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Keskusteluaiheita – Discussion papers

No. 993

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DECOMPOSING PRODUCTIVITY AND WAGE EFFECTS OF INTRA-ESTABLISHMENT LABOR RESTRUCTURING***

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*** Both writers acknowledge financial support provided by Tekes within the Research Programme for Advanced Technology Policy (ProAct) and Maliranta funding by Yrjö Jahnsson Foundation for studying decomposition methods. The data work and computations have been carried out at Statistics Finland, in accordance with the terms and conditions of confidentiality. We have benefited from comments by Rita Asplund. Of course, the usual disclaimer applies. We thank Pekka Vanhala for research assistance. We are also thankful to many individuals at Statistics Finland for their guidance regarding the properties of the data. Please contact the Research Laboratory of the Business Structures Unit, Statistics Finland, FIN-00022, Finland, for access to these data. The SAS and Stata codes used in this study are available from the authors upon request.

ISSN 0781-6847 2.11.2005

MALIRANTA, Mika – **ILMAKUNNAS**, Pekka, **DECOMPOSING PRODUCTIVITY AND WAGE EFFECTS OF INTRA-ESTABLISHMENT LABOR RESTRUCTURING.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2005, 26 p. (Keskusteluaiheita, Discussion papers, ISSN 0781-6847; No. 993).

ABSTRACT: Aggregate productivity growth can be decomposed into growth within establishments, between establishments, and the impact of entering and exiting establishments. We demonstrate that such a productivity decomposition formula can also be used for studying intra-establishment restructuring through the inflow and outflow of workers There are, however, three requirements: Firstly, comprehensive longitudinal linked employer-employee data are needed. Secondly, now the productivity decomposition formula cannot be used for accounting but must be used as an estimation model. Thirdly, the decomposition formula should be such that a meaningful interpretation of its components is possible. The decomposition can also account for different worker types, e.g. age groups. We apply such a method to study the productivity growth and wage growth within the establishments of the Finnish business sector. The results provide empirical evidence on economic incentives for hiring young workers and separating older workers.

Keywords: employer-employee data, labor productivity, productivity decomposition, wage determination, worker turnover
JEL-code: C43, J23, J24, J63, M51

MALIRANTA, Mika – **ILMAKUNNAS**, Pekka, **TOIMIPAIKAN SISÄISEN RAKENNEMUUTOKSEN TUOTTAVUUS- JA PALKKAVAIKUTUSTEN DEKOMPONOINTI.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2005, 26 p. (Keskusteluaiheita, Discussion papers, ISSN 0781-6847; No. 993.

TIIVISTELMÄ: Toimialan tuottavuuden kasvu voidaan dekomponoida toimipaikkojen omaan kasvuun, markkinaosuuksien muutokseen, sekä uusien ja poistuvien toimipaikkojen tuottavuusvaikutukseen. Osoitamme, että samanlaista tuottavuuden dekomponointia voidaan soveltaa myös toimipaikkojen sisäisen rakennemuutoksen tutkimiseen työntekijävirtojen avulla. Tällaisella analyysilla on kuitenkin kolme vaatimusta. Ensiksi, tarvitaan laaja yhdistetty työntekijä-työnantaja-pitkittäisaineisto. Toiseksi, nyt dekomponointimenetelmää ei voida käyttää laskentakaavana vaan estimointiyhtälönä. Kolmanneksi, dekomponointimenetelmän pitää olla sellainen, että sen komponentteja voidaan tulkita mielekkäästi. Dekomponointiin voidaan sisällyttää myös eri työntekijäryhmiä (esim. ikäryhmiä). Käytämme tällaista menetelmää tutkiessamme suomalaisten yrityssektorin toimipaikkojen tuottavuus- ja palkkakehitystä. Tuloksemme antavat empiiristä näyttöä siitä, että yrityksillä on taloudellisia kannustimia palkata nuoria ja irtisanoa vanhempia työntekijöitä.

Avainsanat: työntekijä-työnantaja aineisto, työn tuottavuus, tuottavuus dekomponointi, palkan muodostus, henkilöstön vaihtuvuus
JEL-luokittelu: C43, J23, J24, J63, M51

Ei-tekninen tiivistelmä: Nykyaikaisessa teoreettisessa sekä empiirisessä tuottavuustutkimuksessa tähdennetään yritys- ja toimipaikkarakenteiden muutoksen vaikutusta toimialojen tuottavuuskasvuun. Empiirisessä tutkimuksessa ovat yleistyneet erilaiset tuottavuuden dekomponointimenetelmät, joilla toimialan tuottavuuskasvusta erotellaan yritysten (tai toimipaikkojen) oman tuottavuuskasvun vaikutus, markkinaosuuksien muutosten vaikutus sekä yritysten (tai toimipaikkojen) syntymien ja poistumien tuottavuusvaikutus. Tässä tutkimuksessa näytämme, että dekomponointimenetelmää voidaan käyttää myös tutkittaessa henkilökunnan vaihtuvuuden vaikutusta toimipaikkojen tuottavuuskasvuun.

Menetelmän käytöllä on kuitenkin kolme vaatimusta. Ensiksi, tarvitaan laajat pitkittäisaineistot, joissa työntekijät on yhdistetty työnantajiin. Toiseksi, toisin kuin yritys- tai toimipaikkarakenteiden vaikutusta tutkittaessa nyt dekomponointimenetelmää ei voida käyttää laskentakaavana vaan estimointiyhtälönä. Kolmanneksi, dekomponointimenetelmän pitää olla sellainen, että sen komponentteja voidaan tulkita mielekkäästi. Uusien henkilöiden (tai yritysten/toimipaikkojen) tuottavuutta verrataan jatkavien henkilöiden (tai yritysten/toimipaikkojen) tuottavuuteen aloitusvuotena. Uusilla henkilöillä (tai yrityksillä/toimipaikoilla) on tuottavuutta vahvistava vaikutus siinä tapauksessa, että tuottavuuden kasvu olisi jäänyt pienemmäksi ilman heidän (niiden) ilmaantumista. Käyttämämme dekomponointimenetelmä poikkeaa tässä suhteessa yleisessä käytössä olevasta versiosta, jossa uusien yritysten/toimipaikkojen tuottavuuden tasoa verrataan jatkavien ja poistumassa olevien yritysten/toimipaikkojen keskimääräiseen tuottavuuteen jonakin menneisyyden vuotena. Poistuvien henkilöiden (yritysten/toimipaikkojen) tuottavuusvaikutus määritellään samaan tapaan. Poistumisvaikutus on positiivinen, jos lähtevien tuottavuuden taso on keskimäärin alempi kuin heidän (niiden), jotka jatkavat. Dekomponointiin voidaan sisällyttää myös eri työntekijäryhmiä (esim. ikäryhmiä).

Tulostemme perusteella yrityksille on taloudellisesti kannattavampaa rekrytoida nuoria työntekijöitä (16-29 vuotiaita) kuin keskimmäisen ikäryhmän (30-44 vuotta) tai vanhimman ikäryhmän (45-65 vuotta) työntekijöitä. Juuri rekrytoidut nuoret työntekijät ovat noin 30 prosenttia tuottavampia kuin juuri rekrytoidut vanhimman ikäryhmän työntekijät, mutta näiden ryhmien palkkatasot ovat kuitenkin samat. Vastaava tuottavuusero nuorimman ja keskimmäisen ikäryhmän välillä on vähäinen, mutta jälkimmäisen ryhmän palkkataso on kuitenkin huomattavasti korkeampi. Tutkimuksessa tarkastellaan myös lähtevien työntekijöiden tuottavuus- ja palkkaeroja. Lähtevät nuoret työntekijät ovat selvästi tuottavampia kuin muut ikäryhmät, mutta ikäryhmien väliset palkkaerot ovat tässä pieniä.

Palkkaerot eivät siis näytä heijastavan tuottavuuseroja, mikä herättää hieman epäilyjä tavanomaisen kasvulaskennan luotettavuutta kohtaan. Kasvulaskennassa ryhmien rajatuottavuuden erot mitataan nimittäin palkkaeroilla. Tulostemme perusteella kasvulaskenta antaa luultavasti liian myönteisen kuvan tulevaisuuden kasvuedellytyksistä. Sen lisäksi, että nuorempien ikäluokkien havaitaan olevan tuottavia, heillä on myös korkeat rekrytointi- sekä irtisanoutumisasteet, eli heidän liikkuvuutensa on suurta. Työvoiman liikkuvuuden väheneminen olisi haitallista erityisesti uusille innovatiivisille yrityksille, jotka saattavat tulevaisuudessa kärsiä kasvua hidastavista rekrytointivaikeuksista. Ikääntyvä väestö voi siis haitata sekä toimipaikkojen tuottavuuden kasvua että toimialojen tuottavuutta vahvistavaa yritysrakenteiden muutosta.

I. Background

The increase of GDP per labor input is the driving force of improving living standards. The role of input reallocation in productivity growth has been studied by using various kinds of decomposition methods. Some studies have examined inter-industry restructuring (e.g. Bernard & Jones, 1996) and some other. intra-industry restructuring with firm or establishment data (e.g. Baily et al., 1992; Baily et al., 2001; Foster et al., 2001).[1] Empirical analysis of intra-industry restructuring, in particular, has expanded rapidly in recent years in parallel with the availability of large-scale micro data sets and developments in the theoretical literature. New theories go beyond the representative firm framework by emphasizing the role of firm (and establishment) heterogeneity in the economic development (e.g. Grossman & Helpman, 1991; Hopenhayn, 1992; Melitz, 2003; Helpman et al., 2004; Klette & Kortum, 2004).

However, there may be heterogeneities even at a deeper level. Evidently, the employment structures of the firms/establishments and intra-firm/intra-establishment restructuring through hiring and separation of workers is potentially an important source of heterogeneity for productivity levels and growth rates between firms/establishments. Changes in the employment structures affect the skill structures, which in turn, according to the human capital literature (Becker (1962)), should be reflected in productivity and wage growth at the different levels of aggregation (see e.g. Krueger & Lindahl, 2001). We are, however, unaware of any attempts to go inside the “black boxes” with linked employer-employee data by using a similar decomposition approach. We suggest in this paper a new method that can be used for decomposing productivity growth *within* establishments to the effect of entering, exiting and staying workers. As opposed to familiar analyses of intra-industry restructuring, the productivity decomposition formula cannot be used for accounting but must be used as an estimation model for productivity growth using linked employer-employee data. We illustrate the method using data from the Finnish business sector.

This paper is structured as follows. In section II we develop the productivity decomposition method. In section III we describe the data set that we are using and present the results. In the last section we present conclusions and suggest how the method could be used for shedding new light on the connection of education and productivity growth.

II. Decomposing aggregate productivity change in the different layers of the economy

It is useful to start our discussion from inter-industry restructuring and then proceed to intra-industry and, finally, to intra-establishment restructuring. In this way the differences involved at the different levels of analysis are made clear.

A. Inter-industry restructuring

Output (Y) per labor (L), an economy's labor productivity (PROD), is obtained as follows:

$$PROD_t = \frac{Y_t}{L_t} = \frac{\sum_i Y_{it}}{\sum_i L_{it}} = \sum_i \frac{L_{it}}{\sum_i L_{it}} \frac{Y_{it}}{L_{it}} = \sum_i LSH_{it} \cdot PROD_{it} \ , \qquad (1)$$

where i and t denotes industry and year, respectively. LSH_{it} is the labor share of industry i in year t, and $PROD_{it}$ its productivity level. Productivity change from year s to t ($\Delta PROD_t$) can be decomposed in a familiar way:

$$\Delta PROD_t = \sum_i \overline{LSH}_i \cdot \Delta PROD_{it} + \sum_i \overline{PROD}_i \cdot \Delta LSH_{it} \qquad (2)$$

where $\overline{LSH}_i$ is the average labor share of industry i in year s and t, and $\overline{PROD}_i$ is the corresponding average productivity level.

Expression (2) can be turned into a rate of change form by dividing by the average of productivity in years s and t, $\overline{PROD} = 0.5 \cdot (PROD_s + PROD_t)$:

$$\frac{\Delta PROD_t}{\overline{PROD}} = \sum_i \overline{LSH}_i \frac{\Delta PROD_{it}}{\overline{PROD}} + \sum_i \Delta LSH_{it} \frac{\sum_i \overline{PROD}_i}{\overline{PROD}} \tag{3}$$

The first term on the right-hand side of (3) is the within industry productivity growth component. The second term is the between component which measures aggregate productivity growth due to changes in the employment shares of the industries. It should be noted that (3) is approximately equal to the log-change in productivity; $\frac{\Delta PROD_t}{\overline{PROD}} \cong \ln \frac{PROD_t}{PROD_s}$.

From the standpoint of interpretation, un unattractive feature in (3) is that the denominator in the sums on the right-hand side is the average aggregate productivity, $\overline{PROD}$, not the average productivity of the respective industry *i*, $\overline{PROD}_i$. Maliranta (2003) decomposes the within component of (3) further as

$$\sum_i \overline{LSH}_i \frac{\Delta PROD_{it}}{\overline{PROD}} = \sum_i \overline{LSH}_i \frac{\Delta PROD_{it}}{\overline{PROD}_i} + \sum_i \overline{LSH}_i \cdot \left(\frac{\overline{PROD}_i}{\overline{PROD}} - 1 \right) \cdot \frac{\Delta PROD_{it}}{\overline{PROD}_i} \tag{4}$$

where the first term on the right-hand side can be called the pure within component, which is the labor share weighted average of industry productivity growth rates. The second one can be ascribed as a convergence term. It is negative when the industries of low productivity levels have higher productivity growth rates than the industries of high productivity levels.

B. Intra-industry restructuring

Next we go down to the next layer, the industry level. Industry productivity growth rate $\frac{\Delta PROD_{it}}{\overline{PROD}_i}$ can be decomposed to its establishment-level sources in an analogous manner with one major exception: intra-industry restructuring involves entries and exits, which rarely is the case when restructuring between industries is studied. In what follows, we distinguish between three types of establishments: Continuers (or stayers) (denoted by *C*), who exist both in the initial and the end year, entrants (*N*) that appear in the end year *t* but not in the initial year *s*, and exits (*X*) that appear in the initial year s but not anymore in the end year *t*. Now industry productivity growth can be expressed using the industry-level counterparts of (3) and (4). We insert (3) into (4) and develop it a bit further to obtain:

$$\frac{\Delta PROD_{it}}{\overline{PROD}_i} = \sum_{p\in C} \overline{LSH}_{ip} \frac{\Delta PROD_{ipt}}{\overline{PROD}_{ip}} + \sum_{p\in C} \overline{LSH}_{ip} \cdot \left(\frac{\overline{PROD}_{ip}}{\overline{PROD}_i^C} - 1 \right) \cdot \frac{\Delta PROD_{ipt}}{\overline{PROD}_{ip}} + \sum_{p\in C} \Delta LSH_{i,p\in C} \frac{\sum_i \overline{PROD}_{ip}}{\overline{PROD}_i^C} + LSH_{it}^N \cdot \frac{\left(PROD_{it}^N - PROD_{it}^C\right)}{\overline{PROD}_i} - LSH_{is}^X \cdot \frac{\left(PROD_{is}^X - PROD_{is}^C\right)}{\overline{PROD}_i} \quad (5)$$

where *p* denotes establishment. LSH_{it}^N and LSH_{is}^X are the labor shares of entrants in year *t* and exits in year *s* in industry *i*, respectively. $PROD^C$, $PROD^N$ and $PROD^X$ are aggregate productivity levels among continuers, entrants and exits, respectively. Equation (5) decomposes productivity growth into the pure within, convergence, between, entry, and exit effects. This exact form has been proposed by Maliranta (2003)[2]. Earlier Maliranta (1997) and Vainiomäki (1999) have proposed formulas that have an analogous treatment of entries and exits. Vainiomäki's decomposition was designed for decomposing skill upgrading of establishments and, thus, it was not presented in a rate of change form. Recently Diewert and Fox (2005) have suggested a formula that is exactly the same as the one in Vainiomäki (1999).

Equation (5) bears some resemblance with the now so popular formula advocated by Foster, Haltiwanger and Krizan (2001). However, at least two important differences are worth noting. Firstly, in (5) the productivity level of entrants is compared to the current aggregate productivity of continuers while this is not the case in the formula proposed by Foster, Haltiwanger and Krizan. In contrast to (5), they compare the entrants to the aggregate productivity level in the initial year (5 years back in the past in their case). They therefore compare the entrants to both continuers and destined exitors in the past. In (5) the entry component tells how much lower (or higher) the aggregate productivity rate would have been had the new establishments not entered between years *s* and *t*. The interpretation of the exit component is quite analogous in (5), but the counterfactual is now that exiting establishments had stayed and had had the same productivity growth rate as the continuing establishments.[3] Secondly, in (5) the pure within component (the first component on the right-hand side) has a natural interpretation. It is a labor share weighted average of productivity growth rates of the continuing establishments. This is not the case in the popular formulas, where the sum of the weights of the continuing establishments is less than one if some establishments have exited during the period. The pure within component is likely to be a useful indicator of disembodied technological change (especially when this formula is applied to the total factor productivity measure). The difference between the industry productivity growth rate and the pure within component indicates the magnitude of productivity-enhancing restructuring through entries, exits and job creation and destruction among continuing establishments.

The productivity decompositions presented above and elsewhere in the literature use either industry level or the establishment/firm level data, but stop there. However, this still leaves the sources of a large share of productivity growth hidden in the “black box” of firms or establishments. For example, Maliranta (2003) finds that slightly less than half of productivity growth can be attributed to micro-level restructuring, a major part of which takes place within narrowly defined industries. Slightly more than half of productivity growth is due to productivity growth of the establishments. This pure within establishments productivity growth effect is clearly below the 100% that is assumed in the representative firm models, but still seems to be an important source of industry productivity growth that deserves a closer look. In particular, there may be interesting variation in establishment productivity growth rates.

C. Intra-establishment restructuring

These considerations have motivated us to dive deeper into the productivity growth dynamics. We want to have a look at the sources of productivity growth at the "micro-micro" level. More specifically, we examine intra-establishment labor restructuring through hiring and separation of employees and how this is reflected in establishment productivity growth $\frac{\Delta PROD_{pt}}{\overline{PROD}_p}$. For that purpose we will use a formula that is the establishment-level analogue to (5), with hiring and separation playing the role of entry and exit.

We distinguish between different types of workers that may have varying productivity levels as well as different productivity growth rates over time. The main difference between micro level (i.e. establishment level) and micro-micro level (i.e. worker level) analysis is that we cannot observe the productivity levels of the individuals directly. Therefore we cannot use (5) as an accounting identity for productivity growth but we must use it as an estimation model instead.[4] This is feasible when productivity can be measured at the level of establishments and we observe the labor shares of different types of workers establishment by establishment. This means that linked employer-employee data are needed.

We assume that the type of the worker is time invariant. For example, below we will classify the workers by their age in the end year, i.e. in practise we compare different age cohorts that are time invariant. Therefore there cannot occur a structural change among continuing workers. This is to say that, among the continuing workers, the labor share of each worker group is the same in the initial and the end year. As a consequence, the third term on the right-hand side of equation (5) drops out. Unable to measure $PROD^{C}$, we cannot define the "pure" within component nor distinguish the convergence component. Then we have the following formula:

$$\frac{\Delta PROD_{pt}}{\overline{PROD}_{p}} = \sum_{g} \overline{LSH}^{C}_{pg} \frac{\Delta PROD_{pgt}}{\overline{PROD}_{p}} + \sum_{g} LSH^{N}_{pgt} \cdot \frac{\left(PROD^{N}_{pgt} - PROD^{C}_{pt}\right)}{\overline{PROD}_{p}} - \sum_{g} LSH^{X}_{pgs} \cdot \frac{\left(PROD^{X}_{pgs} - PROD^{C}_{ps}\right)}{\overline{PROD}_{p}} \qquad (6)$$

where the sums are over worker types *g*, *N* denotes hiring (entering workers) and *X* separation (exiting workers). So, equation (6) has three kinds of components: a within continuing workers component, a hiring component and a separation component. The first component measures productivity growth, whereas the second and third measure differences in productivity levels (productivity gaps).

From this formula we obtain an estimation model which can be used for measuring the productivity gaps and growth rates between the worker groups:

$$\frac{\Delta PROD_{pt}}{\overline{PROD}_{p}} = \sum_{g} \theta_{gC} LSH^{C}_{gpt} + \sum_{g} \theta_{gN} LSH^{N}_{gpt} - \sum_{g} \theta_{gX} LSH^{X}_{gps} + \beta' X_{pt} + \varepsilon_{pt} \qquad (7)$$

where LSH^{C}_{gpt} is the share of staying workers of type *g* of all staying workers in establishment *p* in year *t* (note that $LSH^{C}_{gps} = LSH^{C}_{gpt} = \overline{LSH}^{C}_{pg}$ and $\sum_{g} LSH^{C}_{gpt} = 1$), LSH^{N}_{gpt} is the share of hired workers of type *g* of all workers (i.e., newly hired plus staying workers) in establishment *p* in year *t*, and LSH^{X}_{gps} is the share of exiting workers of type *g* of all workers (i.e., exitors plus staying workers) in establishment *p* in year *s*. In addition, various controls *X* may be needed in order to avoid spurious relationships between worker flows and productivity growth. The interesting coefficients to be estimated are θ_{gC}, θ_{gN}, and θ_{gX} for each worker type *g* The first parameters measure the productivity growth rates of the staying workers by type during the period. The second parameters are the relative productivity levels of the newly hired workers by type, and the third ones the relative productivity levels of those leaving. As can be seen from (6), the interpretation of the coefficients of (7) is not quite straightforward. Let us assume that $PROD^C \approx \overline{PROD}$, i.e. the productivity level of staying workers is approximately equal to the average productivity of all workers. This may be a reasonable approximation if the time interval is not very long. We define the productivity gap between entering workers of types g = 1 and g = 2 as follows:

$$NGAP(1,2) = \frac{PROD_{1,t}^N - PROD_{2,t}^N}{0.5 \cdot \left(PROD_{1,t}^N + PROD_{2,t}^N\right)} \left(\cong \ln \frac{PROD_{1,t}^N}{PROD_{2,t}^N}\right) \tag{8}$$

Assuming that $PROD_t^C \approx \overline{PROD}$ we obtain

$$NGAP(1,2) \approx \frac{\theta_{1,N} - \theta_{2,N}}{0.5 \cdot \left(\theta_{1,N} + \theta_{2,N}\right) + 1} \tag{9}$$

The productivity gap between exiting workers of types g = 1 and g = 2 is defined analogously (assuming that $PROD_s^C \approx \overline{PROD}$)

$$XGAP(1,2) \approx \frac{\theta_{1,X} - \theta_{2,X}}{0.5 \cdot \left(\theta_{1,X} + \theta_{2,X}\right) + 1} \tag{10}$$

Both of these measures are symmetric, i.e. $NGAP(1,2) - NGAP(2,1) = 0$ and $XGAP(1,2) - XGAP(2,1) = 0$. After the θ parameters have been estimated, standard errors and confidence levels of these gap measures can be calculated by using the delta method.[5]

The same kind of decomposition methods can be used for estimating the impact of worker flows on average wage growth at the establishment level. Relative wage gaps, which are analogous to the productivity gaps, can then be calculated for the different worker types. In addition, the difference between the productivity and wage gaps tells us the relative profitability of hiring and laying off certain types of workers.[6] For example, a high productivity-wage gap for a worker group on the hiring side indicates that hiring that kind of workers raises productivity more than it raises average wages (in comparison to the reference group) and consequently improves profitability.

III. An empirical application of the productivity decomposition method

Next we use the productivity decomposition formula (7) to study how worker flows affect the productivity growth of establishments. As it will turn out, this kind of analysis may provide fresh insights about the role of various labor characteristics in productivity growth at the micro level.

A. Data

Linked employer-employee data are needed for applying the estimation model (7) for examining productivity-enhancing intra-establishment restructuring through worker flows. Finnish Longitudinal Employer-Employee Data (FLEED) is excellently suited for such an exercise for a number of reasons. The data on individuals originate from the Employment Statistics (ES) that covers practically the total working age population in the years 1990-2002 and has annually about 3.5 million observations. The data have a rich content, including information about age, education, gender, employment status, earnings etc. The workers are linked to their employer companies and establishments on the basis of the employment relationship in the last week of the year. Consequently, we are able to identify worker flows from the year *t-s* to year *t* in each establishment by comparing the work force at the end of these years. Furthermore, we can examine the flows by different labor characteristics, We have classified the workers into three age groups: 16-29 years (young), 30-44 years (prime-aged) and 45-65 years (old) on the basis of their age in the end year of the respective period. The entry and exit of workers in these age groups is measured in 3-year periods: 1992-95, 1995-98 and 1998-2001. It should be noted that the entry of a worker that is followed by the exit within the same 3-year period is not observed in our data because of the way our variables are constructed. There is also some incompleteness in the linking of employers and employees, so that for some individuals no establishment is found and for some establishments not all workers can be found in the data on individuals.

Information on companies and establishments can be found from different data sources. In this study we use the Business Register (BR) of establishments[7] and companies. These data cover basically all companies and establishments in Finland. The variables of this data set include size, the date of entry, industry, region etc. There is also information on sales and employment that can be used for measuring productivity as sales/employee. Because the data are based on administrative registers they should be representative cross-sectionally from the point of view of both employees and employers, in addition to being representative longitudinally (see Abowd & Kramarz, 1999).

We study productivity growth in 3-year intervals, 1993-1996, 1996-99 and 1999-2002. By using long intervals we try to reduce the effects of measurement errors and to allow some time for productivity effects that may be delayed. We link the establishment-level data of worker flows (with 3-year intervals) to productivity growth data using a one year lag. This is because the employer-employee links concern the situation at the end of the calendar year whereas productivity is measured as an average of the current calendar year, the mid-point being at the end of June. So, essentially we use half a year lags of the worker flows.

The so-called "manucentrism" still very much characterizes the literature of worker flows and productivity analysis (see Hamermesh, 2000).[8] This work aims to contribute to correct that imbalance by examining productivity growth in the whole business sector, not in manufacturing only. We focus on establishments that employ at least 20 persons (the average of the initial and the end year). This is because information on these establishments is generally obtained from the Direct Survey of Structural Business Statistics whereas for small establishments information is often imputed by use of various administrative registers. This makes the data for the small establishments unreliable for our current purpose. Furthermore, the measurement accuracy of the dependent and explanatory variables is likely to be substantially better for larger establishments. We have also limited our estimation sample by requiring that the number of individuals in FLEED that can be linked to an establishment is at least 75% of the average employment in the establishment according to the Business Register. Our sample comprises otherwise the whole non-farm business sector, but the financial sector is dropped because of lack of an appropriate output measure. Establishments that lack some variables of our interest are also excluded.[9]

Finally, we have removed some potentially influential outliers that were detected by using the method proposed by Hadi (1992; 1994). The method is useful for detecting of multiple outliers in multivariate data. Identification of outliers was made on the basis of three variables: 1) the growth rate of average monthly earnings calculated from the data on individuals in the Employments Statistics, 2) the growth rate of average wage calculated from the establishment-level data in the Business Register, and 3) the productivity growth rate of the establishment. The first two variables should be highly correlated with each other because they are essentially gauging the same thing, but may still sometimes differ in the data due to imperfect links between workers and establishments. Wage growth is usually correlated with productivity growth, but sometimes they may be very different because of measurement errors in output and/or labor input. We identified 210 outlier establishments out of 16 299 original observations (that employ at least 20 employees).

Table A.1 in the Appendix gives some descriptive summary statistics of our basic sample that is used in the regression analysis below. It includes 16 089 observations. The average number of linked employees per establishment is 86.2, which is close to the average number of employees in these establishments according to the Business Register (83.6 employees, measured in full-time equivalents). In other words, our regressions are based on 1.4 million (16089*86.2) individual observations that we linked to the establishments of our basic sample. Because we investigate three periods, our sample covers annually about 460 000 individuals employed in the non-farm business sector. This is more than one third of the total employment in this sector.

The average nominal productivity growth rate in the 3-year periods is 12.2%. According to the Business Register the average wage growth rate is 11.5%,which is reasonably close to the average growth of monthly earnings of the linked employees (10.6%), obtained from the Employment Statistics. The average level of monthly earnings is €2099 and the average level of sales per employee is €227 845. The average hiring rate is 37.7% (= the sum of the hiring rates of the three worker age groups) and the average separation rate 33.6 % (= the sum of the separation rates of the three worker age groups). Young workers account for 12.0% of the incumbents (i.e. those who have been employed in the same establishment now and three years earlier). However, their share is 44.3% of all newly hired workers and 26.4% of all leaving workers.

B. An econometric investigation

We have estimated equation (7) with our sample of establishments. Because we study the factors of productivity growth, unobservable establishment-specific effects on productivity levels are differenced out and there is no need to include fixed establishment effects in the estimation model. As distinct from a standard difference form estimation, we are, however, able to distinguish the two sides of the employment change of an establishment, i.e. the hiring and separation sides, that may be sometimes asymmetric. The productivity growth and wage growth models are estimated with seemingly unrelated regression (SURE). Both models have a common set of regressors and hence the SURE estimates of the parameters are equal to the OLS estimates. The advantage of using SURE in this case is that we are able to test for differences in the productivity and wage gaps. The estimations have been done by using labor weights (average of employment in years t-3 and t). Table A.2 in the Appendix shows the regression results of six different models (Model (1) – Model (6)). In addition to variables for the entries and exits of workers by worker type, and the labor shares of staying workers by type, all the models have a wide variety of controls. They include the log of average labor productivity (sales per person) and the log of the average wage level in year t-4. Further, we have included dummies for establishment size (4 groups), regional dummies (20 regions), and dummies for 2-digit industries (47 industries) that are interacted with period dummies (3 periods). The latter allow us to use undeflated sales in the productivity measure, since the interaction variables can be regarded as industry-specific price indices. Besides these, Model (6) includes also share variables for entries, exits and stayers by three education groups.

Before going to the results of our main interest, the productivity and wage gaps between different groups of workers, it is interesting to take a look at some estimates given in Table A.2

in the Appendix. As expected, we find that the initial levels of productivity and wage (measured in year t-4) have a negative relationship with subsequent productivity and wage growth, respectively. Somewhat more interestingly, we find evidence that a high initial wage level has a positive impact on subsequent productivity growth, especially among expanding establishments (Model (3)) and in the service sector (Model (5)). One interpretation of these findings is that a higher wage level generates some additional pressure for greater productivity growth. Quite analogously, we find that a high initial productivity level boosts wage growth. High productivity yields profits that may partly be used to reward workers through higher wage growth.

The main results of this paper are reported in Table 1. It shows the estimates of the productivity gaps and wage gaps calculated using equations (9) and (10). In addition, the table includes productivity-wage gaps, which are the differences of productivity and wage gaps. All gaps, their standard errors and significance levels are calculated by applying the delta method.

[INSERT TABLE 1 ABOUT HERE]

These results indicate that it is more profitable for employers to hire young workers than older workers. When all establishments are included in the estimations (Model (1)) the productivity-wage gap between the young and prime-aged (between the young and old workers) workers in the hiring side is 22.2% (28.0%). This productivity-wage gap between the young and prime-aged workers is for the main part derived from the wage gap, which indicates that the young workers obtain 13.3% lower wages. On the other hand, the productivity-wage gap between the young and old workers it is mainly due to the 28.8% productivity gap in favor of the young. The results also show that it is more profitable to lay off older workers than young workers, since the productivity-wage gap of the young vs. prime-aged is 29.2% and that of the young vs. old is 33.1% on the separation side. In both of these cases the productivity-wage gap is due to the productivity gap. In other words, separated young workers are more productive than separated prime-aged workers or old workers. It is worth noting that the productivity gaps between young and prime-aged workers are more favorable to young workers on the separation side than on the hiring side. So, the separating young workers are relatively more productive compared to the separating prime-aged workers, than the newly hired young workers are compared to the newly hired prime-aged workers. An explanation for this is that young workers learn new productive skills as soon as they have become employed, often for the first time. Quite consistently with this, Ilmakunnas, Maliranta and Vainiomäki (2004) find evidence that at the beginning the seniority-productivity profile is upward-sloping but reaches a peak after a few years of seniority. It should be noted that since we use 3-year intervals, an average newly hired worker has worked for one and half years at the same establishment.

The results indicate that employers have opportunities for improving profitability by their personnel policies. Various institutional factors, however, limit the possibilities of making profitable adjustments on the separation side, but less so on the hiring side. The best opportunities for making use of productivity-wage gaps should be available when markets are growing and there is more hiring of new workers. To examine this, we estimated the models separately for growing (i.e. employment has increased at least 10% during the period) and declining (i.e. employment has declined at least 10%) establishments. We find that the productivity-wage gaps are particularly favorable to young workers, when the analysis is limited only to the growing establishments (Model (3) in Table1). Among the declining establishments the potential gains seem to be smaller, as expected. The prime-aged workers, instead, appear to have a high productivity level and a favorable productivity-wage gap in the latter circumstances.

All in all, the productivity gap estimates indicate quite consistently that young workers are more productive than older workers. One explanation might be the superior educational level of the young that has increased rapidly in Finland over time. We have tried to take this into account in Model (6) by including also the hiring and separation rates classified by three education groups (primary, secondary and tertiary level education). The productivity gaps and productivity-wage gaps are quite similar to those calculated from Model (1). The results of Model (6) indicate that the productivity gap between the newly hired highly educated workers and the newly hired low educated workers (primary education only) is economically large and statistically significant (see Table A.2 in Appendix). In addition, the wage gaps appear to have about the equal width. As for the separation side, the coefficient estimates for the productivity and wage effects are quite imprecise, which prevents us from making any definitive conclusions.

We have made various robustness checks that we do not report but comment here briefly. Firstly, the estimations have been done separately for the three periods. These results do not provide us any evidence of noteworthy changes in the gaps over time. Secondly, Model (1) has been estimated with unweighted regression. On the separation side, the productivity gap between the young and prime-aged workers is 15.0% (standard error is 5.2%) and the between young and old workers 20.5% (standard error is 5.0%), but these gaps are insignificant on the hiring side[10]. The smaller coefficients are likely due to attenuation bias especially among smaller establishments that have a larger impact on the results in the unweighted regression than in the employment weighted regression.

Thirdly, we have examined the robustness of our results to the way outliers are handled. Bollinger and Chandra (2005) provide quite a critical analysis of the standard methods of removing outliers and show that the results may be quite sensitive to the method. Although we believe that our cleansing procedure is quite suitable for the current purpose, it is still comforting to find that the conclusions are the same also when those 210 outliers that were identified with Hadi's method are included. For example, according to Model (1) the productivity-wage gap between the young and old workers is now 30.0% (standard error is 8.0%) on the hiring side and 27.9% (standard error is 6.5%) on the separation side.

Above we have reported results related to the two components of equation (6), that is, the hiring and separation components. Next we briefly consider the third component, which is the productivity growth of continuing workers. With the help of this component we can study differences in productivity and wage growth rates between different worker groups. These results are reported in Table 2. It can be hypothesized that young workers have greater productivity growth rates than older workers due to more rewarding learning-by-doing in the beginning of the career. Although the results from the analysis of entering workers supported this argument, our empirical evidence on the continuing workers is, however, not supportive. On the other hand, we might expect that those young workers who stay are those who enjoy higher wage *growth*. This would be consistent with Lazear's (1981) theory of deferred payments, for instance. Young workers are underpaid and therefore employers offer them large pay rises in order to reduce their costly quits. Some support for such conjectures are found in the results of Table 2, especially for the expanding establishments. Finally, the growth effects of education shown in the Appendix indicate that a large proportion of highly educated workers increases productivity growth of the establishment. One interpretation of this is that the highly educated workers generate or implement new innovations, which is reflected in the productivity growth rate of the establishment (see e.g. Benhabib & Spiegel, 1994).

[INSERT TABLE 2 ABOUT HERE]

IV. Concluding remarks

We have demonstrated that productivity-enhancing intra-establishment labor restructuring can be studied by a method that is quite similar to the one that has been used increasingly in investigating intra-industry restructuring, i.e., by means of a productivity decomposition formula. The main difference is that at the "micro-micro" level the productivity decomposition method cannot be used for accounting but must be used as an estimation model. Further, comprehensive longitudinal linked employer-employee data are required for the micro-micro level analysis. Finally, the properties of the productivity decomposition method deserve close attention. This is because an appropriate comparison group (or counterfactual) needs to be specified before an economic interpretation of the results of the decomposition exercise can be done appropriately. Our empirical investigation with Finnish data demonstrates the merits of the use of good quality micro data and an appropriate productivity decomposition method. For example, our results for the age effects help us to understand why employers might be unwilling to hire old workers, and try to persuade them to early retirement.

Economically and statistically significant productivity-wage gaps between age groups cast also doubt on the reliability of the standard growth accounting computations that are built on the assumption that wage gaps reflect gaps in marginal productivities. Our results suggest that growth accounting projections might exhibit excessively favorable prospects regarding economic growth in the future. In addition to that we found young workers to have high productivity, we also found them to have high hiring and separation rates, i.e. they are highly mobile. A less mobile workforce would be a bad news for the new innovative companies that will find it increasingly difficult to hire new workers and grow. Thus, a less mobile workforce poses an imminent threat to micro-level dynamism that arguably is a key factor of sustained economic growth. All things considered, an aging workforce may be an impediment for both productivity-enhancing intra-industry restructuring and productivity growth of the establishments in the future.

This paper also provides a promising approach to analyze the dynamics of the productivity effects of education. A puzzling finding of earlier empirical analyses has been that within establishment variation in the data (i.e. the use of fixed effects models or differenced specifications) seems to indicate an insignificant or even negative relationship between the education of the personnel and establishment productivity (e.g. Haltiwanger et al., 1999; Ilmakunnas & Maliranta, 2005a). It may be hypothesized that this follows from delayed positive effects of high education. High skills may not be particularly valuable in current production but are needed in innovations or to implement new technologies that make an establishment's less educated workers more productive in the future (see Greenwood & Jovanovic, 2001). As a consequence, the separations of highly educated workers may have an immediate productivity effect which is insignificant or even negative. This is an issue that we will pursue in future work.

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Appendices

Table A.1. Descriptive statistics of the sample

Variable	**N**	**Mean**	**p5**	**p50**	**p95**
Employees (ES)	16089	86.2	20.0	42.0	283
Employees (BR)	16089	83.6	19.5	40.0	274
Prod. growth rate	16089	0.122	-0.471	0.115	0.728
Wage growth rate (ES)	16089	0.106	-0.056	0.104	0.277
Wage growth rate (BR)	16089	0.115	-0.137	0.116	0.368
Sales per person (€)	16089	227845	36636	114581	566125
Average monthly earnings (€)	16089	2099	1222	2009	3309
Entry shares					
Young	16089	0.167	0.000	0.131	0.444
Prime-aged	16089	0.142	0.000	0.120	0.345
Old	16089	0.068	0.000	0.043	0.226
Exit shares					
Young	16089	0.089	0.000	0.053	0.306
Prime-aged	16089	0.136	0.000	0.111	0.346
Old	16089	0.111	0.000	0.089	0.295
Distribution of continuers					
Young	16089	0.120	0.000	0.083	0.364
Prime-aged	16089	0.452	0.200	0.446	0.731
Old	16089	0.429	0.091	0.438	0.721
Entry shares					
Primary education	16089	0.088	0.000	0.061	0.269
Secondary education	16089	0.243	0.042	0.220	0.529
Tertiary education	16089	0.046	0.000	0.020	0.209
Exit shares					
Primary education	16089	0.100	0.000	0.078	0.281
Secondary education	16089	0.201	0.036	0.169	0.477
Tertiary education	16089	0.035	0.000	0.008	0.160
Distribution of continuers					
Primary education	16089	0.304	0.000	0.294	0.623
Secondary education	16089	0.600	0.300	0.600	0.889
Tertiary education	16089	0.097	0.000	0.038	0.467

Note: The data consist of three 3-year periods and include non-farm business sector establishment employing at least 20 persons (average of the initial and end year). ES refers to Employment Statistics and BR to Business Register.

Table A.2. Seemingly unrelated regressions for productivity and wage growth

	Model (1)		Model (2)		Model (3)		Model (4)		Model (5)		Model (6)	
	prod. growth	wage growth	prod. growth	wage growth	prod. growth	wage growth	prod. growth	wage growth	prod. growth	wage growth	prod. growth	wage growth
log of	-0.080***	0.010***	-0.077***	0.016***	-0.070***	0.009***	-0.072***	0.010***	-0.089***	0.008***	-0.081***	0.009***
productivity level	(0.004)	(0.002)	(0.009)	(0.003)	(0.006)	(0.003)	(0.006)	(0.002)	(0.005)	(0.002)	(0.004)	(0.002)
log of wage level	0.081***	-0.132***	-0.051	-0.219***	0.100***	-0.128***	0.031	-0.146***	0.089***	-0.130***	0.048***	-0.171***
in t-4	(0.017)	(0.006)	(0.039)	(0.013)	(0.022)	(0.009)	(0.028)	(0.010)	(0.020)	(0.008)	(0.018)	(0.007)
Entry of young	0.034	-0.078***	0.066	-0.072**	-0.033	-0.131***	0.213***	-0.096***	-0.167***	-0.075***	0.169**	0.159***
	(0.039)	(0.014)	(0.106)	(0.036)	(0.059)	(0.023)	(0.062)	(0.022)	(0.050)	(0.019)	(0.084)	(0.031)
Entry of prime	-0.054	0.053***	0.372***	0.111***	-0.199***	0.021	-0.145**	0.081***	-0.065	0.006	0.021	0.221***
	(0.046)	(0.017)	(0.118)	(0.040)	(0.064)	(0.025)	(0.074)	(0.026)	(0.057)	(0.022)	(0.078)	(0.029)
Entry of old	-0.226***	-0.086***	-0.153	-0.162***	-0.337***	-0.084***	-0.039	-0.029	-0.438***	-0.138***	-0.027	0.182***
	(0.055)	(0.020)	(0.141)	(0.048)	(0.073)	(0.029)	(0.085)	(0.031)	(0.071)	(0.028)	(0.093)	(0.034)
Exit of young	-0.086	-0.005	0.013	0.000	-0.139*	-0.005	-0.288***	0.034	0.069	-0.022	-0.017	-0.052
	(0.053)	(0.020)	(0.127)	(0.043)	(0.075)	(0.030)	(0.108)	(0.039)	(0.060)	(0.023)	(0.667)	(0.246)
Exit of prime	0.227***	-0.004	0.070	0.011	0.183***	0.036	0.275***	-0.058**	0.209***	0.028	0.237	-0.130
	(0.043)	(0.016)	(0.094)	(0.032)	(0.066)	(0.026)	(0.071)	(0.025)	(0.053)	(0.020)	(0.665)	(0.245)
Exit of old	0.282***	0.000	0.395***	0.058**	0.149*	0.005	0.246***	0.032	0.335***	-0.035	0.271	-0.084
	(0.042)	(0.016)	(0.083)	(0.029)	(0.077)	(0.031)	(0.062)	(0.022)	(0.057)	(0.022)	(0.669)	(0.246)
Share of young	-0.001	0.020	0.050	0.020	-0.022	0.051**	-0.051	0.012	0.046	0.018	-0.004	0.011
	(0.040)	(0.015)	(0.093)	(0.032)	(0.051)	(0.020)	(0.065)	(0.023)	(0.048)	(0.019)	(0.041)	(0.015)
Share of prime	-0.020	0.017*	0.089	-0.020	-0.082**	0.027*	-0.063	0.000	0.025	0.030**	-0.036	-0.003
	(0.027)	(0.010)	(0.062)	(0.021)	(0.036)	(0.014)	(0.040)	(0.015)	(0.035)	(0.014)	(0.028)	(0.010)
Share of old	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.
Entry of primary											-0.299***	-0.290***
educated											(0.089)	(0.033)
Entry of second.											-0.091	-0.234***
Educated											(0.083)	(0.031)
Entry of tert.											0.000	0.000
educated											(0.000)	(0.000)
Exit of primary											0.102	0.089
educated											(0.668)	(0.246)
Exit of second.											-0.065	0.102
educated											(0.666)	(0.245)
Exit of tert.											-0.015	0.072
educated											(0.671)	(0.247)
Share of primary											-0.093**	-0.079***
educated											(0.042)	(0.015)
Share of											-0.071*	-0.049***
second.											(0.041)	(0.015)
Sh. of tert. edu.											ref.	ref.
Observations	16089	16089	3913	3913	6966	6966	8350	8350	7739	7739	16089	16089
R-squared	0.1199	0.1353	0.1985	0.2160	0.1657	0.1451	0.1167	0.1354	0.1353	0.1392	0.1220	0.1506
Correlation	0.3235		0.3353		0.3118		0.3306		0.3122		0.3210	

Standard errors in parentheses
*Significance level: * 10%; ** 5%; *** 1%*
Note: “Correlation” refers to the correlation of the residuals of the productivity and wage equations. According to Breusch-Pagan test we can reject the hypothesis that this correlation is zero. Other variables include industry dummies (47 industries) that are interacted with period dummies (3 periods), dummies for regions (20 regions) and dummies for size groups (4 groups). The models are estimated by weighting by establishment employment (average of the initial and end year).

Table 1
Productivity, wage and productivity-wage gaps between age groups, in %-units

	Model (1)				Model (2)				Model (3)				Model (4)				Model (5)				Model (6)			
	All				Declining				Expanding				Manufacturing				Services				All (with education)			
Prod.	**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**	
Young vs	8.9		29.2	***	-25.1	*	5.4		18.7	**	31.5	***	34.6	***	56.7	***	-11.5		12.3	*	13.5	**	22.9	
prime	(6.7)		(6.9)		(13.3)		(14.5)		(9.0)		(9.8)		(11.0)		(16.0)		(8.8)		(7.1)		(6.1)		(15.5)	
Prime vs	20.0	*	4.4		47.4	**	26.4	**	18.8		-2.9		-11.6		-2.3		49.8	***	9.9		4.8		2.7	
old	(10.3)		(5.7)		(19.8)		(11.1)		(14.6)		(9.1)		(15.3)		(9.1)		(15.1)		(6.9)		(9.2)		(6.2)	
Young vs	28.8	***	33.5	***	22.9		31.7	**	37.2	***	28.6	***	23.2	**	54.6	***	38.8	***	22.1	***	18.3	***	25.6	
old	(7.7)		(6.5)		(18.2)		(12.5)		(10.6)		(10.1)		(9.8)		(14.7)		(13.0)		(6.9)		(6.6)		(16.2)	
Wage	**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**	
Young vs	-13.3	***	0.1		-17.9	***	1.1		-16.2	***	4.0		-17.8	***	-9.3	*	-8.4	***	5.0		-5.3	**	-8.6	**
prime	(2.4)		(2.7)		(5.4)		(5.1)		(3.3)		(3.8)		(4.0)		(5.1)		(3.1)		(3.1)		(2.1)		(3.8)	
Prime vs	14.1	***	0.4		28.0	***	4.6		10.9	**	-3.0		10.7	**	9.2	**	15.5	***	-6.3	*	3.3		5.2	
old	(3.3)		(2.7)		(7.6)		(4.5)		(4.4)		(4.1)		(4.9)		(4.2)		(4.5)		(3.5)		(2.8)		(3.4)	
Young vs	0.8		0.5		10.2		5.7		-5.3		1.0		-7.1	*	-0.2		7.1	*	-1.2		-2.0		-3.4	
old	(2.6)		(2.5)		(6.6)		(4.6)		(3.5)		(4.0)		(3.9)		(4.3)		(3.7)		(3.3)		(2.1)		(2.9)	
Prod-wage	**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**		**Entry**		**Exit**	
Young vs	22.2	***	29.2	***	-7.2		4.3		34.9	***	27.5	***	52.4	***	66.0	***	-3.2		7.3		18.8	***	31.5	*
prime	(6.3)		(6.6)		(12.6)		(13.7)		(8.6)		(9.3)		(10.4)		(15.1)		(8.4)		(6.8)		(5.8)		(16.2)	
Prime vs	5.9		4.0		19.3		21.8	**	7.9		0.1		-22.3		-11.5		34.3	**	16.1	**	1.5		-2.5	
old	(9.7)		(5.4)		(18.7)		(10.5)		(13.9)		(8.7)		(14.4)		(8.7)		(14.3)		(6.7)		(8.7)		(6.1)	
Young vs	28.0	***	33.1	***	12.7		26.0	**	42.6	***	27.7	***	30.3	***	54.8	***	31.7	**	23.4	***	20.3	***	29.0	*
old	(7.3)		(6.1)		(17.2)		(11.8)		(10.1)		(9.7)		(9.2)		(13.9)		(12.4)		(6.7)		(6.3)		(16.4)	

Standard errors in parentheses
*Significance level: * 10%; ** 5%; *** 1%*

Note: The gap (in productivity level or in wage level) between the young and the prime-aged plus the gap between the prime-aged and the old is equal to the gap between the young and the old. The productivity-wage gap is the productivity level gap minus the wage level gap. The standard errors have been calculated by the delta method. All numbers may not, however, add up in all cases due to rounding.

Table 2

Productivity, wage and productivity-wage growth differences of continuing workers by age groups, in %-units

	Model (1)		Model (2)		Model (3)		Model (4)		Model (5)		Model (6)
Prod.	All		Declining		Expanding		Manufacturing		Services		All (with education)
Young vs	1.9		-4.0		6.0		1.2		2.1		3.2
prime	(4.3)		(10.1)		(5.5)		(7.2)		(5.1)		(4.3)
Prime vs	-2.0		8.9		-8.2	**	-6.3		2.5		-3.6
old	(2.7)		(6.2)		(3.6)		(4.0)		(3.5)		(2.8)
Young vs	-0.1		5.0		-2.2		-5.1		4.6		-0.4
old	(4.0)		(9.3)		(5.1)		(6.5)		(4.8)		(4.1)
Wage											
Young vs	0.3		3.9		2.4		1.2		-1.2		1.4
prime	(1.6)		(3.5)		(2.2)		(2.6)		(2.0)		(1.6)
Prime vs	1.7	*	-2.0		2.7	*	0.0		3.0	**	-0.3
old	(1.0)		(2.1)		(1.4)		(1.5)		(1.4)		(1.0)
Young vs	2.0		2.0		5.1	**	1.2		1.8		1.1
old	(1.5)		(3.2)		(2.0)		(2.3)		(1.9)		(1.5)
Prod-wage											
Young vs	1.5		-7.9		3.6		0.0		3.3		1.7
prime	(4.1)		(9.5)		(5.3)		(6.8)		(4.9)		(4.1)
Prime vs	-3.6		10.9	*	-11.0	***	-6.3	*	-0.4		-3.3
old	(2.5)		(5.8)		(3.5)		(3.8)		(3.4)		(2.7)
Young vs	-2.1		3.0		-7.3		-6.3		2.9		-1.5
old	(3.7)		(8.7)		(4.9)		(6.2)		(4.6)		(3.8)

Standard errors in parentheses

*Significance level: * 10%; ** 5%; *** 1%*

Note: The difference in growth rate between the young and the prime-aged plus the difference between the prime-aged and the old is equal to the difference between the young and the old. The productivity-wage growth difference is the productivity growth difference minus the wage growth difference. The standard errors have been calculated by the delta-method. All numbers may not, however, add up in all cases due to rounding.

ENDNOTES

[1] For a review of such studies, see e.g. Bartelsman and Doms (2000).
[2] The only difference is that Maliranta (2003) measured entry and exit effects in log terms.
[3] An additional advantage of (5) is that price indices are not needed to compute the entry or exit effects, because cross-sectional comparisons between the entrants and the incumbents and between the exitors and the incumbents can be made here using the current prices.
[4] The fact that the productivity of individuals cannot be measured is the background also in recent research where the productivity effects of age, education, and experience are investigated by estimating plant-level production functions with average worker characteristics or shares of workers in various age etc. groups included (see e.g. Hellerstein, Neumark, and Troske, 1999).
[5] For example, when there are three groups (g) of workers, nine parameters need to be estimated.
[6] The profit margin over worker costs of type g is $(S-w_gL_g)/w_gL_g = (S/L)/w_g - 1 = PROD_g/w_g - 1$, where S is sales, productivity *PROD* is measured by S/L, and w_g is wage. The relative gap in the term $PROD_g/w_g$ between groups 1 and 2 is $\ln(PROD_1/PROD_2) - \ln(w_1/w_2)$, which can be approximated by the difference of a productivity gap ((9) for entering or (10) for exiting workers) and a wage gap calculated in an analogous way.
[7] In the Finnish Business Register the delineation of establishment is made in conformity with the local kind-of-activity unit concept (see Laukkanen, 2004).
[8] A few recent exceptions notwithstanding (see e.g. Ilmakunnas & Maliranta, 2005b, 2005a),
[9] For example, our data set includes only those establishments that appear in the data in the years t-4 (the initial productivity level is measured at this point), t-3 (the initial year of productivity growth) and t (the end year of productivity growth).
[10] In unweighted regression, R-squared of Model (1) for productivity growth and wage growth is 0.0873 and 0.1407, respectively.

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KESKUSTELUAIHEITA - DISCUSSION PAPERS ISSN 0781-6847

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