the paper is as follows. The next section derives the estimation equations while section 3 outlines the empirical setting and the data used. Section 4 presents and discusses the main findings while section 5 concludes.

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6 Our productivity measure is based on real value added net of training expenditure.

2. DERIVING ESTIMATION EQUATIONS

The firm's workforce is assumed to consist of three types of workers, $j=1,2,3$. The first group covers the workers with only basic schooling (low skills), the second group those with a vocational education (specialized skills) and the third group those with a university degree (general skills). This division of the workers can be justified on several grounds. Most importantly, the university educated workers are costly to the firm but their general human capital is particularly useful in generating, implementing and adopting new techniques, thus paving the way for productivity growth in the longer term (the Nelson–Phelps effect).[7] Arguably the skills learned in vocational education are of a different kind not only with respect to specificity and costs but also to productivity dynamics (see e.g. Krueger and Kumar, 2004).

The firm's output (value added) in period 1 is defined as the sum of the outputs of the three groups of differently educated workers:

$$Y_1 = \sum_j Y_{1j} \; . \qquad (1)$$

The firm's labor productivity is the labor share weighted average of the groups' labor productivities:

$$\frac{Y_1}{L_1} = \sum_j \frac{L_{1j}}{L_1}\frac{Y_{1j}}{L_{1j}} \; . \qquad (2)$$

Each worker group can be further divided into two sub-groups: those workers who were employed by the firm in the previous period, 0, that is, staying workers (*stay*), and those who were not, that is, hired workers (*hire*). Thus, the firm's labor productivity becomes

$$\frac{Y_1}{L_1} = \sum_j \frac{L_{1j,stay}}{L_1}\frac{Y_{1j,stay}}{L_{1j,stay}} + \sum_j \frac{L_{1j,hire}}{L_1}\frac{Y_{1j,hire}}{L_{1j,hire}} \; . \qquad (3)$$

Because the labor shares must add up to one

$$\sum_j \frac{L_{1j,stay}}{L_1} + \sum_j \frac{L_{1j,hire}}{L_1} = 1 \; .$$

Equation (3) can be re-written as[8]:

[7] Coherently with this view, Bartel and Lichtenberg (1987) show that the demand for highly educated labor is strongest in plants where the age of equipment is low and especially in R&D-intensive industries. The relative demand for educated workers is claimed to decline when the capital stock (and the technology embodied therein) ages. Also see Romer (1990), Benhabib and Spiegel (1994; 2005), and Vandenbussche et al. (2006).

[8] The derivation of Equation (4) from Equation (3) is available from the authors upon request.

$$\frac{Y_1}{L_1} = \sum_j \frac{L_{1j,stay}}{\sum_j L_{1j,stay}} \frac{Y_{1j,stay}}{L_{1j,stay}} + \sum_j \frac{L_{1j,hire}}{L_1}\left(\frac{Y_{1j,hire}}{L_{1j,hire}} - \sum_j \frac{L_{1j,stay}}{\sum_j L_{1j,stay}} \frac{Y_{1j,stay}}{L_{1j,stay}}\right)$$
$$= \sum_j \frac{L_{1j,stay}}{\sum_{1j} L_{1j,stay}} \frac{Y_{1j,stay}}{L_{1j,stay}} + \sum_j \frac{L_{1j,hire}}{L_1}\left(\frac{Y_{1j,hire}}{L_{1j,hire}} - \frac{Y_{1,stay}}{L_{1,stay}}\right). \quad (4)$$

Upon considering period 0, it is also necessary to account for those workers who will no longer be employed by the firm in period 1, that is, the separating workers (*sepa*). Noting that

$$\sum_j \frac{L_{0j,stay}}{L_0} + \sum_j \frac{L_{0j,hire}}{L_0} = 1,$$

the firm's labor productivity in period 0 is

$$\frac{Y_0}{L_0} = \sum_j^M \frac{L_{0j,stay}}{\sum_{0j} L_{0j,stay}} \frac{Y_{0j,stay}}{L_{0j,stay}} + \sum_j^M \frac{L_{0j,sepa}}{L_0}\left(\frac{Y_{0j,sepa}}{L_{0j,sepa}} - \frac{Y_{0j,stay}}{L_{0j,stay}}\right). \quad (5)$$

By definition, the staying workers in period 0 and in period 1 are the same individuals. Assuming that they belong to the same education worker group in both periods, we have

$$L_{0j,stay} = L_{1j,stay}.$$

The difference in productivity levels between period 0 and period 1 is

$$\Delta \frac{Y}{L} = \frac{Y_1}{L_1} - \frac{Y_0}{L_0}, \quad (6)$$

and after slight manipulation

$$\frac{Y_1}{L_1} - \frac{Y_0}{L_0} =$$
$$\sum_j \frac{L_{0j,stay}}{\sum_j L_{0j,stay}}\left(\frac{Y_{1j,stay}}{L_{1j,stay}} - \frac{Y_{0j,stay}}{L_{0j,stay}}\right) +$$
$$\sum_j \frac{L_{1j,hire}}{L_1}\left(\frac{Y_{1j,hire}}{L_{1j,hire}} - \frac{Y_{1,stay}}{L_{1,stay}}\right) + \quad (7)$$
$$\sum_j \frac{L_{0j,sepa}}{L_0}\left(\frac{Y_{0,stay}}{L_{0,stay}} - \frac{Y_{0j,sepa}}{L_{0j,sepa}}\right)$$

The first term on the right-hand side of Equation (7) captures the change in the firm's labor productivity attributable to the staying workers, calculated as the labor share weighted average of the productivity change occurring across the staying education worker groups. Following Nelson and Phelps (1966), this term can be interpreted as reflecting the dynamic long-term impact that these workers may have on the firm's productivity.

The second term on the right-hand side of Equation (7) captures the change in the firm's labor productivity attributable to new hires. Hiring workers into education group j boosts productivity provided that the new hires have (immediately) a higher productivity level than j's average stayer in period 1. The new hires' relative productivity is net of adjustment costs implying that hiring-related adjustment costs are included implicitly.

The third and final term on the right-hand side of Equation (7) captures the change in the firm's labor productivity attributable to separating workers. Workers separating from group j will boost productivity given that they have a lower productivity level than j's average stayer in period 1.

Dividing the terms in Equation (7) by the average productivity level in periods 0 and 1 yields a close approximation of a more common log-difference:

$$\frac{Y_1/L_1 - Y_0/L_0}{0.5\left(Y_1/L_1 + Y_0/L_0\right)} \cong \ln\frac{Y_1/L_1}{Y_0/L_0}. \quad (8)$$

A similar decomposition can be performed for the firm's average wage level by simply substituting W for Y. Accordingly, the following estimation equations can be specified:

$$\frac{\Delta(Y/L)}{\overline{(Y/L)}} = \alpha + \sum_j^M \beta_{(Y/L),j,hire} HR_j + \sum_j^M \beta_{(Y/L),j,sepa} SR_j + \sum_j^{M-1} \chi_{(Y/L),j,stay} STAYSH_j + \delta'\mathbf{Z} + \varepsilon, \quad (9)$$

$$\frac{\Delta(W/L)}{\overline{(W/L)}} = \alpha + \sum_j^M \beta_{(W/L),j,hire} HR_j + \sum_j^M \beta_{(W/L),j,sepa} SR_j + \sum_j^{M-1} \chi_{(W/L),j,stay} STAYSH_j + \delta'\mathbf{Z} + \varepsilon, \quad (10)$$

where $\overline{(Y/L)} = 0.5\left[\left(Y_0/L_0\right) + \left(Y_1/L_1\right)\right]$ and $\overline{(W/L)} = 0.5\left[\left(W_0/L_0\right) + \left(W_1/L_1\right)\right]$ are, respectively, the average productivity and wage level. $HR_j = \frac{L_{1j,hire}}{L_1}$ is the hiring rate and $SR_j = \frac{L_{0j,sepa}}{L_0}$ the separation rate for respective j group, while $STAYSH_j = \frac{L_{0j,stay}}{L_{0,stay}}\left(= \frac{L_{1j,stay}}{L_{1j,stay}}\right)$ is the group's share of staying workers. Z represents a vector of other covariates exerting an exogenous influence on the dependent variables and ε is a stochastic error term. The labor productivity effects of hired and separating workers in group j may thus be written as

$$\beta_{(Y/L),j,hire} = \frac{(Y/L)_{1,j,hire} - (Y/L)_{1,stay}}{\overline{(Y/L)}} \quad (11)$$

$$\beta_{(Y/L),j,sepa} = \frac{(Y/L)_{0,stay} - (Y/L)_{0,j,sepa}}{\overline{(Y/L)}}. \quad (12)$$

Finally, the intercept (α) indicates the growth rate in the reference group of stayers with $\chi_{(Y/L),j,stay}$ thus capturing the growth rate differential between group j and its reference category, that is, group j's stayers.[9]

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[9] Because the sum of the stayers' share variables (contrary to that of the hiring and separation variables) is always one by construction, one of the three worker group stayer variables has to be dropped from the equation because of perfect multicollinearity. The omitted group serves as the reference category (staying workers with a basic education only in our estimations below).

Firms are ultimately interested in their profitability, which for the present purposes is defined as

$$\Pi = 1 + \frac{OPM}{W(1+a)} = \frac{Y}{W(1+a)} = \frac{Y/L}{(1+a)\left(W/L\right)}, \tag{13}$$

where OPM denotes the operating margin $\left(OPM = Y - W(1+a)\right)$ with a, the ratio of payroll taxes to wages, assumed to be constant over time and across education worker groups.[10] The growth rate of profitability is thus simply the difference between the growth rates of productivity and wages approximated by

$$\frac{\Delta\Pi}{\overline{\Pi}} \cong \frac{\Delta\left(Y/L\right)}{\overline{\left(Y/L\right)}} - \frac{\Delta\left(W/L\right)}{\overline{\left(W/L\right)}}, \tag{14}$$

where $\overline{\Pi} = 0.5\left[\Pi_0 + \Pi_1\right]$. The growth rate of profitability then becomes

$$\frac{\Delta\Pi}{\overline{\Pi}} = \alpha + \sum_j^M \beta_{\Pi,j,hire} HR_j + \sum_j^M \beta_{\Pi,j,sepa} SR_j + \sum_j^{M-1} \chi_{\Pi,j,stay} STAYSH_j + \delta' \mathbf{Z} + \varepsilon, \tag{15}$$

where, on the basis of Equation (14), the following approximations hold true:

$$\beta_{\Pi,j,hire} \approx \beta_{(Y/L),j,hire} - \beta_{(W/L),j,hire} \tag{16}$$

$$\beta_{\Pi,j,sepa} \approx \beta_{(Y/L),j,sepa} - \beta_{(W/L),j,sepa}. \tag{17}$$

Since

$$\beta_{(Y/L),j,hire} = \frac{\left(Y/L\right)_{1,j,hire} - \left(Y/L\right)_{1,stay}}{\overline{\left(Y/L\right)}} \approx \ln\frac{\left(Y/L\right)_{1,j,hire}}{\left(Y/L\right)_{1,stay}} \tag{18}$$

and

$$\beta_{(W/L),j,hire} = \frac{\left(W/L\right)_{1,j,hire} - \left(W/L\right)_{1,stay}}{\overline{\left(W/L\right)}} \approx \ln\frac{\left(W/L\right)_{1,j,hire}}{\left(W/L\right)_{1,stay}} \tag{19}$$

Equation (16) can be transformed into

$$\begin{aligned} \beta_{\Pi,j,hire} &\approx \ln\frac{\left(Y/L\right)_{1,j,hire}}{\left(Y/L\right)_{1,stay}} - \ln\frac{\left(W/L\right)_{1,j,hire}}{\left(W/L\right)_{1,stay}} = \ln\frac{\left(Y/W\right)_{1,j,hire}}{\left(Y/W\right)_{1,stay}} \\ \Leftrightarrow \beta_{\Pi,j,hire} &\approx \ln\frac{\Pi_{1,j,hire}}{\Pi_{1,stay}} \end{aligned} \tag{20}$$

which shows that the parameter of the hiring variable for worker group j in the profit equation (18) can be interpreted as a measure of the profitability level of those hired into worker group j relative to all stayers in period 1. Analogously we obtain

$$\beta_{\Pi,j,sepa} \approx \ln\frac{\Pi_{0,j,sepa}}{\Pi_{0,stay}}, \tag{21}$$

which provides a measure of the relative profitability level of those having left worker group j previous to their separation.

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10 Admittedly this is a crude measure of profitability because capital costs are not taken into account. However, in our empirical analysis we include industry dummies and, more importantly, capital intensity, which should control for the differences in capital costs.

Equations (9), (10) and (15) form the framework for our empirical analysis. One of our main interests concerns the effects of firm-provided formal training. As training can be expected to increase the trainees' productivity and ultimately boost the firm's productivity growth, we augment our three estimation equations with a variable measuring the intensity of worker training (*TRAIN*).

Training-augmented labor productivity growth equation:

$$\frac{\Delta(Y/L)}{\overline{(Y/L)}} = \alpha + \beta_{(y/l),train} TRAIN + \sum_{j}^{M-1} \chi_{(y/l),j,stay} STAYSH_j + \sum_{j}^{M} \delta_{(y/l),j,hire} HR_j + \sum_{j}^{M} \delta_{(y/l),j,sepa} SR_j + \phi' \mathbf{Z} + \varepsilon \tag{22}$$

Training-augmented wage growth equation:

$$\frac{\Delta(W/L)}{\overline{(W/L)}} = \alpha + \beta_{(w/l),train} TRAIN + \sum_{j}^{M-1} \chi_{(w/l),j,stay} STAYSH_j + \sum_{j}^{M} \delta_{(w/l),j,hire} HH_j + \sum_{j}^{M} \delta_{(w/l),j,sepa} SR_j + \phi' \mathbf{Z} + \varepsilon \tag{23}$$

Training-augmented profitability equation:

$$\frac{\Delta\Pi}{\overline{\Pi}} = \alpha + \beta_{\pi,train} TRAIN + \sum_{j}^{M-1} \chi_{\pi,j,stay} STAYSH_j + \sum_{j}^{M} \delta_{\pi,j,hire} HR_j + \sum_{j}^{M} \delta_{\pi,j,sepa} SR_j + \phi' \mathbf{Z} + \varepsilon \tag{24}$$

There are three main potential sources of bias in an econometric analysis of firm performance and labor characteristics. First, there may be unobservable firm heterogeneity both in productivity and wage levels, which is correlated with the firms' choices of labor input. For example, the firm vintage and worker cohorts tend to be tied together with young workers being employed in firms having new equipment and high productivity. Since we use *growth rates* as our dependent variable, unobservable firm heterogeneity is not an issue of great concern here, as these rates of change will effectively eliminate any unobserved time-invariant firm-specific components in the productivity or average wage levels. Our approach is related to the use of differences for eliminating fixed firm effects (e.g. Griliches and Mairesse, 1998), where we define growth rates and labor flows in a two-year window. In order to control for various time-variant firm-specific components of firm performance in an attempt to avoid the potential presence of omitted variable bias, we have included a relative broad number of observable firm characteristics in the Z vector (see section 3 below).

Second, there is heterogeneity across workers. This would not be an issue if the firms randomly chose new employees from the pool of applicants or randomly picked those who are laid off. This is not likely to be the case, though, since firms attempt to hire the best and lay off the poorest performers. The hiring and separation flows may, as a consequence, be unrepresentative with respect to the corresponding groups in the whole population. This selection bias, however, should affect productivity growth and wage growth in the same way (Hellerstein and Neumark, 2007) and, hence, be eliminated when calculating their difference, that is, the profitability (the productivity–wage gap).

Third, the hiring and separation rates are dependent on the firms' decisions and, hence, are possibly correlated with the error term. This simultaneity problem may be the most pronounced for inputs that are the most adjustable (Marschak and Andrews, 1944). For example, a positive productivity shock may lead to the hiring of young workers (who are more mobile compared to their older counterparts), which then causes an overestimate of their productivity effect. Likewise, a positive productivity and profitability shock may induce firms to undertake investments (cf. Olley and Pakes, 1996). For instance, Blomström et al. (1996) provide evidence that economic growth stimulates fixed investments but not the other way around. Accordingly, if highly educated new hires are regarded as an investment (as we do here), then a positive productivity shock could be expected to stimulate the hiring of highly educated workers. This may induce a spurious correlation with highly educated workers appearing as more productive than they actually are. An obvious and easy way to escape, or at least mitigate, this simultaneity problem is to use lagged explanatory variables, since the current productivity (or profitability) shock should not have an impact on hirings (or separations) in the past.

3. EMPIRICAL SETTING AND DATA

An empirical application of Equations (22) – (24) requires longitudinal data on both employees and employers that, moreover, are mutually linkable. The *Finnish Longitudinal Employer-Employee Data* (FLEED), which is publicly available for research purposes (subject to terms and conditions of confidentiality), excellently suits such purposes. FLEED merges comprehensive administrative records of all labor force members as well as all (private sector) employers/firms (including their establishments). Basically FLEED is a kind of virtual combination of various mutually linkable administrative data records (Ilmakunnas, Maliranta, and Vainiomäki, 2001). It is the fruit of the Finnish statistical system, which is heavily based on administrative register networks with unique identification codes for individuals, firms and establishments constituting the backbone of the system. Accordingly this statistical system provides excellent possibilities to construct both cross-sectionally and dynamically representative datasets (Abowd and Kramarz, 1999). Moreover, since these same identifying codes are used also in surveys, FLEED can be complemented with more detailed survey information such as that contained in the Continuing Vocational Training Survey (CVTS2), an opportunity utilized for the purposes of the present study.

The empirical setting and the data linking procedures are described in Figure 1. The individual-level data in FLEED is mainly based on Employment Statistics compiled by Statistics Finland. This data allows us to trace the background characteristics (like educational attainment) and employment histories of virtually all Finns aged between 16 and 70 who lived in Finland in the period 1988 to 2003. Each employed individual is also assigned a firm code which indicates his or her main employer during the year in question. Using these data we are able to identify firm-specific worker flows (hiring and separation) and stayers for our two-year window extending from 1998 to 2000 (see upper panel of Figure 1). For sake of a more detailed analysis of possible time lags involved we have computed worker flow variables also for the periods 1996–1998 and 2000–2002.

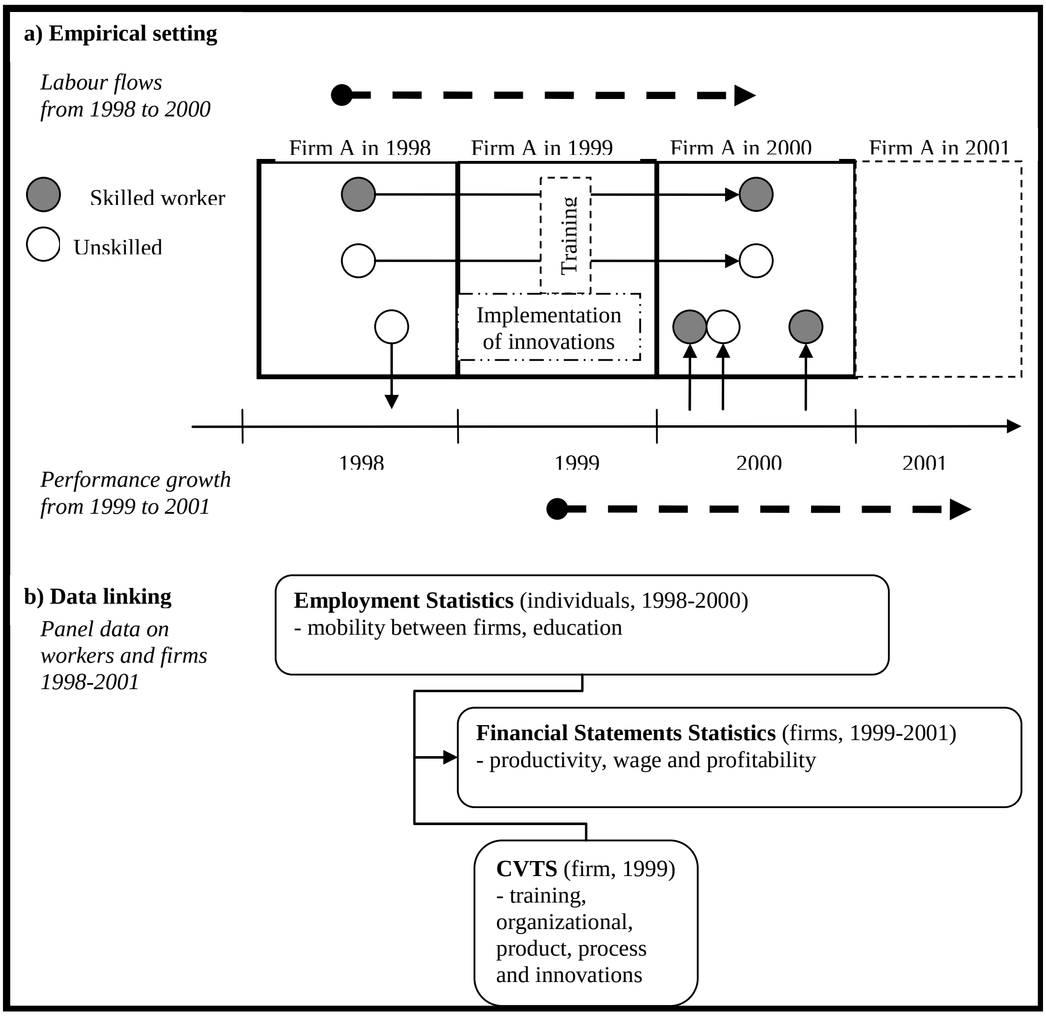

Figure 1. Empirical setting and data linking procedures

The information required for measuring the change in firm performance (i.e. profitability, labor productivity and average firm wages) is obtained from Financial Statements Statistics, also compiled by Statistics Finland. Profitability is defined as value added per labor compensation (wages plus social security payments paid by the firm per person). Labor productivity is measured by value added per person, and the average wage is the wage bill divided by the number of persons. In addition we have included the log-change of capital intensity (capital per person) in our estimation models. Capital is measured by the book value of tangible capital. Variables measured in monetary units are deflated by the same industry-specific price indexes of production used for Finland in the EU–KLEMS database (http://www.euklems.net).

This firm-level data is available since the 1980s but covers a substantially smaller number of firms up to 1994. For our baseline estimations the change in firm performance is measured over the years 1999 to 2001 (see upper panel of Figure 1), which can be seen as a natural window for examining the productivity and profitability effects of the firm-provided training in 1999 as recorded in the CVTS2 survey (see below).[11] The information on firm performance change is linked to that on worker flows using the firm code. It is worth noting that our baseline estimations involve a one-year shift in the windows of worker flows and firm performance change, thus allowing a lag in the worker flow effects.

The 1999 Continuous Vocational Training Survey (CVTS2) constitutes our third data source. This firm-level dataset contains information on the formal training provided by firms in 1999. From this data we have constructed three alternative gauges for the firms' training investments in their personnel, and merged them with the rest of our data using the firm code. The first training variable measures the proportion of the firm's employees having received at least some formal training (attended courses). The second shows the average number of days (paid working time) in the firm's workforce spent in training organized either internally (by the firm itself) or externally (by some outside body). Our third training measure indicates the training costs per employee incurred by the firm. Hence, we have incidence, intensity and cost-based measures of firm-level training. In addition to firm-specific information on training, the CVTS2 survey also contains separate questions concerning whether or not the firm has introduced technologically new or improved products (product innovation), implemented new technology for producing products (process innovation) and/or undergone any other major organizational change (organization innovation).

The data linking procedure causes, for various reasons, a certain loss of observations. First, we need to focus on firms that appear both in the initial and the end year meaning that, in practice, our firms must be observable in all years from 1998 to 2001. Second, we have excluded small firms to ensure data reliability. More precisely, we have required that at least 10 employees can be linked to the firm in both 1998 and 2000 and, furthermore, that the average number of persons in the firm in these two years is no less than 20. Third, the largest loss of firms was caused by missing information on some key variable. For example, all firms in the banking and insurance sector were omitted for this reason. Fourth, we have excluded all firms for which the number of linked employees (using the individual-level data) differ more than 15% from the number of employees recorded in the firm-level data.

[11] We have also made some robustness checks by using alternative windows for the change in firm performance: the period 1999–2002 (a longer window of the future), the period 1998–2000 (current), the period 1997–1999 (preceding) and the period 1996–1998 (preceding longer back). We do not report these results here but just mention that these experiments provided support to the view that the period 1999–2001 is the most appropriate window for firm performance in our analysis.

4. EMPIRICAL ANALYSIS

4.1. Some descriptive statistics

After having linked data on worker flows, firm performance change and employer-provided training we are left with a sample of 916 observations (firms). Table 1 provides descriptive statistics on this estimation dataset. The average labor productivity and wage growth rates in the period 1999–2001 are 5.0% and 8.0%, respectively. Profitability is declining at the rate of –2.3%.

As described in the previous section, we use three alternative gauges of training input. The first indicates the share of the firm's employees having received at least some formal training. The unweighted average of this incidence indicator is 46.1% in our sample. The corresponding employment weighted average, which corrects for the fact that large firms tend to train a larger share of their workforce, is 51.6%. Our second training measure gives the training time per employee in the firm, measured in full-time units (7.25 hours). The average is 2.0 days per employee per year, which thus corresponds to an annual average of 14.6 hours per employee. When dividing this intensity measure into time spent in training organized internally or externally, our data shows that an annual average of 0.8 days was spent in internally organized training and the remainder (1.2 days) in externally organized training. Our third training measure refers to the total amount of training expenditure per employee per year in the firm, the annual average being 654 euros per employee in our data.

Our second key set of explanatory variables pertains to the firm's implementation of organizational, process or product innovations. Of the firms in our estimation sample, 26.4% have undergone a fundamental organizational change. Process and product innovations are substantially more common, the unweighted firm shares being 63.0% and 57.4%, respectively.

Our third key set of explanatory variables concerns worker flows. The average hiring rate between 1998 and 2000 is 26.5% (the sum of the hiring rates of the three educational groups defined in section 2). The highest share, 66.9% (=17.7%/26.5%), is attributed to employees with a vocational education, 21.1% (=5.6%/26.5%) to employees with only basic schooling, and the remaining 12.1% (=3.2%/26.5%) to employees with a Bachelor's degree or more. The average separation rate over our two-year window is 25.6%. The two post-compulsory educational groups have slightly higher hiring than separation rates while the reverse situation holds for those with only a basic education, which indicates a clear skills upgrading tendency in the Finnish business sector. The vocationally educated make up 63.3% and the university educated 10.4% of the staying workers, that is, of all workers employed in the same firm in both 1998 and 2000.

Table 1. *Descriptive statistics derived from the estimation sample*

Variable	Period	Unit	Mean	Std	Percentile p1	p25	p50	p75	p99
Productivity growth	1999-2001	%	5.0	27.0	-66.0	-7.9	4.9	16.3	99.3
Wage growth	1999-2001	%	8.0	14.1	-34.4	2.5	7.8	12.9	52.8
Profitability growth	1999-2001	%	-2.3	25.1	-75.8	-11.4	-1.4	7.4	86.2
Share of trained	1999	%	46.1	30.6	1.6	19.5	42.5	69.8	100.0
Training time per employee	1999	days	2.0	3.0	0.0	0.4	1.2	2.6	11.0
Training time per employee, internal	1999	days	0.8	1.7	0.0	0.0	0.2	1.0	5.9
Training time per employee, external	1999	days	1.2	2.1	0.0	0.2	0.6	1.5	7.7
Training expenditures per employee	1999	€	654	853	11	155	404	800	4514
Employment (average)	1998&2000		277	720	22	62	106	211	3204

Shares

Variable	Period	Unit	Share
Major organizational change	1999	%	26.4
New process technology	1999	%	63.0
Introduction of a new product	1999	%	57.4
Hired, basic education	1998-2000	%	5.6
Hired, vocational education	1998-2000	%	17.7
Hired, university degree(Bachelor-)	1998-2000	%	3.2
Separated, basic education	1998-2000	%	6.7
Separated, vocational education	1998-2000	%	16.2
Separated, univ. degree(Bachelor-)	1998-2000	%	2.7
Stayers, basic education	1998-2000	%	26.3
Stayers, vocational education	1998-2000	%	63.3
Stayers, univ. degree(Bachelor-)	1998-2000	%	10.4

Sample size: 916 firms

Table 2. *Correlation matrix*

Panel (a)

	Share of trained	Training time	Training time, internal	Training time, external	Training expend.	Organi-zational innov.	Process innov.	Product innov.
Share of trained	1							
Training time	0.4802*	1						
Training time, internal	0.3382*	0.7121*	1					
Training time, external	0.3898*	0.8194*	0.1810*	1				
Training expenditure	0.4426*	0.4747*	0.2337*	0.4672*	1			
Organizational innov.	0.1275*	0.1931*	0.1450*	0.1521*		1		
Process innovation		0.1650*	0.1700*		0.1246	0.2183*	1	
Product innovation		0.1356*	0.1493*		0.1296*	0.2156*	0.5576*	1

Panel (b)

	Training time, internal	Training time, external	Organi-zational innov.	Process innov.	Product innov.	Hiring, basic educ.	Hiring, voc. educ.	Hiring, univ. educ.
Training time, internal	1							
Training time, external	0.1810*	1						
Organizational innov.	0.1450*	0.1521*	1					
Process innovation	0.1700*		0.2183*	1				
Product innovation	0.1493*		0.2156*	0.5576*	1			
Hiring, basic educ.	-0.1053	-0.1658*				1		
Hiring, voca.educ.						0.4779*	1	
Hiring, univ. degree	0.1227*	0.1651*	0.1370*		0.1285*	-0.1367*	0.1081	1

Note: Correlation coefficients appearing without a star are significant at the level of 5% and those with the star at the level of 1%. Empty cells indicate that the correlation is not statistically significant

Table 2 exhibits correlation patterns for the main explanatory variables in our data. Panel (a) shows that the share of trained workers is significantly correlated with all the other training variables as well as with organizational change but not with process or product innovations. Externally organized training time exhibits a similar correlation pattern. The training expenditure indicator, in contrast, is positively correlated with process and product innovations but uncorrelated with organizational change. Internally organized training time, finally, correlates positively with all three types of innovation. Panel (b) sheds further light on the different skills upgrading strategies by exploring the simple correlation between the training, innovation and hiring variables. Hiring low educated workers (i.e. basic education only) is negatively correlated with internally and externally organized training time. Hiring workers with only a basic or vocational education is uncorrelated with all three types of innovation, while new hires with a university degree show a strong positive correlation with both training and innovation activities (except for process innovations). These correlation patterns point to the importance of considering the two alternative skills upgrading strategies jointly.

4.2. Econometric analysis of firms’ training and hiring strategies

Table 3 presents our baseline results for productivity growth.[12] The training intensity estimate is negatively signed and only weakly statistically significant (columns (1) and (3)). These two models, however, also include a term describing interaction between training time and process innovations[13], implying that the training coefficient actually reflects the average productivity effect among firms not having implemented any process innovations. The positive and statistically significant coefficient for the interaction term points to non-negligible complementarity between implementing process innovations and providing training. On the basis of the estimates given in column (1) of Table 3 it can be calculated that process innovations coupled with a training spell of 2.64 days (amount equaling the 3rd quartile) would yield –5.7 percentage points (= –0.065 + 2.64*(–0.031 + 0.034)) lower productivity growth compared with no innovations and no training.

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[12] All models reported in this paper include the log of the labor productivity level in 1999 (to control for the catching-up potential), the log of the firm average wage level in 1999 and the log-change of capital intensity (capital per person) to control for the effect of capital deepening on labor productivity growth. Furthermore, all models include a set of industry dummies.

[13] The independent effect of process innovations is estimated to be negative and statistically significant, an outcome repeated in Table 4 below. It may be noted in this context that also Maliranta (2000) reports process innovations to have a negative impact on (labor as well as total factor) productivity growth of Finnish business firms.

Table 3. *Firms' skills upgrading strategies and productivity growth, weighted OLS*

	(1)	(2)	(3)
Training time	-0.031+	-0.001	-0.030+
	(0.016)	(0.005)	(0.017)
Process innovation	-0.065+		-0.055
	(0.034)		(0.035)
(Process inn.)x(training time)	0.034*		0.035*
	(0.016)		(0.017)
Hired, basic education	-0.891*	-0.882*	
	(0.348)	(0.348)	
Hired, voc. education	-0.048	-0.056	
	(0.175)	(0.177)	
Hired, university degree	-0.804+	-0.760+	
	(0.423)	(0.420)	
Separated, basic educ.	0.664+	0.680+	
	(0.363)	(0.373)	
Separated, voc. educ.	-0.230	-0.230	
	(0.262)	(0.267)	
Separated, university degree	0.697	0.774	
	(0.672)	(0.673)	
Stayers, voc. educ.	0.254*	0.252*	
	(0.125)	(0.126)	
Stayers, university degree	0.423+	0.413+	
	(0.227)	(0.229)	
Ln(value added / emp.),1999	-0.123***	-0.121**	-0.122**
	(0.036)	(0.039)	(0.039)
Ln(wage / emp.),1999	-0.103	-0.123	0.060
	(0.095)	(0.095)	(0.099)
Δln(K/L),1999-2001	0.047	0.041	0.066+
	(0.039)	(0.038)	(0.038)
No. of observations	916	916	916
R squared	0.303	0.292	0.248
Adj. R squared	0.256	0.246	0.204

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Note: Other control variables include 45 industry dummies. Employment weighted estimation (the average of years 1998 and 2000).

Table 4 reports results from models that involve three extensions to the models in Table 3. First, internally organized training time is now distinguished from that organized externally. Second, we consider profitability growth along with productivity growth. Third, we also cover the potential impact of organizational change. The results in column (1) suggest that internally organized training time has a negative impact on productivity growth in firms not having implemented process innovations but a productivity-enhancing effect in firms having implemented process innovations (0.014 = –0.047 + 0.061), which is statistically significant at the level of 2.2% (calculated by the post-estimation of the linear combinations of coefficients).[14] However, a considerable amount of internal training is needed to turn the productivity effect of process innovations positive. According to our estimates the break-even point is achieved at the level of 5.1 days (= 0.071 / (–0.047 + 0.061)) per employee. And according to the estimates in column (3), the firms' investments in internally organized training time would need to be more than doubled (11.3 days = 0.079 / (–0.051 + 0.058)) in order to achieve the break-even point of profitability growth within a two-year period. The results shown in columns (2) and (4) indicate that a fundamental organizational change leaves both productivity and profitability growth unaffected, at least in the short term. There are no complementarity effects of internally organized training time and organizational change on productivity or profitability growth either. In all specifications in Table 4 externally organized training time and its interactions result in insignificant estimates.

Experiments with our alternative training measures (results not reported here) gave no indication whatsoever of a positive productivity or profitability growth effect for the share of trained workers, nor of any complementarity between this share and process innovations. Weak evidence in support of such complementarity effects was obtained for average training expenditure per employee but only in the case of productivity growth (not for profitability growth).

We next turn to the hiring strategy results reported in Tables 3 and 4. Unsurprisingly, low educated new hires (those with basic education only) have a substantially lower productivity level than the average worker continuing in the firm. Accordingly these new hires influence productivity growth negatively. Their effect on profitability growth is less negative (columns (3) and (4) in Table 4) being in effect statistically insignificant. This is also to be expected in view of their relatively low wage level. More intriguingly, the university educated new hires turn out to have a similar negative effect on productivity growth. Due to their relatively high wage level the effect is even more negative on profitability growth (Table 4). The results for the share of incumbent workers with a post-compulsory education provide some support to productivity growth involving a Nelson–Phelps effect. In particular, although the university educated new hires are costly to the firm, these investments seem to pay off in the longer run, at least in terms of productivity growth. The corresponding effects on profitability growth are positive but statistically insignificant (Table 4).

[14] We also obtained support for internally (but not externally) organized training time being complementary to product innovations (results not reported here), the coefficient of the interaction term being a statistically significant 0.041 in the productivity growth model. Neither the coefficient of the product innovation variable (–0.025) nor that of the internally organized training time variable (–0.027) were statistically significant. Based on these estimates, the break-even point of product innovations is achieved with an internally organized training time of 1.8 days per employee per year.

Table 4. *Skills upgrading strategies and change in firm performance, weighted OLS*

	productivity growth		profitability growth	
	(1)	(2)	(3)	(4)
Internal training time	-0.047*	0.002	-0.051*	-0.011
	(0.020)	(0.011)	(0.021)	(0.012)
External training time	-0.021	-0.021	-0.013	-0.010
	(0.018)	(0.013)	(0.018)	(0.013)
Process innovation	-0.071*		-0.079*	
	(0.033)		(0.032)	
(Proc. inn.)x(int. train.)	0.061**		0.058**	
	(0.020)		(0.021)	
(Proc. inn.)x(ext. train.)	0.017		0.013	
	(0.018)		(0.018)	
Organizational innovation		-0.018		-0.031
		(0.028)		(0.030)
(Organ. inn.)x(int. train.)		0.009		0.020
		(0.013)		(0.013)
(Organ. inn.)x(ext. train.)		0.018		0.012
		(0.014)		(0.014)
Hired, basic education	-0.880*	-0.895*	-0.559	-0.562
	(0.348)	(0.352)	(0.358)	(0.360)
Hired, voc. education	-0.055	-0.059	-0.042	-0.044
	(0.176)	(0.180)	(0.180)	(0.185)
Hired, univ. degree	-0.794+	-0.810+	-0.997*	-0.990*
	(0.421)	(0.431)	(0.410)	(0.416)
Separated, basic educ.	0.652+	0.681+	0.228	0.258
	(0.363)	(0.374)	(0.295)	(0.301)
Separated, voc. educ.	-0.226	-0.239	-0.089	-0.101
	(0.262)	(0.268)	(0.253)	(0.258)
Separated, univ. degree	0.728	0.752	0.338	0.366
	(0.670)	(0.676)	(0.668)	(0.672)
Stayers, voc. educ.	0.249*	0.266*	0.116	0.141
	(0.125)	(0.127)	(0.116)	(0.115)
Stayers, univ. degree	0.411+	0.446+	0.146	0.179
	(0.225)	(0.230)	(0.223)	(0.228)
Ln(value added /emp.),1999	-0.126***	-0.121**	-0.136**	-0.135***
	(0.036)	(0.038)	(0.038)	(0.040)
Ln(wage / emp.),1999	-0.094	-0.122	0.153+	0.134+
	(0.095)	(0.096)	(0.083)	(0.081)
Δln(K/L),1999-2001	0.048	0.042	-0.022	-0.024
	(0.039)	(0.038)	(0.037)	(0.036)
No. of observations	916	916	916	916
R squared	0.308	0.299	0.242	0.232
Adj. R squared	0.260	0.250	0.189	0.178

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Note: Other control variables include 45 industry dummies. Employment weighted estimation (the average of years 1998 and 2000).

The above results reveal certain findings which are both statistically significant and interesting from the standpoint of the existing theoretical and empirical literature on the issue. Nevertheless a word of caution for drawing too strong conclusions is warranted. Two problems emerge due to the use of training and innovation survey data. First, the firm sample size shrinks more than one would wish when trying to examine volatile changes such as those of firm performance. Additionally, the measurement accuracy of the variables of our interest may not be satisfactory in all cases. A relatively small number of firms may thus pivot the results. This should be of concern especially as we found positive effects of training for a particular sub-group of firms only, that is, for firms having implemented process innovations. For this reason we have undertaken various robustness checks of our key findings.

The measurement accuracy of the variables used can be expected to be worse among smaller firms than among larger ones. This is one major reason for only reporting results obtained from (employment) weighted estimations. Unweighted estimations may be particularly vulnerable to outlier firms, many of which are often small. Yet, also these estimations indicate complementarity between process innovations and internally organized training time, and if excluding this interaction term, both the process innovation and the internally organized training time variable come out with a significantly negative impact on productivity as well as profitability growth. Moreover, also these unweighted estimations point to a statistically significant Nelson–Phelps effect of highly educated workers on productivity growth.[15] Arguably median regression and so-called robust regression should produce more reliable results than OLS regression when not using weights. Hence, results corresponding to those presented in Table 4 but obtained from robust regression are given in Appendix Table A.1.

Notwithstanding some differences to the results in Table 4, robust regression estimations[16] seem to provide further support to our key findings: complementarity between process innovations and internally organized training time, no complementarity between organizational change and internally organized training time, no effect of externally organized training time, a short-term negative impact on productivity and profitability growth of university educated new hires, and a Nelson–Phelps productivity growth effect of highly educated workers. Also the median regression estimations reveal a similar but slightly weaker pattern of effects (not reported here).

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[15] The coefficient for the share of university educated workers is 0.350 (statistically significant at the 1.6% level).

[16] This estimation method has been proposed by Li (1985). The method runs an initial OLS regression, then calculates Cook’s distance, eliminates outliers for which Cook’s distance exceeds 1 and, finally, performs iterations based on Huber weights followed by iterations based on a biweight function (see the STATA manual).

4.3 A closer look at the hiring strategy

We now leave training aside and focus in more detail on the hiring strategy of firms. This increases our sample size to 3,718 firms, which offers a substantial amount of additional degrees of freedom for our analysis. The new hires are split into two groups: those who were recently hired (employed in the firm in 2000 but not in 1998 or 1999) and those who were hired a year ago (employed in the firm in 1999 and 2000 but not in 1998). Table 5 presents the results.

Table 5. *Hiring strategy and change in firm performance (Bachelor's degree delineation), weighted OLS*

	productivity profitability growth	wage growth	growth
	(1)	(2)	(3)
Hired, basic educ., 1 year	-0.697*	-0.331*	-0.386
	(0.297)	(0.131)	(0.263)
Hired, voc. educ., 1 year	-0.316*	-0.154**	-0.197
	(0.135)	(0.049)	(0.131)
Hired, univ. degree, 1 year	-0.590+	0.366*	-0.913**
	(0.311)	(0.152)	(0.309)
Hired, basic educ., 2 year	0.323	0.298	0.033
	(0.379)	(0.263)	(0.211)
Hired, voc. educ., 2 year	-0.094	-0.028	-0.042
	(0.144)	(0.083)	(0.115)
Hired, univ. degree, 2 year	-0.767*	-0.017	-0.779*
	(0.360)	(0.159)	(0.356)
Separated, basic educ.	0.108	0.074	0.078
	(0.206)	(0.137)	(0.142)
Separated, voc. educ.	-0.080	-0.052	-0.029
	(0.105)	(0.059)	(0.091)
Separated, univ. degree	0.600*	0.157	0.577*
	(0.286)	(0.137)	(0.289)
Stayers, voc. educ.	0.167*	0.126***	0.082
	(0.065)	(0.036)	(0.062)
Stayers, univ. degree	0.386***	0.330***	0.079
	(0.101)	(0.049)	(0.099)
Ln(value added / emp.),1999	-0.177***	0.031***	-0.198***
	(0.028)	(0.008)	(0.024)
Ln(wage / emp.),1999	-0.110*	-0.330***	0.183***
	(0.052)	(0.026)	(0.047)
Δln(K/L),1999-2001	0.055*	0.071***	-0.020
	(0.022)	(0.012)	(0.017)
No. of observations	3718	3718	3718

R squared	0.252	0.344	0.231
Adj. R squared	0.238	0.332	0.216

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Note: Other control variables include 54 industry dummies. Employment weighted estimation (the average of years 1998 and 2000).

The results suggest that new hires initially slow down productivity growth irrespective of their educational attainment level, even though this negative effect is found to be notably lower for those with a vocational education as compared to their less and more educated counterparts (column (1) in Table 5). The wage growth effects in column (2) show that new hires with a university degree have high wages. The profitability effects are negative for all three education groups but because of relatively large standard errors only the coefficient for the university educated new hires is statistically significant (column (3) in Table 5). When considering new hires made one year ago we find that the coefficients for the two lowest education groups are pretty close to zero while it is significantly negative for the university educated workers. The results for separating workers provide further support to the conjecture that workers with a university degree are not directly engaged in production: the immediate effect of them leaving the firm is improved productivity and profitability growth.

Why then do firms hire university educated people? And why do they not try to get rid of their highly educated workers? At least part of an answer is offered by the results in Table 5 for staying workers. By hiring university educated individuals and by trying to keep them in the firm, the share of staying workers with a university degree increases. According to our estimates, a one percentage point increase in the share of university educated workers will, if accompanied by a corresponding decline in the share of the least educated, boost productivity growth by 0.386 percentage points over a two-year period (i.e. by 0.193 %-points per year). Assuming that the average tenure is roughly 10 years and the average share of the university educated among the stayers is about one-tenth, these workers can be shown to make a substantial contribution to their firm's productivity performance over a decade (some 20 percentage points). Obviously there must be some optimum level above which it is not productive for a firm to increase the share of the university educated workers. There must also be workers who use the technology to produce output. The hired university educated workers also raise the wage level in the firm, which tends to leave the profitability growth effect positive but statistically insignificant.

So far the group of university educated has comprised all workers with a Bachelor's degree or more. In order to deepen our investigation of the role of university education further we have also used an alternative grouping of workers by education. More precisely, we have re-classified those with a Bachelor's degree and moved them to the group containing workers with a vocational education. The results with the re-classified education groups are given in Table 6. These results reveal a few conspicuous changes compared to those reported in Table 5. Most notably, the immediate productivity effect of the university educated new hires becomes even more negative and that of the university educated leavers correspondingly more positive. Indeed, these two effects are roughly doubled compared to the estimates displayed in Table 5. Also the Nelson–Phelps effect on productivity growth is strengthened relative to both groups of less educated workers. Table A.2 in the Appendix reports the corresponding estimates obtained with (unweighted) median regression. These results provide further support to our main findings.

Table 6. *Hiring strategy and change in firm performance (Master's degree delineation, (a)), weighted OLS*

	productivity growth	wage growth	profitability growth
Hired, basic educ., 1 year	-0.742*	-0.361**	-0.399
	(0.291)	(0.135)	(0.255)
Hired, voc. educ.[(a)], 1 year	-0.301*	-0.127**	-0.210+
	(0.124)	(0.046)	(0.121)
Hired, univ. degree[(a)], 1 year	-1.460**	0.522*	-1.812***
	(0.508)	(0.253)	(0.490)
Hired, basic educ., 2 year	0.375	0.326	0.057
	(0.383)	(0.265)	(0.215)
Hired, voc. educ.[(a)], 2 year	-0.169	-0.047	-0.098
	(0.131)	(0.073)	(0.108)
Hired, univ. degree[(a)], 2 year	-0.871	0.060	-1.025+
	(0.566)	(0.270)	(0.548)
Separated, basic educ.	0.104	0.062	0.084
	(0.206)	(0.134)	(0.141)
Separated, voc. educ.[(a)]	-0.056	-0.050	-0.000
	(0.099)	(0.055)	(0.087)
Separated, univ. degree[(a)]	1.074**	0.228	1.025**
	(0.412)	(0.232)	(0.396)
Stayers, voc. educ.[(a)]	0.212**	0.181***	0.074
	(0.065)	(0.037)	(0.061)
Stayers, univ.degree[(a)]	0.537***	0.447***	0.098
	(0.157)	(0.089)	(0.152)
Ln(value added / emp.),1999	-0.176***	0.031***	-0.197***
	(0.028)	(0.008)	(0.024)
Ln(wage / emp.),1999	-0.103*	-0.324***	0.184***
	(0.052)	(0.026)	(0.046)
Δln(K/L),1999-2001	0.054*	0.071***	-0.021
	(0.022)	(0.012)	(0.017)
No. of observations	3718	3718	3718
R squared	0.251	0.336	0.234
Adj. R squared	0.237	0.324	0.220

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Note: Other control variables include 54 industry dummies. Employment weighted estimation (the average of years 1998 and 2000).

Finally we examine the underlying dynamics in greater detail. As before, productivity and profit growth is measured over the period 1999 to 2001. In addition to the worker flows for the period 1998–2000 we now also include as explanatory variables the corresponding worker flows for the periods 1996–1998 and 2000–2002. The results are reported in Table 7.[17]

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[17] This part of our analysis bears some resemblance to that of Blomström et al. (1996). With panel data from different countries they examine how past, current and future investments are associated with current economic growth. They find a strong positive relationship between current economic growth and

The results fit well to the general picture that has emerged in the above analysis. Columns (1) and (2) in Table 7 show that university educated new hires are initially highly productivity-decreasing and costly to the firm (evident from the economically and statistically significant negative coefficients in the productivity and profitability equations for the contemporary, i.e. the 1998–2000 period, hiring variable for university educated workers). However, the corresponding lagged variable (for the period 1996–1998) is statistically insignificant implying that this negative effect on productivity and profitability growth is only temporary. Furthermore, the significantly positive estimate of the lagged variable for the share of staying university educated workers suggests that university educated new hires are productivity-enhancing given that they stay with their firm. Columns (3) and (4), finally, also include variables for future hirings and separations. These results show that current productivity and profitability growth is negatively correlated with future separations of university educated workers. In other words, a negative productivity or profitability shock in the firm seems to lead to a decline in the number of university educated workers through increased separations.

All in all, there appears to be a clear-cut link from productivity (and profitability) growth to the net growth in the share of university educated workers which might give rise to a simultaneity problem and, as a consequence, upward-biased estimates. However, it seems highly unlikely that a productivity (or profitability) shock experienced between 1999 and 2001 has had a marked impact on the firm's hiring (or separation) behavior in the previous period, that is, in 1998 to 2000. First, it certainly takes time for a firm to realize that it has experienced such a positive (and permanent) shock that it would make the hiring of university educated workers a good strategy. Secondly, recruitment of highly educated workers takes time, for which reason we can expect to observe a profit-stimulated increase in hiring rates only after a certain lag.[18] Indeed, according to our results in columns (3) and (4) of Table 7 there is a positive relationship between *current* (1999–2001) productivity (and profitability) growth and *subsequent* (2000–2002) university educated new hires (which is consistent with the idea of a positive shock inducing firms to invest in their human capital by a hiring strategy) but the coefficients are statistically insignificant.

These findings also underline the importance of carefully considering timing when analyzing changes in firm performance in order to eliminate, or at least substantially mitigate, any potential simultaneity bias arising from firms' propensity to respond to productivity and profitability shocks in their hiring and separation strategies. All in all, one of our main findings –that the university educated new hires are initially (very) costly to the firm – is hardly a fallacy derived from a simultaneity bias.

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future capital formation, indicating that favorable economic development induces investments. Current investments have an insignificant and past investments a significant negative effect on economic growth when fixed country effects are controlled.

[18] For example, Lynch (2007) finds that past profits are positively correlated with organizational innovation.

Table 7. *Productivity and profit growth in 1999-2001 and worker flows in different time-windows (Master's degree delineation, (a)), weighted OLS*

	productivity growth (1)	profit growth (2)	productivity growth (3)	profit growth (4)
Hired, basic education, 96-98	-0.115	0.085	-0.158	0.045
	(0.261)	(0.233)	(0.271)	(0.249)
Hired, basic education, 98-00	-0.276	-0.202	-0.314	-0.251
	(0.266)	(0.185)	(0.316)	(0.231)
Hired, basic education, 00-02			0.250	0.247+
			(0.182)	(0.132)
Hired, voc. education[(a)],96-98	-0.198+	-0.217*	-0.191+	-0.226*
	(0.113)	(0.105)	(0.114)	(0.105)
Hired, voc. education[(a)], 98-00	0.184+	-0.102	-0.152	-0.080
	(0.098)	(0.095)	(0.119)	(0.117)
Hired, voc. education[(a)], 00-02			-0.017	0.058
			(0.103)	(0.100)
Hired, univ. education[(a)], 96-98	0.409	0.394	0.417	0.342
	(0.494)	(0.456)	(0.449)	(0.411)
Hired, univ. education[(a)],98-00	-1.063**	-1.392***	-0.754+	-1.087**
	(0.384)	(0.354)	(0.420)	(0.404)
Hired, univ. education[(a)], 00-02			0.376	0.410
			(0.401)	(0.362)
Separated, basic educ., 98-00	0.298	0.312	0.252	0.276
	(0.213)	(0.192)	(0.222)	(0.200)
Separated, basic educ., 98-00	0.133	-0.081	0.017	-0.193
	(0.288)	(0.229)	(0.286)	(0.230)
Separated, basic educ., 98-00			-0.008	-0.010
			(0.214)	(0.180)
Separated, voc. educ.[(a)], 96-98	-0.163	-0.113	-0.158	-0.108
	(0.143)	(0.136)	(0.147)	(0.140)
Separated, voc. educ.[(a)], 98-00	0.064	0.133	0.199	0.257+
	(0.135)	(0.124)	(0.140)	(0.132)
Separated, voc. educ.[(a)], 00-02			-0.194	-0.202+
			(0.121)	(0.107)
Separated, univ. educ.[(a)], 96-98	0.287	0.485	0.244	0.461
	(0.369)	(0.319)	(0.352)	(0.305)
Separated, univ. educ.[(a)], 98-00	0.438	0.498	0.203	0.392
	(0.530)	(0.514)	(0.556)	(0.521)
Separated, univ. educ.[(a)], 00-02			-0.814+	-0.895+
			(0.486)	(0.488)
Stayers, voc. educ.[(a)], 96-98	0.162	-0.069	0.076	-0.124
	(0.191)	(0.156)	(0.196)	(0.160)
Stayers, voc. educ.[(a)], 98-00	0.156	0.246	0.247	0.316+
	(0.207)	(0.173)	(0.214)	(0.176)
Stayers, univ. educ.[(a)], 96-98	0.607*	0.240	0.541*	0.213
	(0.240)	(0.199)	(0.246)	(0.201)
Stayers, univ. educ.[(a)], 98-00	-0.009	-0.133	0.112	-0.049
	(0.270)	(0.287)	(0.273)	(0.272)
Observations	3395	3395	3240	3240
R-squared	0.267	0.249	0.282	0.262
Adj. R-squared	0.251	0.232	0.264	0.244

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Note: Other control variables include the initial productivity and wage levels in 1999 (in logs), log-change in capital per labor and 54 industry dummies. Employment weighted estimation (the average of years 1998 and 2000).

5. CONCLUSIONS

Our study has shed new light on the crucial role of intangible asset accumulation for firm performance using a rich longitudinal register-based employer–employee dataset augmented with information on firm-level training and innovation activities drawn from the 1999 Continuous Vocational Training Survey (CVTS2). The focus has been on the two major strategies that the firm has at hand when upgrading the human capital of its personnel. The firm can either hire highly educated labor (or try to keep it in the firm) or train its current personnel, or do both.

First, internally (but not externally) organized employer-provided training is found to stimulate subsequent growth of productivity and profitability but only when combined with the implementation of new process or product technologies. This finding also suggests that omitted variable bias is a potential explanation for the still rather inconclusive evidence on the productivity and profitability effects of firm-provided training. On the other hand, in our productivity and profitability analyses we do not find any evidence on complementarity between training and organizational innovation. One possible explanation for this outcome is that in the case of a fundamental organizational innovation the time-window as well as the array of other complementary factors involved may be too broad to be captured with our current data. Further efforts in this area are left for future work.

Second, our findings suggest that training investments need to be measured in a way that properly takes into account the intensity of training (we use the number of training days per employee as our preferred measure). Hence, the way training is measured is not irrelevant for the analysis, which offers another potential explanation for the inconclusiveness of the existing evidence.

Last but not least, the university educated new hires initially have a strongly negative impact on productivity and profitability, but in the longer term they contribute markedly to productivity growth. Hence, this finding provides support for the so-called Nelson–Phelps hypothesis stating that highly educated workers are more like a factor of technical *change* and productivity *growth* in the firm and should not be seen narrowly as just another factor of production. In particular, our results show that when it comes to productivity dynamics, the strategy of hiring university educated workers differs strikingly from that of hiring vocationally educated workers or providing training for incumbent workers. Positive productivity effects of university educated workers seem to emerge only gradually in the course of time through the Nelson–Phelps effect. We interpret our results as providing support to the conjecture that the general skills of university educated workers help the firm to create or adopt effectively new technologies and this shows up later on in the firm’s productivity performance. It is also possible that highly educated workers provide informal training to less educated workers and stimulate their productivity growth in that way. Thus, this mechanism may also explain a positive relationship between the share of highly educated workers and the firm's productivity growth found in our results.

Different firms experience different productivity dynamics depending on their human resource management strategies. Differences in productivity growth may be particularly pronounced in eras of rapid technological change. For instance, Krueger and Kumar (2004) argue that differences in productivity development between the United States and Europe during the past four decades can be explained by differences in the focus of education systems and, consequently, in the prominence of different kinds of skills of workers. As their argument goes, vocational and specialized education has gained more attention in Europe compared to the United States. This was beneficial, initially, for Europe's productivity growth during the 1960s and 1970s but became a burden during the 1980s and 1990s, when new technologies emerged at a more rapid rate. Education policies in the United States, instead, have leaned more on general university education, which is seen to have facilitated the adoption of new techniques.

While this study demonstrates the importance of intangible capital (firm-specific resources more specifically) built by training, product and process innovations and recruitment policies, our results also point to some challenges in explaining economic development by use of standard growth accounting methods and aggregate data. Summing the costs involved over all firms may not be enough. Owing to complementarities at the firm level it is crucial to account for how training and innovations coincide in firms. We have shown that firm-provided training, process and product innovations, organizational change and hiring of university educated workers usually go hand in hand in the firm. Additionally we have reported evidence that providing training to the employees or implementing a process innovation (or making a product innovation) by its own is more likely to deteriorate rather than to improve the firm's performance whereas implementing them together is likely to lead to positive outcomes. Another important issue concerns the role of higher education in the economic growth process, as also emphasized by Nelson and Phelps (1966) and more recently by e.g. Benhabib and Spiegel (1994) and Vandenbussche et al. (2006) (see also the discussion in Krueger and Lindahl (2001)). Both the change and the level of human capital matter for productivity growth. This is because human capital is needed not only for using technologies but also for generating new technologies as well as for adopting and implementing the current leading-edge technologies. Finally, the substantial time lags occurring at the firm level may within the standard growth accounting framework lead to serious distortions in the interpretation of economic development, especially in eras of rapid and profound technological revolutions when new technologies are adopted which require general skills achieved in universities.

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Appendix

Table A.1. *Skills upgrading strategies and change in firm performance, robust regression*

	productivity growth		profitability growth	
	(1)	(2)	(3)	(4)
Internally organized training time	-0.025	-0.002	-0.016	0.000
	(0.015)	(0.008)	(0.012)	(0.006)
Externally organized training time	0.005	-0.001	0.006	0.003
	(0.008)	(0.006)	(0.006)	(0.005)
Process innovation	-0.020		-0.018	
	(0.017)		(0.014)	
(Proc. inn.)x(int. train.)	0.035*		0.023+	
	(0.016)		(0.012)	
(Proc. inn.)x(ext. train.)	-0.008		-0.005	
	(0.008)		(0.007)	
Organizational innovation		-0.003		-0.005
		(0.019)		(0.015)
(Organ. inn.)x(int. train.)		0.013		0.006
		(0.009)		(0.007)
(Organ. inn.)x(ext. train.)		-0.001		-0.001
		(0.007)		(0.006)
Hired, basic education	-0.276+	-0.288+	-0.162	-0.157
	(0.158)	(0.158)	(0.125)	(0.125)
Hired, voc. education	-0.111	-0.117	-0.097	-0.100
	(0.084)	(0.084)	(0.066)	(0.066)
Hired, university degree	-0.600*	-0.631*	-0.422*	-0.425*
	(0.248)	(0.249)	(0.195)	(0.196)
Separated, basic educ.	0.309*	0.312*	0.202+	0.197+
	(0.146)	(0.146)	(0.115)	(0.116)
Separated, voc. educ.	-0.025	-0.023	0.145*	0.156*
	(0.088)	(0.088)	(0.069)	(0.069)
Separated, university degree	0.593+	0.626*	0.385	0.397
	(0.308)	(0.309)	(0.243)	(0.244)
Stayers, voc. educ.	-0.026	-0.010	-0.098+	-0.095
	(0.074)	(0.074)	(0.058)	(0.058)
Stayers, university degree	0.191+	0.205+	-0.081	-0.079
	(0.113)	(0.113)	(0.089)	(0.090)
Ln(value added/emp.),1999	-0.109***	-0.105***	-0.135***	-0.134***
	(0.021)	(0.021)	(0.017)	(0.017)
Ln(wage / emp.),1999	-0.069	-0.084+	0.184***	0.178***
	(0.043)	(0.043)	(0.034)	(0.034)
Δln((K/L)),1999-2001	0.022	0.024	-0.006	-0.005
	(0.017)	(0.017)	(0.013)	(0.013)
No. of observations	916	916	916	916
R squared	0.191	0.190	0.230	0.225
Adj. R squared	0.134	0.133	0.175	0.170

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Note: Note: Other control variables include 45 industry dummies.

Table A.2. *Hiring strategy and change in firm performance, (Master's degree delineation, (a)), (unweighted) median regression*

	productivity growth	wage growth	profitability growth
	(1)	(2)	(3)
Hired, basic educ., 1 year	-0.183+	-0.146**	0.068
	(0.107)	(0.045)	(0.062)
Hired, voc.[a] educ., 1 year	-0.204***	-0.104**	-0.127*
	(0.052)	(0.037)	(0.050)
Hired, univ.[a] educ., 1 year	-0.367	0.424**	-0.594*
	(0.350)	(0.152)	(0.234)
Hired, basic educ., 2 year	-0.170	-0.192*	-0.040
	(0.132)	(0.086)	(0.134)
Hired, voc.[a] educ., 2 year	-0.035	0.027	-0.021
	(0.064)	(0.041)	(0.057)
Hired, univ.[a] educ., 2 year	-0.425	-0.051	-0.505
	(0.407)	(0.197)	(0.420)
Separated, basic educ.	0.058	0.068	0.047
	(0.088)	(0.043)	(0.046)
Separated, voc.[a] educ.	-0.034	-0.048*	0.024
	(0.045)	(0.023)	(0.042)
Separated, univ.[a] educ.	0.523+	0.112	0.221
	(0.289)	(0.142)	(0.208)
Stayers, voc.[a] educ.	0.111**	0.097***	0.015
	(0.040)	(0.018)	(0.020)
Stayers, univ.[a] educ.	0.309*	0.195***	0.031
	(0.155)	(0.053)	(0.078)
Log(val. ad. / emp.),1999	-0.212***	0.012+	-0.232***
	(0.014)	(0.007)	(0.018)
Log(wage / emp.),1999	0.017	-0.206***	0.272***
	(0.026)	(0.017)	(0.029)
Δln(K/L),1999-2001	0.059***	0.041***	0.007
	(0.016)	(0.007)	(0.009)
Observations	3718	3718	3718
Pseudo R-squared	0.081	0.082	0.076

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Note: Other control variables include 54 industry dummies.

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