Micro-components of aggregate wage dynamics[*]

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Abstract

This paper presents a decomposition of the standard aggregate wage growth that is a sum of an index measuring wage growth of job stayers and various components for the effects of job and worker restructuring. With this method we are first to present explicit expressions for various composition effects consistently in a coherent framework and with clear interpretation. In contrast to earlier literature, we are able to simultaneously address numerous topics relevant for the macroeconomic literature and show their linkages. Further, our approach opens opportunities for a deeper analysis of essential micro-level mechanisms. We demonstrate the advantages of the approach with empirical analyses about the effect of job restructuring on labor input efficiency and about the cyclical patterns in different micro-components by using comprehensive longitudinal employer-employee data over a long period of time. We show that wage formation is significantly more flexible than aggregate numbers suggest and indicate micro-level mechanisms explaining greater flexibility.

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1. Introduction

Aggregate wage growth is an essential part of the growth of the national income and economic well-being. In order to understand both its long-run determinants and its cyclical behavior a sharp distinction should be made between two separate mechanisms: 1) wage growth of the job stayers (those who stay in the same occupation and firm) and 2) the effect of compositional changes on aggregate wage growth. For understanding long-run economic growth this distinction is essential since incessant changes in the *job composition* (i.e. job restructuring) increase the efficiency of the hours worked in the economy. For cyclical aspect, there is a need for isolating the effect of the changing *worker composition* (i.e. worker restructuring) on aggregate wage growth over business cycles (e.g. Bils 1985 , Solon et al. 1994). Otherwise the picture on the macro-economic flexibility of wage inflation will be distorted. More generally, we need a rich account of different aspects and dimensions of the composition effect and, importantly, in a way that links them consistently and accurately to the standard aggregate wage growth measure – that is used in the empirical macroeconomic literature and can be read from the National Accounts, for example.

We propose an approach for measuring and analyzing dynamics of the standard aggregate wage growth of macro statistics with micro-data. We are first to present a decomposition of the standard aggregate wage growth that includes explicit expressions for various composition effects with clear interpretations. The earlier literature has only implicitly shown the role of compositional changes in explaining the behavior of aggregate wages (see Shin 1994 , Solon et al. 1994 , Abraham and Haltiwanger 1995 , Devereux 2001). One advantage of our approach is that it allows examining several key research questions of the modern macro literature consistently in a coherent framework. Moreover our approach opens new opportunities for a deeper analysis of various micro-level mechanisms and their cyclicality.

Our approach makes use of the formula that is partly based on a Bennet (1920) [2] type of decomposition and bears resemblance to the those used by Vainiomäki (1999) in the analysis of skill-upgrading and those used by Maliranta (1997), Maliranta (2005), Diewert and Fox (2009), and Böckerman and Maliranta (2011) in the analysis of aggregate productivity growth. It includes a within component that provides an appropriate index for the wage growth of job stayers and a wide array of other components that gauge the effects of distinct changes in worker and job compositions. In this formula, the within component is a weighted average growth rate of the stayers measured in accordance of the divisia-index principle. Another key aspect of the decomposition is that the entry and exit components are mutually symmetric and they also have clear interpretations. This is because both components are based on comparisons with the stayers at a relevant point in time (i.e. the initial year for exit and the end year for entry). Finally, an important property of our method is that its aggregate wage growth rate is very close approximation of the standard aggregate wage growth measure. This property derives from fact that our method is based on aggregation of the normal absolute wages and not log-wages. As a result we avoid log-bias that is usual and potentially troublesome in these kinds of analyses.

In our method the formula is applied in a manner that allows distinguishing between the effects of job and worker restructuring. The results of the decomposition can be used for addressing various different, but interrelated, topics that are relevant in the macroeconomic literature, including the role of labor efficiency growth as a determinant of nominal aggregate wage growth. Other important topics include cyclical patterns in wage growth of the job stayers, in the effects of compositional changes and in the wage drift between wage growth of job stayers and contractual wage increases.

[2] As for a more detailed description of Bennet index, see e.g. Balk (2003) and Diewert (2005).

We apply our method to comprehensive longitudinal employer-employee data from the Finnish private sector covering drastic boom-bust-boom-bust cycles between years 1985 and 2009. Our main findings fall into three main categories. The first category concerns the difference between aggregate wage growth and wage growth of the job stayers. The main finding here is that, on average, wages of the job stayers increase more rapidly than aggregate wages. This reflects the fact that the turnover of workers negatively contribute to aggregate wage growth as highly paid older workers retire and low-paid young worker enter the labor markets.

The second set of results concerns the effect of job restructuring, i.e. changing job composition, to aggregate wage growth. In our study a unit refers to an occupation group in a firm and a job means an employment position in a unit that is filled by a worker. We show that the labor input share of the high-wage jobs (i.e. occupations and firms that have a high wage level) increases steadily over time through exit of the low-wage units and expansion of high-wage units in terms of hours worked. Changes in the job composition increase the efficiency of hours worked, which positively contributes to aggregate wage growth. Interestingly, we find that the trends in the effect of job restructuring on aggregate wage growth mirror empirically very closely the traditional estimate of labor quality change obtained with the standard growth accounting method. This finding is an example of how our method is able to encompass various mechanisms that are previously analyzed in isolation.

The third set of results concerns the role of changing *worker composition* in cyclical variation of aggregate wages. We find that aggregate wage growth is much less procyclical than wage growth of the job stayers because the worker composition has strongly countercyclical effect on aggregate wage growth. Our results show explicitly the magnitudes and cyclical sensitivity of the restructuring components of aggregate wage growth. The fact that wage growth of the job stayers is more sensitive to business cycles than aggregate wage growth can be totally attributed to the job-to-non-job leavers and non-job-to-job hires, which both include unemployment flows. We also find that wage growth of the job stayers is procyclical predominantly thanks to the wage drift when defined in an appropriate manner as a gap between wage growth of the job stayers and the contractual wage increase, which essentially dictates the minimum wage increases for the job stayers in Finland. On the other hand, with the official measure we find much smaller role for the wage drift, apparently because it is confounded with the cyclical effect of worker restructuring. This finding illustrates the usefulness of our decomposition method in evaluation of the labor market system.

2. *Related literature*

Our paper is related to several strands of literature. First, it is linked to growth accounting literature that has examined the contribution of labor quality growth to aggregate productivity growth (Ho and Jorgenson 1999). The approach of growth accounting is based on a cross-classification of hours worked on the basis of worker characteristics (usually gender, age, education and self-employment status).[3] Typically these analyses have found labor quality growing about half of a percentage point per year but with substantial cyclical variation (Schwerdt and Turunen 2007). In our decomposition approach labor efficiency growth is based on job characteristics and is directly linked to the standard measure of aggregate wage growth. In addition, in our approach labor efficiency change consists of three distinct sub-components measuring job restructuring; entry, exit and between components, which augments the interpretation of the underlying dynamics.

[3] The quality change is the difference between a quality adjusted measure of aggregate labor input (using cross-classification of labor input) and a raw measure of aggregate labor input (computed without cross-classification of labor input).

Second, our approach is also related to another and more recent strand of productivity literature, and as such provides explanations for the long-run growth of real wages. It makes use of various methods for decomposing aggregate productivity growth into components gauging the contribution of entries, exits and reallocation between continuing firms (or plants) alongside with productivity growth of firms. These analyses indicate the importance of analyzing aggregate productivity growth in the context of heterogeneous firm framework.[4] This paper is similar in spirit, but applies these ideas to aggregate wages. Our formula differs from some popular alternatives proposed in the literature regarding the interpretation of the components, the within component in particular (see Baily et al. 1992 , Griliches and Regev 1995 , Foster et al. 2001 , Balk 2003). However, the formula applied in this paper is particularly suitable for our current purpose not least since we need a measure of wage growth of the job stayers as distinct from that of aggregate wage growth and its other micro-components

Third, our paper is related to the literature on low frequency shocks and aggregate wages (Weinberg 2001 , Devereux 2005). This question is highly relevant since a part of economic growth comes from changing composition of industries. Devereux (2005) finds that low elasticity of industry wages to employment changes is a result of composition bias: quality of workforce is declining in growing industries and increasing in declining industries.

Fourth, our approach is linked to the large literature studying how the movement of aggregate wages is linked to the cyclicality of labor market dynamics. This literature has three main findings. First, Solon et al. (1994) show that the quality of the workforce (measured by earnings) varies over the business cycle due to changing worker composition, leading to smoother cyclical behavior of aggregate wages. The second main finding is that wages of job changers are more cyclical than

[4] For nice reviews of this literature, see Bartelsman and Doms (2000) and Syverson (2011).

stayers (e.g. Shin 1994 , Solon et al. 1994 , Barlevy 2001 , Devereux 2001 , Devereux and Hart 2006 , Carneiro et al. Forthcoming). Third finding is that, even within firms, movements between positions may be cyclical (Solon et al. 1997 , Devereux and Hart 2006). Such cyclical job movements may affect the behavior of aggregate wages even though wages in all jobs would be rigid. Our approach extends these analyses by taking an accounting approach and showing analytically the link between aggregate wage and the various composition effects. The richness of the composition effects allows us to give more detailed picture of the composition bias than has previously been available. Our decomposition also makes it possible to study the previously mentioned three main findings simultaneously and calculating exactly their effect to aggregate wage fluctuations. Prior studies have looked at these effects in isolation, e.g. Solon et al. (1994) abstract away from changes in job composition whereas e.g. Solon et al. (1997) and Devereux and Hart (2006) do not consider worker composition. Further, we empirically measure the magnitude of worker restructuring effect and its subcomponents in the manufacturing sector over business cycles. By definition, cyclicality of these components sum up to the cyclical changes in the standard measures of aggregate wages. This link has not been shown explicitly before.

Fifth, in the theoretical macroeconomic literature the cyclical flexibility of new hires vs. incumbents is an important question. Gertler and Trigari (2009) argue that most empirical studies cannot study this, because one should observe multiple workers in the same firm to compare incumbents and new hires. Carneiro et al. (Forthcoming) use linked employer-employee data to study the cyclical flexibility of wages comparing incumbents and new hires. Our decomposition shows clearly the contribution of new hires to aggregate wage flexibility. Moreover, we distinguish between job-to-job hires and other hires – as well as separations.

3. Micro-level mechanisms and their measurement

3.1. Illustrations of the mechanisms

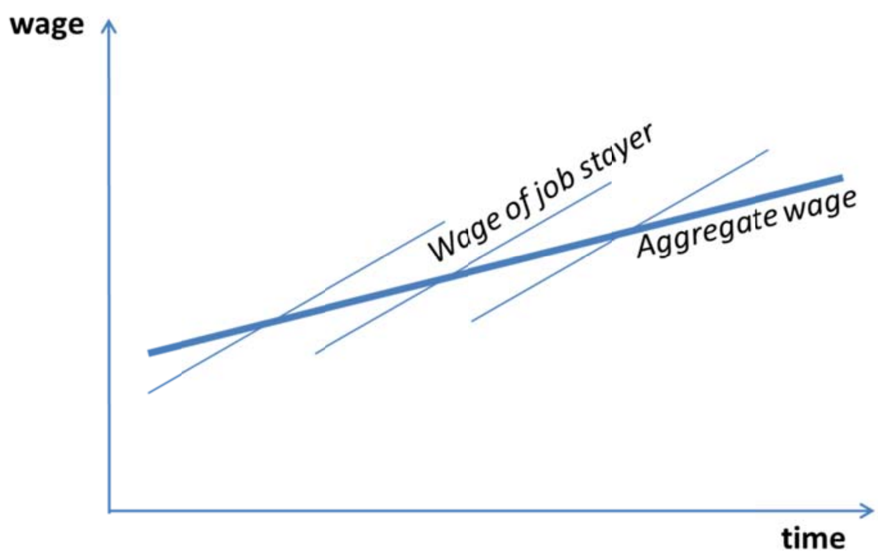
Job and worker restructuring

Panels A and B in Figure 1 illustrate the mechanisms underlying aggregate wage growth that we aim to measure and analyze. In the analysis we need several key concepts, which we define next. A *unit* refers to an occupation group in a firm, a *job* means an employment position in a unit that is filled by a worker, and a *job stayer* is an employee who stays in the same unit in two consecutive time periods. With these definitions in hand, we can turn to Panel A in Figure 1 which shows a situation where wage growth of the job stayers continuously exceeds that of aggregate wage as low-wage workers enter and high-wage workers retire from labor markets. In our analysis we measure the slopes of the wages of the job stayers and aggregate wages, and factors that drive a wedge between these slopes. In Panel A aggregate wage growth is lower than that of the job stayers because *worker restructuring* (older high wage workers are replaced by younger low wage workers). Panel B instead demonstrates a situation where *job restructuring* has a positive impact on aggregate wage (that is an average of wages of the units weighted by hours worked). In this example there is job destruction in the low productivity/wage unit (it first shrinks and later makes an exit) and job creation in higher and highest productivity/wage units (either via expansion or entry). Curved double lines indicate worker flows (these are job movers) between jobs that is a necessary, but not sufficient, condition for job restructuring. In this example the average wage growth of the units is zero. It is possible, however, that the average growth of the job stayers (who can be found, by definition, only in the continuing units) is positive or, in principal, even higher than aggregate wage growth. This is possible when worker restructuring within units has a negative effect because newly hired workers earn less and separating workers earn more than the job stayers of the unit.

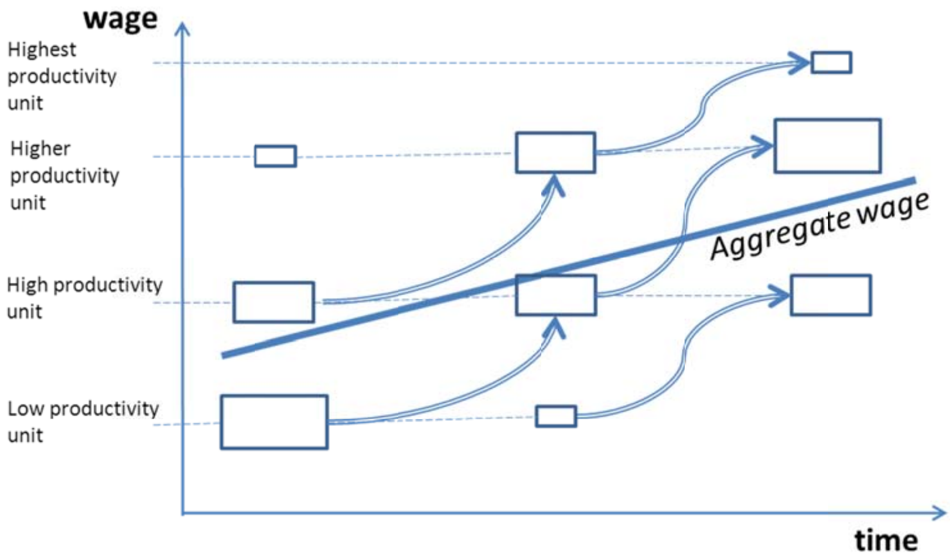
An important point here to note is that job restructuring may have a sustained positive impact on aggregate wage growth when it involves entry of new high-wage (and high productivity) units that replaces older low-wage (and low productivity) units. As a result, this mechanism can be important for long-run growth.

Figure 1. Graphical illustration of the roles of worker restructuring and job restructuring

Panel A: Worker restructuring



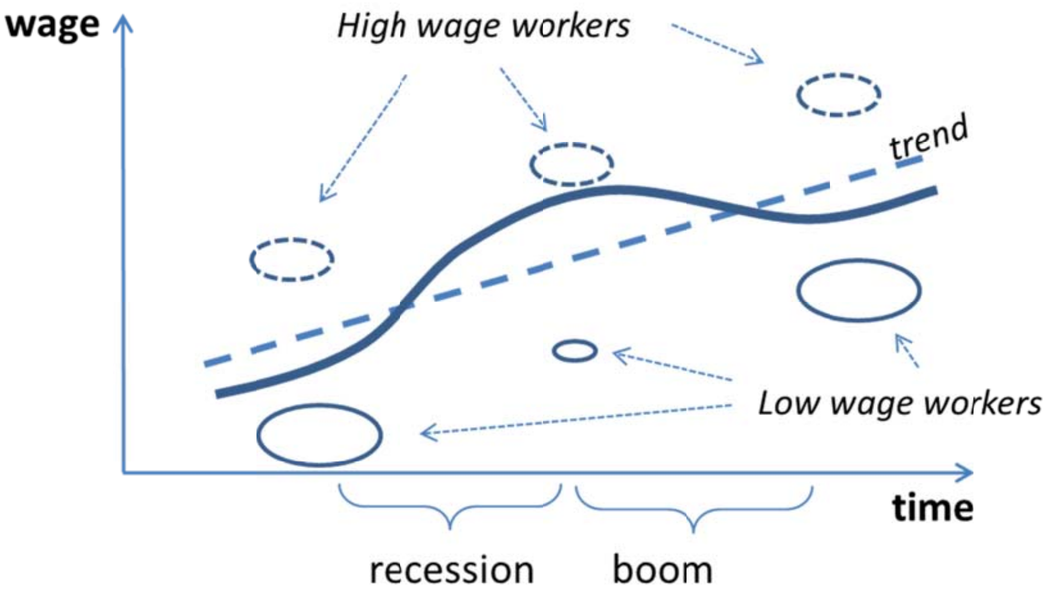
Panel B: Job restructuring



Worker restructuring and business cycles

Also the effect of worker restructuring is important to identify because the structure and intensity of worker flows is expected to vary over business cycles, and therefore the cyclical patterns of aggregate wage growth may differ from that of wage growth of the job stayers (or units). Figure 2 provides a simple illustration of this. There are two groups of workers; high and low wage workers. During a recession the number (and the employment share) of low wage workers declines and during a boom it increases, but the number of high wage workers stays constant (and the employment share increases). As a result, aggregate wage growth exhibits a countercyclical pattern in spite of stable wage growth of the job stayers.

Figure 2. Worker restructuring, wage growth and a business cycle



3.2. Basic structure of decomposition

In this section we present the basic idea behind our decomposition of aggregate wage growth that will be used for identifying and measuring the mechanisms described above. To implement it we apply a formula that is particularly suitable for analyzing wage growth of the job stayers as an integrated part of the standard measure of aggregate wage growth. For sake of clarity, we approach our decomposition in two steps. The basic structure of our decomposition is illustrated in Figure 3. In the first step, we present the decomposition of the unit-level sources of the aggregate growth rate. First, our decomposition include a *within* component of the units, which a weighted[5] average wage growth rate of the units. The following three components measure the different aspects of the inter-unit compositional changes that indicate the role of job restructuring: 1) changing input (hours worked) shares *between* the continuing units, 2) the *entry* of units, and 3) the *exit* of units. Moreover, decomposition includes four cross terms, one for each of the four components of described above. Cross terms make the decomposition to add up to the

[5] Each unit is weighted by its average input share (among continuing units) in the initial and end year, in accordance of divisia-index approach.

standard aggregate measure of wage growth, and in addition, allow a useful interpretation for all components of our interest.

In the second step, we apply the decomposition formula one more time, but now at a lower level of aggregation, that is for each of continuing units. This provides us a break-down of the within component of the units into four worker-level sources (see Figure 3). The first is the *within* component of the job stayers[6]. It is a weighted[7] average wage growth rate of the job stayers in the continuing units. The second is the changing input shares *between* the job stayers within the continuing units, the third is the *entry* of workers (i.e. hiring) into the continuing units, the fourth is the *exit* of workers (i.e. separation of workers) from the continuing units. Decompositions made for each of continuing units is then aggregated by use of their labor input shares (again, using the average in the initial and end year).

After these two steps we have seven main components of the standard aggregate measure of wage growth. The most important of these is the within component of the job stayers, which measures the wage growth rate of an average job stayers in an average continuing unit. In addition we have two sub-components for each of the three restructuring components (i.e. entry, exit and between components). The first refer to job restructuring and the second to worker restructuring. In addition, this decomposition yields a cross term for each of the seven components. As will be shown below, some of these "correction components" have an economic interpretation.[8] Their economic importance is, however, an empirical matter that will be examined

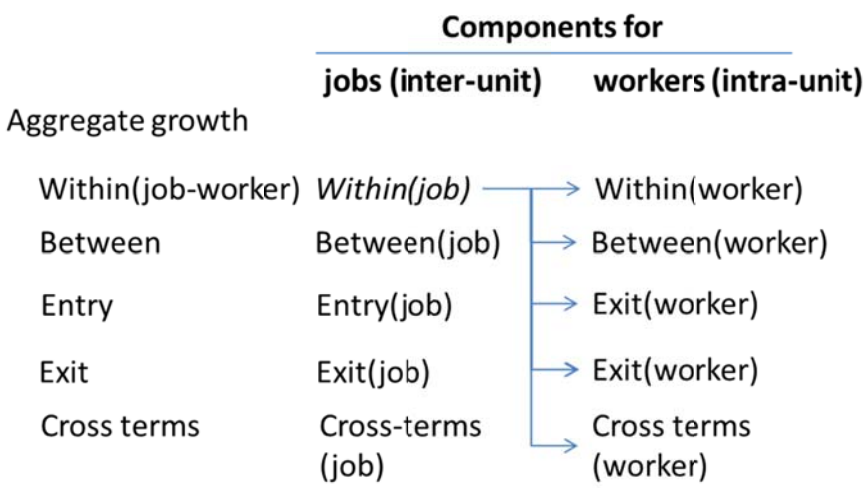
[6] As noted above, job stayers can be found, by definition, only in the continuing units. In our empirical data there are some continuing units that do not have any job stayers. In these rare cases we assume that the unit has exited and a new unit has made an entry. This is needed for a consistent decomposition.

[7] Each worker is weighted by its average input share (among continuing units) in the initial and end year, in accordance of the divisia-index approach.

[8] The cross terms arise from use of absolute wages and not their logs as usually. The cross terms measure together the bias (i.e. the discrepancy to the standard aggregate wage growth rate) that emerges when aggregation is made using log wages.

in our empirical application. The sum of these fifteen components is a very close approximation of the standard aggregate wage growth rate.

Figure 3. Structure of decomposition of aggregate wage growth



3.3. Decomposition formula

Ultimately we are interested in the standard measure of aggregate wage per labor input in year t, W_t, that can be presented formally as follows;

$$W_t = \frac{\sum_i \sum_j w_{ijt} \cdot h_{ijt}}{\sum_i \sum_j h_{ijt}} \tag{1}$$

where w_{ijt} is hourly wage and h_{ijt} hours worked of worker *j* who works in unit *i* (e.g. in a certain task in a certain firm) in year *t*.

We want to measure the growth rate of the standard aggregate wage between years *s* and *t*. Typically it is done by use of a log difference but, following the example of Davis and Haltiwanger (1992), wage growth is here converted into a growth rate by use of the average wage as a denominator. This provides us with a very close approximation of the standard measures of growth rate (e.g. log-difference of the absolute aggregate wage levels between two consecutive years). A great advantage of our measure of aggregate growth rate is that it can be decomposed into several interesting components by applying the formula used in Maliranta (2005), and Böckerman and Maliranta (2011).

Step 1: Unit level decomposition

We first present the decomposition into unit-level sources, and later integrate the aspect of worker mobility into it. The aggregate wage growth rate can be decomposed into unit-level sources with the following formula;

$$
\begin{aligned}
&\ln\frac{W_t}{W_s} \cong \frac{W_t - W_s}{\overline{W}_t} = \\
&\sum\nolimits_{i\in C(i)} \overline{s}_{it}^{C(i)} \frac{\left(w_{it}-w_{is}\right)}{\overline{w}_{it}} + \\
&\sum\nolimits_{i\in C(i)} \left(s_{it}^{C(i)} - s_{is}^{C(i)}\right)\frac{\overline{w}_{it}}{\overline{W}_t^{C(i)}} + \\
&\sum\nolimits_{i\in N(i)} s_{it} \frac{\left(w_{it}-W_t^{C(i)}\right)}{W_t^{C(i)}} + \\
&\sum\nolimits_{i\in X(i)} s_{is} \frac{\left(W_s^{C(i)}-w_{is}\right)}{W_s^{C(i)}} + \\
&\textit{cross terms of units}
\end{aligned}
\tag{2}
$$

where $s_{it}^{C(i)} = \frac{h_{it}}{\sum_{i\in C(i)} h_{it}}$, $\overline{s}_{it}^{C(i)} = 0.5\left(s_{is}^{C(i)} + s_{it}^{C(i)}\right)$, $W_t^{C(i)} = \frac{\sum_{i\in C(i)} w_{it}\cdot h_{it}}{\sum_{i\in C(i)} h_{it}}$, $\overline{W}_t^{C(i)} = 0.5\left(W_s^{C(i)} + W_t^{C(i)}\right)$,

i refers to a unit, *t* to an end period and *s* to an initial period (e.g. in case of annual changes *s*=*t*-1), *C(i)* refers to the group of continuing units (that existed both in *t* and *s*), *N(i)* refers to the group of entering units (that existed in *t* but not in *s*), and *X(i)* refers to the group of exiting units (that existed in *s* but not in *t*).

The formula makes use of a Bennet (1920) type decomposition of aggregate wage growth of the continuing units (the second and third rows). This is an important aspect of our decomposition since the Bennet index has strong justifications from the axiomatic theory, as shown by Diewert (2005). Further, the interpretation of the components of Equation (2) is intuitive and useful for our purposes. The first component shown in the second row of (2) is the within component of the jobs, which indicates the weighted average of wage growth rates of the units. It should be noted that a specific property of this decomposition is that $\sum_{i\in C(i)} \overline{s}_{it}^{C(i)} = 1$, which means that the within component indicates the growth rate of an average hour worked in the continuing units.[9] The third row presents the between component, which measures the contribution of changes in the composition of hours worked between the continuing units. It is positive (negative) if those continuing units that have relatively high wage level, i.e. $\frac{\overline{w}_{it}}{\overline{W}_t^{C(i)}} > 1$, have increased (decreased) their share of hours worked among the continuing units, i.e. $s_{it}^{C(i)} > s_{is}^{C(i)}$ ($s_{it}^{C(i)} < s_{is}^{C(i)}$). The forth row indicates the entry component of the units and the fifth row the exit component (i.e. exit of units). It is easy to see that the entry component is positive (negative) if the wage level of the new units is higher (lower) than that of the continuing units in the year of appearance. The magnitude of the component depends on the hour share of the new units, i.e. $\sum_{i\in N(i)} s_{it}$ (≤ 1). Analogously, the exit component is positive if the wage level of exiting units is lower (higher) than in those units that will continue in the next period, and the magnitude depends on the hour share of the exiting units, i.e. $\sum_{i\in X(i)} s_{is}$ (≤ 1).

[9] It is worth noting that $\sum_{i\in C(i)} \overline{s}_{it}^{C(i)} \frac{\left(w_{it} - w_{is}\right)}{\overline{w}_{it}} \cong \sum_{i\in C(i)} \overline{s}_{it}^{C(i)} \ln \frac{w_{it}}{w_{is}}$. In our empirical application the difference in the annual growth rates of these alternative measures is always less than 0.02%-points absolute

The cross terms and their interpretation

These components are purposely derived in these forms for allowing useful interpretation. As a consequence, this decomposition also includes a set of “correction” components that are called “cross terms”;

$$\begin{aligned}
&\textit{cross terms of units} = \\
&\sum_{i\in C(i)} \overline{s}_{it}^{C(i)} \frac{\left(w_{it}-w_{is}\right)}{\overline{w}_{it}}\left(\frac{\overline{w}_{it}}{\overline{\overline{W}}_t}-1\right)+ \\
&\sum_{i\in C(i)} \left(s_{it}^{C(i)}-s_{is}^{C(i)}\right)\frac{\overline{w}_{it}}{\overline{W}_t^{C(i)}}\left(\frac{\overline{W}_t^{C(i)}}{\overline{\overline{W}}_t}-1\right)+ \\
&\sum_{i\in N(i)} s_{it} \frac{\left(w_{it}-W_t^{C(i)}\right)}{W_t^{C(i)}}\left(\frac{W_t^{C(i)}}{\overline{\overline{W}}_t}-1\right)+ \\
&\sum_{i\in X(i)} s_{is} \frac{\left(W_s^{C(i)}-w_{is}\right)}{W_s^{C(i)}}\left(\frac{W_s^{C(i)}}{\overline{\overline{W}}_t}-1\right)
\end{aligned} \qquad (3)$$

Besides making all components to add up very closely to the standard aggregate measure of productivity growth rate these components have economic interpretations, too. This is true especially for the first component in the second row of Equation (3), which is associated with the within component (we call it the cross term of the within component of the units). If units with relatively low wage levels have a tendency to have higher wage growth rates (i.e. there is a kind “ β -convergence” in wage levels among continuing units), the cross term of the within component is negative. This reflects the fact that if two units are of the same size and have the same wage growth rate, a unit having a lower wage level has a smaller contribution to the standard aggregate wage growth. Put differently, if low wage units have higher wage growth rates, the within component, as measured a weighted average growth rate of the units, overrates the contribution of wage growth of the units to the standard aggregate wage growth.

We illustrate this phenomenon with Example 1 in Table 1 that is borrowed from the study by Fox (2011). Each unit uses one labor input. Therefore, for example, the wage levels of Unit 1 and Unit 2 in period 0 are 1 and 19, respectively. The standard aggregate wage level increases from 10 to 15, so that the growth rate is 40.0% (40.5% in log-difference). The within component indicates that the average growth rate of the units is 84.4% ($=0.5\times163.6\%+0.5\times5.1\%$). The within component exceeds the aggregate wage growth rate since Unit 1 has a high wage growth rate, but its wage level is low. So, in this example there is a decline in wage dispersion between units, which is reflected in a negative cross term of the within component. As the amount of labor input does not change in either units in this example, the between component is zero. In addition, as there are no entrants and exiting units, the entry and exit components are zeros as well.

Table 1: Illustration of decomposition of unit-level sources of wage growth

	Example 1			Example 2				
	Unit 1	Unit 2	Aggregate	Unit 1	Unit 2	Unit 3	Unit 4	Aggregate
	y1	y2	(y1+y2)/2	y1	y2	y3	y4	(y1+…+y4)/4
Period 0	1	19	10	1	19	2		7.33
Period 1	10	20	15	10	20		18	16.00
Period average	5.5	19.5	12.5	5.5	19.5			11.67
Growth rate	163.6 %	5.1 %	**40.0 %**	163.6 %	5.1 %	n/a	n/a	**74.3 %**
Components of aggregate growth								
Within			**84.4 %**					**84.4 %**
Between			**0.0 %**					**0.0 %**
Entry			**0.0 %**					**6.7 %**
Exit			**0.0 %**					**26.7 %**
Cross term of within			**-44.4 %**					**-41.5 %**
Cross term of between			**0.0 %**					**0.0 %**
Cross term of entry			**0.0 %**					**1.9 %**
Cross term of exit			**0.0 %**					**-3.8 %**

Note: Each unit uses one input.

Example 2 is similar to Example 1 except now we have added an exiting unit (Unit 3) and an entering unit (Unit 4). It should be noted that inclusion of entries and exits does not have any impact on the within component. This demonstrates one feature of the formula that is particularly important for our current purpose: the number of entrants and exiting units does not have any direct effect on the within component (in an accounting sense). Put differently, our formula measures the wage growth rate of the continuing units with a suitable index, which is not confounded with other micro-level mechanisms including entries and exits of units.

Since the wage level of the exiting unit is lower than the average wage level of continuing units in period 0 (2 vs. 10), the exit component is positive, i.e. $1/3 \times (10-2)/10 = 4/15 \approx 26.7\%$. The entry component is positive because the wage level of the entrant is higher than the average wage level of continuing units in period 0, i.e. $1/3 \times (18-15)/15 = 1/15 \approx 6.67\%$. The cross terms of entry and exit components are also reported in Table 1. Due to these terms, the entry and exit components have useful interpretation (since they are the products of the relative wage levels and input shares) and the components of the decomposition add up to the standard measure of aggregate wage growth rate, i.e. 74.3%=84.4+(-41.5%)+6.7%+26.7%+1.9%+(-3.8%).

Step 2: Worker level decomposition

The within component of Formula (2) is not ideal for measuring wage inflation because it indicates the average wage growth rate of the continuing units and not that of the job stayers. An important insight of our decomposition is that job stayers can be found only in the continuing units, and that the contribution of the job stayers to the wage growth of the unit can be measured in a same way as measuring the contribution of the continuing units to aggregate wage growth.

Formally this can be written as follows:

$$
\begin{aligned}
&\sum\nolimits_{i\in C(i)} \overline{s}_{it}^{C(i)} \frac{\left(w_{it} - w_{is}\right)}{\overline{w}_{it}} = \\
&\sum\nolimits_{i\in C(i)} \overline{s}_{it}^{C(i)} \sum\nolimits_{j\in C(j)} \overline{s}_{ijt}^{C(j)} \frac{\left(w_{ijt} - w_{ijs}\right)}{\overline{w}_{ijt}} + \\
&\sum\nolimits_{i\in C(i)} \overline{s}_{it}^{C(i)} \sum\nolimits_{j\in C(j)} \left(s_{ijt}^{C(j)} - s_{ijs}^{C(j)}\right) \frac{\overline{w}_{ijt}}{\overline{w}_{it}^{C(j)}} + \\
&\sum\nolimits_{i\in C(i)} \overline{s}_{it}^{C(i)} \sum\nolimits_{j\in N(j)} s_{ijt} \frac{\left(w_{ijt} - w_{it}^{C(j)}\right)}{w_{it}^{C(j)}} + \\
&\sum\nolimits_{i\in C(i)} \overline{s}_{it}^{C(i)} \sum\nolimits_{j\in X(j)} s_{ijs} \frac{\left(w_{is}^{C(j)} - w_{ijs}\right)}{w_{is}^{C(j)}} + \\
&cross\ terms\ of\ workers
\end{aligned} \tag{4}
$$

where $s_{ijt}^{C(j)} = \frac{h_{ijt}}{\sum_{j\in C(j)} h_{ijt}}$, $\overline{s}_{ijt}^{C(j)} = 0.5\left(s_{ijs}^{C(j)} + s_{ijt}^{C(j)}\right)$, $\overline{w}_{ijt} = 0.5\left(w_{ijs} + w_{ijt}\right)$, $w_{it}^{C(j)} = \frac{\sum_{j\in C(j)} w_{ijt} \cdot h_{ijt}}{\sum_{j\in C(j)} h_{ijt}}$,

$\overline{w}_{it}^{C(j)} = 0.5\left(w_{is}^{C(j)} + W_{it}^{C(j)}\right)$,

j refers to a worker, *C(j)* refers to the group of job stayers (that worked in the same occupation and firm in *t* and *s*), *N(j)* refers to the group of hired workers (that worked in the unit in *t* but not in *s*), and *X(j)* refers to the group of separated workers (that worked in the unit in *s* but not in *t*).

The second row of Formula (4) indicates our measure of wage inflation that is a weighted average wage growth rate of the job stayers. Note that now we have an important property $\sum_{i\in C(i)} \overline{s}_{it}^{C(i)} \sum_{j\in C(j)} \overline{s}_{ijt}^{C(j)} = 1$, which means that the within component indicates the growth rate of hourly wage worked by an average job stayer in the continuing firms. The third row is the between component of workers. It is positive when there is a positive relationship between the wage level and the change in hours worked between job stayers within continuing units. The fourth row is the entry component of workers. It is positive when hired new workers have, on average, a higher wage level than the job stayers in the unit where they have been hired into. The fifth row is the exit component of workers. It is positive when separating workers have, on average, a lower wage level than the job stayers in the unit where they separate from.

Similarly to the decomposition of the unit-level sources, the components measuring worker-level sources of wage growth include cross terms. They are as follows:

$$
\begin{aligned}
& \textit{cross terms of workers} = \\
& \sum_{i \in C(i)} \bar{s}_{it}^{C(i)} \sum_{j \in C(j)} \bar{s}_{ijt}^{C(j)} \frac{\left(w_{ijt} - w_{ijs}\right)}{\bar{w}_{ijt}} \left(\frac{\bar{w}_{ijt}}{\bar{w}_{it}} - 1 \right) + \\
& \sum_{i \in C(i)} \bar{s}_{it}^{C(i)} \sum_{j \in C(j)} \left(s_{ijt}^{C(j)} - s_{ijs}^{C(j)} \right) \frac{\bar{w}_{ijt}}{\bar{w}_{it}^{C(j)}} \left(\frac{\bar{w}_{it}^{C(j)}}{\bar{w}_{it}} - 1 \right) + \\
& \sum_{i \in C(i)} \bar{s}_{it}^{C(i)} \sum_{j \in N(j)} s_{ijt} \frac{\left(w_{ijt} - w_{it}^{C(j)}\right)}{w_{it}^{C(j)}} \left(\frac{w_{it}^{C(j)}}{\bar{w}_{it}} - 1 \right) + \\
& \sum_{i \in C(i)} \bar{s}_{it}^{C(i)} \sum_{j \in X(j)} s_{ijs} \frac{\left(w_{is}^{C(j)} - w_{ijs}\right)}{w_{is}^{C(j)}} \left(\frac{w_{is}^{C(j)}}{\bar{w}_{it}} - 1 \right)
\end{aligned}
\qquad (5)
$$

Incorporating Equations (2) - (5) gives us the decomposition of the standard aggregate wage growth rate that includes separate components for job and worker restructuring. We call this Version 1.

3.4. Decomposition with a break-down by worker type

Similar formulas can be applied for examining the role of worker composition in greater detail. In what follows we ignore the job restructuring dimension but in exchange classify workers into three separate worker groups. The first group is the familiar “job stayers” whose wage growth indicate, again, the rate of wage inflation. The second group is called “job-to-job movers” who worked both in the initial and end year but in a different unit. We denote this group of workers by

Ω_{JM} . The third group is called "non-job movers" who did not work either in the initial or end year (i.e. has either entered or exited the labor markets). This group is denoted by Ω_{NM} .[10]

We next present Equation (6.a) that is a modification of Equation (2) in two main respects. First, unit indicator *i* is replaced by worker indicator *j*. Second, both the entry and exit components are now split into two sub-components, one for job-to-job movers and other for non-job movers. The second row shows the within component of the workers, which is a weighted[11] average hourly wage growth rate of the job stayers because $\sum_{i\in C(j)} \overline{s}_{jt}^{C(j)} = 1$. The third row indicates the between component, which measures the effect of changing composition of hours worked between the job stayers. The fourth row presents the entry component of workers that consists of the separate effects of job movers (on the left-hand side) and non-job movers (on the right-hand side). The fourth row shows the exit components that also include the effects of the job movers and the non-job movers.

$$\begin{aligned}
&\ln\frac{W_t}{W_s} \cong \frac{W_t - W_s}{\overline{W}_t} = \\
&\sum_{j\in C(j)} \overline{s}_{jt}^{C(j)} \frac{\left(w_{jt} - w_{js}\right)}{\overline{w}_{jt}} + \\
&\sum_{j\in C(j)} \left(s_{jt}^{C(i)} - s_{js}^{C(i)}\right) \frac{\overline{w}_{jt}}{\overline{W}_t^{C(j)}} + \\
&\sum_{j\in N(j)\cap\Omega_{JM}} s_{jt} \frac{\left(w_{jt} - W_t^{C(j)}\right)}{W_t^{C(j)}} + \sum_{j\in N(j)\cap\Omega_{NM}} s_{jt} \frac{\left(w_{jt} - W_t^{C(j)}\right)}{W_t^{C(j)}} + \\
&\sum_{j\in X(j)\cap\Omega_{JM}} s_{js} \frac{\left(W_s^{C(j)} - w_{js}\right)}{W_s^{C(j)}} + \sum_{j\in X(j)\cap\Omega_{NM}} s_{js} \frac{\left(W_s^{C(j)} - w_{js}\right)}{W_s^{C(j)}} + \\
&\textit{cross terms of workers}
\end{aligned} \tag{6.a}$$

[10] Of course, a more detailed break-down by worker type can be applied. For instance, the job-to-job movers can split into those who have moved between firms and those who have moved between occupations within a firm.

[11] Each job stayer is now weighted by the average hours worked in the initial and end year.

By use of some algebra, Equation (6.a) can be derived in an alternative but equivalent form shown in Equation (6.b).[12] It presents the entry and exit effects of the job movers and non-job movers in a different form[13]:

$$
\begin{aligned}
&\ln\frac{W_t}{W_s} \cong \frac{W_t - W_s}{\overline{W}_t} = \\
&\sum_{j\in C(j)} \overline{s}_{jt}^{C(j)} \frac{\left(w_{jt} - w_{js}\right)}{\overline{w}_{jt}} + \\
&\sum_{j\in C(j)} \left(s_{jt}^{C(i)} - s_{js}^{C(i)}\right) \frac{\overline{w}_{jt}}{\overline{W}_t^{C(j)}} + \\
&\left(\sum_{j\in N(j)\cap\Omega_{JM}} s_{jt}\right)\left(\frac{W_t^{JM} - W_t^{C(j)}}{W_t^{C(j)}}\right) + \left(\sum_{j\in N(j)\cap\Omega_{NM}} s_{jt}\right)\left(\frac{W_t^{NM} - W_t^{C(j)}}{W_t^{C(j)}}\right) + \\
&\left(\sum_{j\in X(j)\cap\Omega_{JM}} s_{js}\right)\left(\frac{W_s^{C(j)} - W_s^{JM}}{W_s^{C(j)}}\right) + \left(\sum_{j\in X(j)\cap\Omega_{NM}} s_{js}\right)\left(\frac{W_s^{C(j)} - W_s^{NM}}{W_s^{C(j)}}\right) + \\
&\textit{cross terms of workers}
\end{aligned}
\tag{6.b}
$$

where W^{JM} and W^{NM} denote the aggregate (i.e. labor input weighted average) wage levels of the job movers and non-job movers, respectively. It should be noted that the aggregate wage level of the job movers in the initial year *s* and *t* is refer, by definition, to the same group of the workers. This fact can be used to compute the wage growth rate of the job movers (as we will do in Section 6.5 below). On the other hand, the aggregate wage levels of the non-job movers in year s and t are computed, again by definition, with the totally different groups of the workers.

The equations (6.a) and (6.b) also include the cross terms for components. They are slightly modified versions those found in Equation (5):

[12] Derivation for the entry effect of the job movers is presented in Appendix A.
[13] Of course, similar alternative formulations can be given for the equations (2) and (4).

$$
\begin{aligned}
&\textit{cross terms of workers} = \\
&\sum\nolimits_{i\in C(j)} \overline{s}_{jt}^{C(j)} \frac{\left(w_{jt}-w_{js}\right)}{\overline{w}_{jt}}\left(\frac{\overline{w}_{jt}}{\overline{W}_t}-1\right)+ \\
&\sum\nolimits_{i\in C(j)}\left(s_{jt}^{C(i)}-s_{js}^{C(i)}\right)\frac{\overline{w}_{jt}}{\overline{W}_t^{C(j)}}\left(\frac{\overline{W}_t^{C(j)}}{\overline{W}_t}-1\right)+ \\
&\sum\nolimits_{i\in N(j)\cap\Omega_{SW}} s_{jt}\frac{\left(w_{jt}-W_t^{C(j)}\right)}{W_t^{C(j)}}\left(\frac{W_t^{C(j)}}{\overline{W}_t}-1\right)+\sum\nolimits_{i\in N(j)\cap\Omega_{NS}} s_{jt}\frac{\left(w_{jt}-W_t^{C(j)}\right)}{W_t^{C(j)}}\left(\frac{W_t^{C(j)}}{\overline{W}_t}-1\right)+ \\
&\sum\nolimits_{i\in X(j)\cap\Omega_{SW}} s_{is}\frac{\left(W_s^{C(j)}-w_{js}\right)}{W_s^{C(j)}}\left(\frac{W_s^{C(j)}}{\overline{W}_t}-1\right)+\sum\nolimits_{i\in X(j)\cap\Omega_{NS}} s_{is}\frac{\left(W_s^{C(j)}-w_{js}\right)}{W_s^{C(j)}}\left(\frac{W_s^{C(j)}}{\overline{W}_t}-1\right)+
\end{aligned}
\tag{7}
$$

Equations (6) and (7) together provide us a decomposition formula that ignores the role of job restructuring but allows a more detailed analysis of worker restructuring thanks to a break-down by worker flow type. We call this Version 2, which complements Version 1 in the empirical analysis. It is particularly useful in a more detailed analysis of wage dynamics at business cycle frequencies.

4. *Institutional setting/background*

Here we outline some of the key features of the Finnish labor market systems as they apply to wage increases[14]. Most of the employees in Finnish manufacturing are covered by collective agreements. A large part of employers and employees are organized and the collective agreements are often extended to cover non-signatory parties. Collective bargaining typically takes place at the industrial level, although the negotiations are often preceded by a comprehensive agreement by the central organizations of employer organizations and labor unions.

The most important issue in the negotiations is wage increases. The negotiated wage increase sets the contractual *minimum* wage increase that may be absolute amounts, percentages or some

[14] More detailed descriptions can be found in Asplund (2007) and Böckerman et al. (2006).

combination of these (most typical). The increase applies to current wages, not only tariff wages. Typically ¾ of total wage increase has been an across-the-board increase. This means that wages for each individual in all sectors are increased similarly. These contractual wage increases have been on average about 1/3 of the actual wage increase. This difference is called “wage-drift”.

The contractual increase set the floor for the wage increases of the job stayers. For other workers (e.g. those who have changed their job), the contractual increase has an effect through increased tariff wages. Thus, although the contractual increases affect wage increases especially for job stayers, the wage drift means that there has been considerable room for heterogeneity in wage increases.

5. Data

We use wage data from the Confederation of Finnish Industries (EK), which is the central organisation of employer associations. The main industries covered by the data are manufacturing, construction, energy and transportation. Member firms of EK employ the majority of employees in manufacturing and roughly every third Finnish employee. Wage data are based on an annual survey of employers and, except for the smallest firms, a response is mandatory for member firms. The data cover the years 1985-2009. Wage data are used in collective bargaining and form the basis of the private sector wage structure data maintained by Statistics Finland, the country’s statistical authority. The information we use here thus comes from the wage records of firms and is highly reliable. We concentrate on the manufacturing sector. The sectoral composition of the data is given in in Appendix B. The data contain on average around 250 000 persons and 1100 firms annually.

The data include detailed information on wages and job titles as well as unique person and firm identifiers. Thus, it forms a linked employer-employee panel that allows for following persons over time, possibly in different firms. These data contain all necessary information to implement our methods.

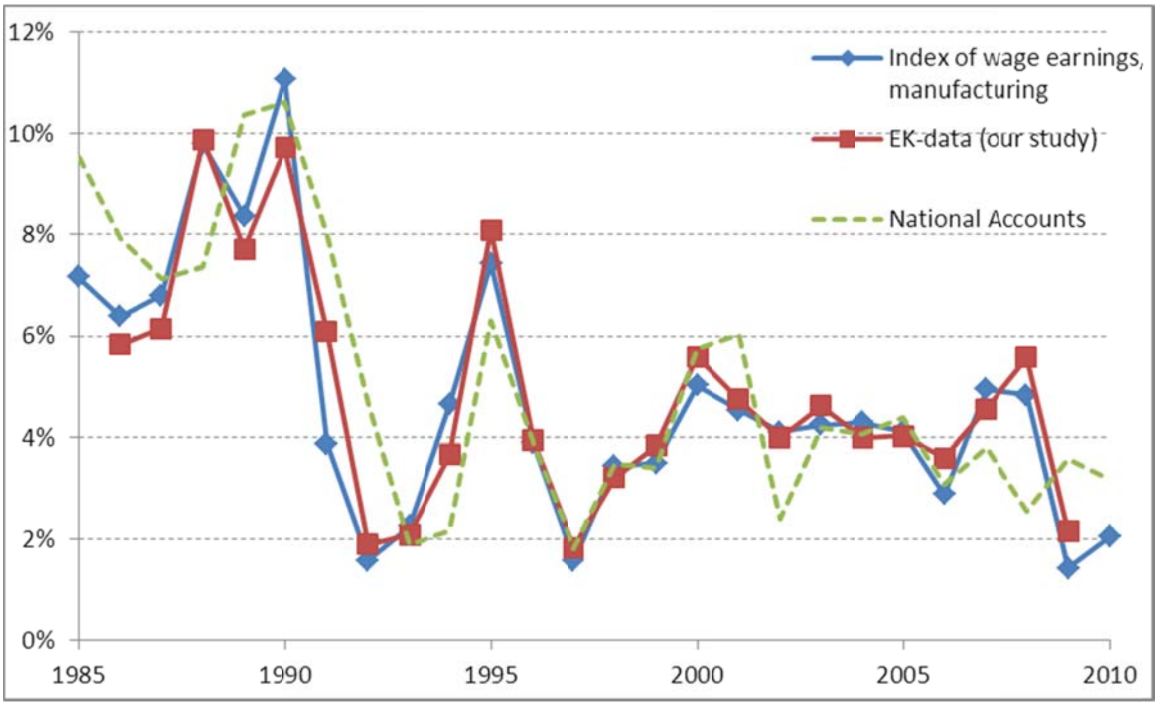
Wage variables differ for blue- and white-collar employees. For blue-collar employees, the data include hourly wages divided to fixed hourly wage, reward rates and piece rates, as well as hours worked for the quarter of the year of the survey. The earnings include overtime pay, various wage supplements (e.g. sunday compensation), but exclude bonuses. The hourly earnings are calculated as hourly wages divided by hours worked. For white-collar employees, hourly earnings are calculated as monthly earnings (inclusive of base salary, and some minor wage supplements) divided by contract hours. Bonuses are excluded.

Job titles for white-collars are uniform over the various industries. Before 2002 there were 75 job titles in use. In 2002 the titles were reformed and there are 56 titles in use after 2002. Due to this break year 2002 is omitted from all analyses, where job titles are needed. For blue-collar workers the titles are often specific to an industry and there are 141 titles in the data for the whole period of observation. The weighted[15] average number of job titles for white-collar and blue-collar employees in a given firm in 1995-2009 is 40 (17) and 6(4), respectively.

Since the data source does not cover the whole manufacturing sector (not all firms are members of EK) we assessed the representativeness of these data by comparing the aggregate wage series to figures from other data sets. Comparisons of EK-data with the National Accounts data and especially with the official index of wage earnings of Statistics Finland presented in Figure 4 indicate that our data give highly representative picture of the standard aggregate wage growth in the manufacturing sector.

[15] The weight is hours worked in a firm. The figures in parenthesis give the unweighted numbers.

Figure 4. Alternative measures for aggregate nominal wage growth in manufacturing



Notes:

6. Results

6.1. General patterns

Table 2 presents the average annual nominal aggregate wage growth rate and its components separately for years 1995-2009 and years 1985-1995. Four main findings of the table merit attention. First, the aggregate wage growth rate is lower than the wage growth rate of the job stayers (3.97% vs. 4.24% in years 1995-2009)[16]. An important part of this difference can be attributed to restructuring components (-0.22% in years 1995-2009) but also the cross terms have some role to play. Second, job restructuring has an important effect on aggregate wage growth (0.57% in years 1995-2009). The main part of this comes from the between component of the units whereas the effects of entry and exit of the units are limited. Third, worker restructuring within units has a significant negative effect. This is due to a large negative effect of entries of the workers indicating that newly hired workers typically earn currently less than the job stayers of the unit. The exit effect of the workers, on the other hand, is positive, which means that, on average, separating workers earn currently less than the job stayers of the unit. However, the net entry effect (the sum of entry and exit effect) is clearly negative (-0.77% in years 1995-2009). Fourth, the basic patterns in the components are quite similar in years 1995-2009 and 1985-1995.

[16] It should be noted that since the within component indicates the differences in wage levels between two points in time the effects of all time invariant factors are eliminated by construction. However, as for the job stayers the effect of accumulated human capital through increased experience can be expected to be limited. For example, Manning (2003, chap. 6) points out that much of the returns of experience materializes via job mobility. This is an issue that will be considered in Section 6.5.

Table 2. Decomposition aggregate wage growth in the manufacturing sector by Version 1, annual averages, %-points

	Years 1995-2009			Years 1985-1995		
	Total	Restructuring		Total	Restructuring	
		Jobs	Workers		Jobs	Workers
	(1)	(2)	(3)	(4)	(5)	(6)
Aggregate	3.97			6.11		
Within/job stayers	4.24			6.31		
Restructuring	-0.22	0.57	-0.79	-0.12	0.34	-0.46
between	0.48	0.50	-0.02	0.31	0.32	-0.01
entry	-1.07	-0.02	-1.05	-1.02	-0.16	-0.85
exit	0.37	0.09	0.28	0.58	0.18	0.40
net entry	-0.70	0.07	-0.77	-0.43	0.02	-0.45
Cross-terms	-0.05	0.00	-0.05	-0.08	-0.06	-0.02
within	0.00	0.00	0.00	-0.01	-0.05	0.04
between	0.00	0.00	0.00	0.00	0.00	0.00
entry	-0.11	0.00	-0.11	-0.11	-0.01	-0.11
exit	0.07	0.00	0.06	0.04	0.00	0.05

Notes: Year 2002 is removed due to the break in our data.

6.2. Temporal patterns

Trends in the effect of job restructuring

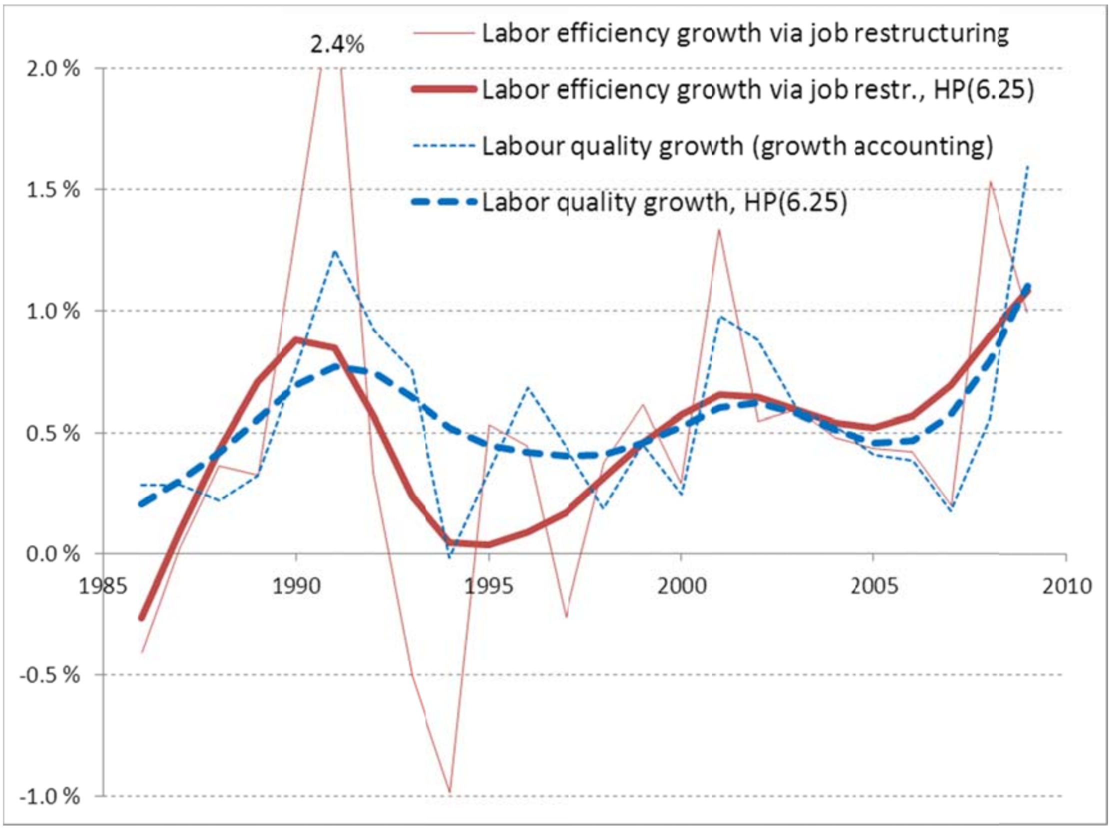
The numbers shown in Table 2 hide important time trends and cyclical patterns of the components. Figure 5 shows how the effect of job restructuring has evolved over time. To see more clearly the trends in this effect we have drawn a smoothed trend computed with a Hodrick-Prescott filter.[17] As for comparison, we have also included the growth of labor quality calculated by use of growth accounting approach and its smoothed trend.[18] The figure shows that job restructuring has an important, but somewhat countercyclical, role in growth of aggregate wages. Striking similarity of the series, both in short-run variation and in long-run trends, found in Figure 5

[17] We have used a lambda parameter value of 6.25, as proposed by Ravn and Uhlig (2002).

[18] For a more detailed description of the methodology and these growth accounting computations, see the web pages of Statistics Finland http://tilastokeskus.fi/til/ttut/index_en.html (accessed on January 4, 2012). We thank Antti Pasanen from Statistics Finland who kindly provided us the annual numbers of the growth accounting computations by Statistics Finland.

is outstanding given that the two alternative measures of labor input efficiency growth are based on different approaches (our wage decomposition vs. the traditional growth accounting) and different data (EK-data vs. register and survey data underlying the National Accounts). All in all, Figure 5 provides an empirical confirmation that the components of job restructuring in our wage decomposition capture micro-level mechanisms that are essential for long-run growth of labor productivity.[19] These components explain an essential part of the standard aggregate wage growth. An additional finding from our decomposition is that the increase in the efficiency of labor input can be predominately attributed to restructuring between continuing units, as shown in Table 2.

Figure 5. The effect of job restructuring compared to the change in labor quality according to the growth accounting, Version 1



Notes: Annual figures for labor quality estimates in the manufacturing sector are obtained from Statistics Finland. Computations are based on the cross-tabulations of labor input into 18 groups

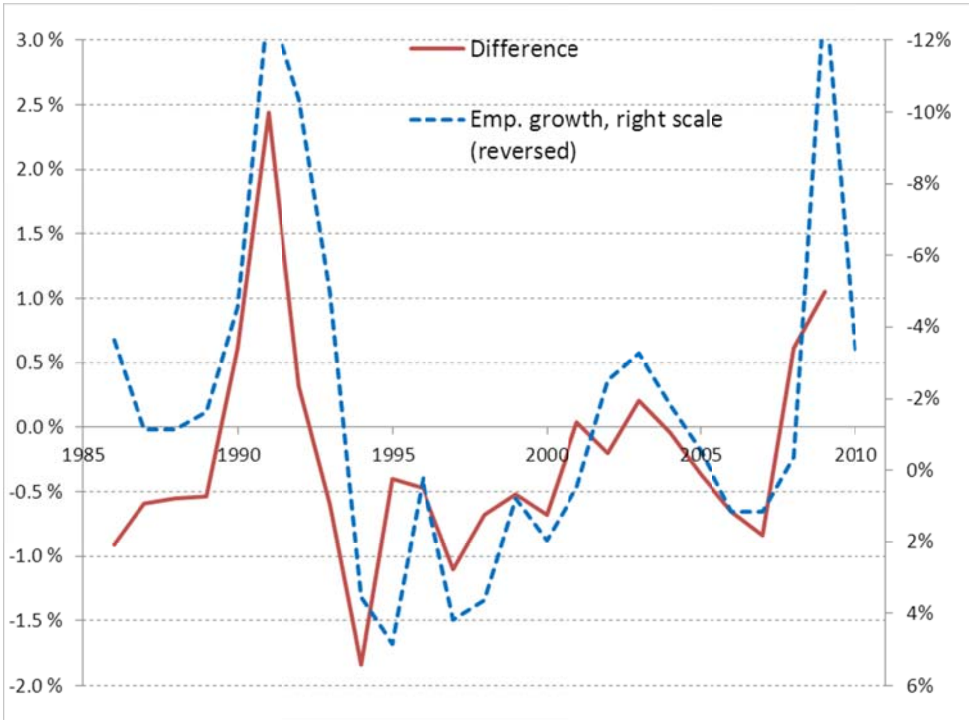
[19] A graphical illustration of these mechanisms were presented in Figure 1, panel A.

(by age, education and gender). The numbers for the effect of job restructuring are from this study. Both time-series are smoothed by Hodrick-Prescott filter with a lambda parameter of 6.25, which is denoted by HP(6.25).

Patterns in the effect of worker restructuring

Figure 6 shows another important temporal aspect that our decomposition method is able to identify, that is the role of business cycles. Earlier literature has shown that aggregate wages exhibit less cyclicality than wages of individuals (e.g. Solon et al. 1994 , Devereux 2001 , Devereux and Hart 2006). Figure 6 shows the difference of standard aggregate wage growth and wage growth of job stayers over time. By definition, this difference consists of two main parts: 1) the restructuring components (both job and worker) and 2) the cross terms. As such, it is a measure of the composition bias (Solon et al. 1994). The difference of standard aggregate wage growth and wage growth of job stayers has cyclical patterns that are as striking as those in labor efficiency growth through job restructuring. As an indicator of economic fluctuations, we have added growth of hours worked in manufacturing to the figure. Since it is presented on a reversed scale, the close co-movement of the two series indicates a strong countercyclicality in the difference between aggregate and job stayer wage growth. This means that compositional changes in the labor market smooth out aggregate wage changes compared to the wage changes of job stayers. This result corroborates the earlier findings in the literature.

Figure 6. Patterns in the difference between aggregate and job stayer wage growth, Version 1



Notes: Figures for growth of hours worked in the manufacturing sector are obtained from the National Accounts of Statistics Finland. Note that the right scale is reversed so that co-movement of the series indicates countercyclicality of the difference in the growth rates. Note also that the numbers for labor input growth rates refer to the annual averages whereas our data refer to the final quarter of the year. This difference in the timing is likely to explain some discrepancies between the series in certain years.

Before going to a more detailed analysis of the cyclicality, which is made in Section 6.3, we first look at the temporal patterns of the cross terms and consider their implications.

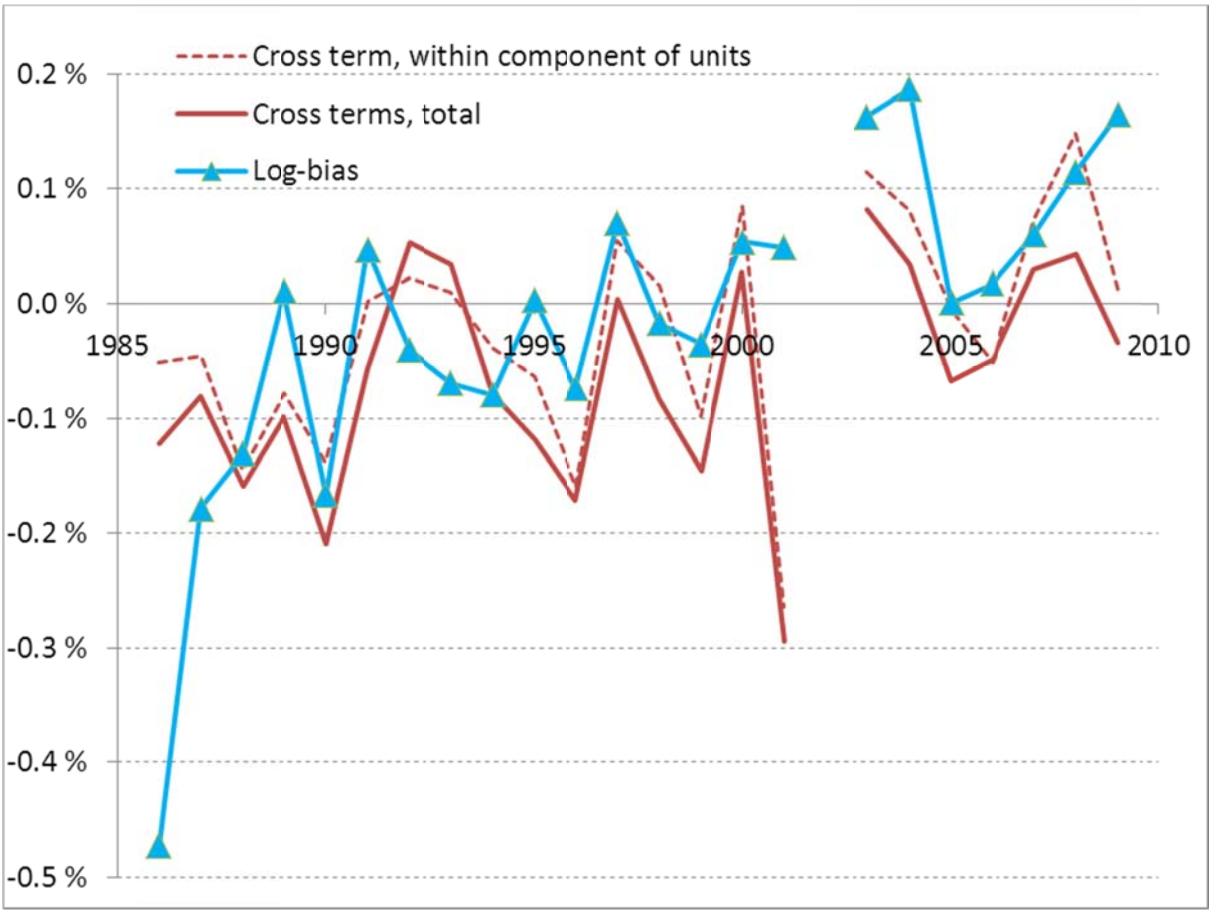
Patterns in log-bias of aggregation

Figure 7 shows the log-bias in the aggregate measure of wage growth. It is the difference between the standard aggregate wage growth and the aggregate wage growth that is obtained by aggregating the log wages of workers (by use of shares of hours worked).[20] As can be seen, on average, the log-bias is not very large but nonetheless it has non-trivial amount of temporal variation (some annual fluctuation and an upward-sloping trend). Interestingly, the figure shows

[20] All these computations have been made with the same data and following analogous procedures as in other computations.

that the log-bias is strongly correlated with the sum of all cross terms of Version 1, the main exceptions are years 1986 and 2001.[21] The figure also shows that the sum of the cross terms is heavily dominated by the cross term of the within component of the units. The interpretation of this component is not quite straightforward for its somewhat complicated structure, but a negative value may provide indication of a tendency that low-wage units have higher wage growth rates than high-wage units. Table 1 provides a demonstration of such situation.

Figure 7. Cross terms and log-bias in the measurement of aggregate wages, Version 1



[21] Note that there is a break in our data in year 2002 and therefore these numbers are excluded from the figure.

6.3. The cyclicality of the micro-components

In this section we perform a systematic analysis of the cyclical behavior of the standard aggregate wage growth and its micro-level components with regression models. To examine the aspects of worker restructuring in greater detail we now apply Version 2 of our decomposition that includes a distinction by the type of worker flows (i.e. job-to-job and non-job flows). However, before going to regression analyses based on the time series we first present the general patterns (i.e. the period averages) in the micro-level components of the standard aggregate wage growth computed by Version 2.

General patterns in worker restructuring with a distinction by the type of movement

Main results obtained with Version 2 of our wage decomposition are presented in Table 3. First, the average wage growth rate of job stayers is 4.15% in years 1995-2009 that slightly differs from the one obtained with Version 1 and presented in Table 2 (4.24%). The gap is due to slightly different weighting structure between the methods.[22] However, these two series are extremely similar (correlation is 99.2%). The aggregate wage growth rate (3.97% in years 1995-2009) is identical by definition. Second, worker restructuring has a negative effect (-0.19 %-points in 1995-2009) on aggregate wage growth. Third, the negative effect is due to the negative entry effect (-.66 %-points). Fourth, the negative entry effect in turn is solely contributed by the non-job movers (that include worker flows from the unemployment or education). This negative effect (-1.24 %-points) indicates that these entrants have a wage level that is lower than that of the job stayers of the manufacturing sector in the year of entry. Fifth, the exit effect is positive (0.33 %-points), which comes from the contribution of non-job movers (those who did not appear in our data in

[22] In Version 1 weighting is based on the input share of the continuing units (that implicitly also involves hours worked by job movers and non-job movers of the continuing units in the initial and end year) whereas Version 2 takes into account only the hours worked by the job stayers. The weighting structure of Version 2 is somewhat more ideal than that of Version 1 but its inability to capture the roles of job restructuring is its caveat.

the next year because of unemployment or retirement, for example).[23] The positive contribution indicates that these workers earned less than the job stayers in the manufacturing sector before they left the labor markets. Later we examine the time patterns of the relative wage levels and input shares of the non-job movers in greater detail in Figure 8. Sixth, the effects of the cross terms are generally of minor importance.

Table 3. Decomposition aggregate wage growth in the manufacturing sector by Version 2, annual averages, %-points

	Years 1995-2009				Years 1985-1995			
	Total	Job stayers	Job movers job-to-job	non-job	Total	Job stayers	Job movers job-to-job	non-job
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(3)
Aggregate	3.97				6.11			
Within/job stayers	4.15				6.22			
Restructuring	-0.19	0.15	0.14	-0.47	-0.08	0.18	0.12	-0.38
between	0.15	0.15			0.18	0.18		
entry	-0.66		0.58	-1.24	-1.35		0.07	-1.43
exit	0.33		-0.44	0.77	1.09		0.04	1.05
net entry	-0.33		0.14	-0.47	-0.26		0.12	-0.38
Cross-terms	0.01		0.02	-0.04	-0.03		0.00	-0.09
within	0.03	0.03			0.05	0.05		
between	0.00	0.00			0.00	0.00		
entry	-0.02		0.01	-0.03	-0.07		0.00	-0.07
exit	0.00		0.01	-0.01	-0.02		0.00	-0.02

Notes: Year 2002 is excluded from the calculations due to change in the occupational titles.

Regression analysis of the components

Next we study the cyclicality of the components of worker restructuring with simple OLS regressions. The dependent variable is the nominal aggregate wage growth rate or one of its

[23] It should be noted that non-job movers are those who have found in our data either only in the initial year (entrants) or only in the end year (exiting workers). As a result these worker flows also include workers who have stayed in the labor markets but have, for example, moved between the manufacturing sector and other sectors. On the other hand, according to Napari (2009) such transitions are relatively rare. However, as these flows are nonetheless a less-than perfect measure of the transitions between the employment and non-employment our empirical analysis can be expected to give a somewhat mitigated role for these transitions as a source of worker restructuring.

micro-level components. All in all, we have 22 different dependent variables in the analysis. As explanatory variables we use growth of a price index (consumer prices or the price of value added in the manufacturing sector) and an indicator of business fluctuation (growth of GDP, hours worked in the manufacturing or unemployment), whose coefficient is of our main interest here.

The coefficients of business cycle indicators and their statistical significance levels are reported in Table 4. By construction, the coefficients are mutually related according to Version 2 presented in Equations (6) and (7), and shown in Table 3. Panel A reports the results obtained by using the growth rate of gross domestic product. A number of interesting findings can be made. First, we note that there is positive relationship between the standard aggregate wage growth (the coefficient is 0.101) indicating some procyclical flexibility in aggregate wages. However, the relationship is not statistically significant. The coefficient of the within component instead is statistically highly significant, giving indication of procyclical flexibility in wages of the job stayers. The coefficient implies that a deceleration of GDP growth by one percentage point leads to a decline of wage growth of the job stayers by 0.29 %-points. This result shows that aggregate wages are smoothed out by job and worker restructuring. This finding is similar to e.g. Solon et al. (1994) and Shin (1994). Moreover, our finding that wages of job stayers are about twice as cyclically sensitive as aggregate wages is similar to their finding for the difference between results from aggregate data and micro data. Our finding that wages of job stayers are quite cyclically flexible is similar to Devereux and Hart (2006). However, our results show less cyclical sensitivity than their results for UK.

Second, the difference in the aggregate wage and job stayer wage flexibility can be totally attributed to the countercyclical pattern of the restructuring effect (-0.17). This result shows explicitly the magnitude of the composition bias identified by the earlier literature. Third, the negative restructuring effect results almost entirely from the net entry effect of the non-job movers (-0.156), which is dominated by the exit effect (-0.092). This is an important result, because it reveals the nature of the composition bias. Aggregate wage fluctuations are smoothed out by low wage workers entering the labor market in upturns and exiting in downturns as illustrated in Figure 2 above. On the other hand, job-to-job movers do not contribute to the restructuring component. In fact, this is not at all a surprising finding since each job-to-job mover is both an entrant and an exiting worker and therefore by construction these movements do not involve any worker restructuring. The cyclicality of wage growth of job-to-job movers is a different issue that will be tackled later. Fourth, when business cycle fluctuations are measured by a sector specific indicator (the growth rate of hours worked in the manufacturing sector), the absolute values of the coefficients for the job stayers and restructuring are somewhat smaller than above, but their general patterns are quite similar. The use of unemployment rate as an indicator of business cycles leads to similar conclusions concerning the cyclicality of wage growth of the job stayers and the effect of restructuring (not reported here).

Table 4. Regression coefficients of business cycles indicators, components based on Version 2

	PANEL A: GDP of the economy				*PANEL B: Hours worked in the manufacturing*			
	Total	Job	Job movers		Total	Job	Job movers	
		stayers	job-to-job	non-job		stayers	job-to-job	non-job
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Aggregate	0.117				0.096			
Within	0.286***	0.286***			0.221***	0.221***		
Restructuring	-0.168***	-0.016	0.005	-0.156***	-0.123***	-0.008	0.004	-0.119***
between	-0.016	-0.016			-0.008	-0.008		
entry	-0.045		0.019	-0.064**	-0.031		0.020	-0.051**
exit	-0.106**		-0.014	-0.092***	-0.084**		-0.016	-0.068***
net entry	-0.151***		0.005	-0.156***	-0.115***		0.004	-0.119***
Cross-terms	-0.002				-0.002			
within	0.001	0.001			-0.001	-0.001		
between	-0.000**	-0.000**			-0.000*	-0.000*		
entry	-0.003		0.001	-0.003*	-0.002		0.001	-0.002*
exit	0.000		0.001	-0.001	0.000		0.001	-0.000

Note: All regressions include growth rate of consumer prices and time trend as explanatory variables, 23 observations (year 2002 is excluded).

Another issue of great interest concerns the role of the price concept because the macroeconomic literature emphasizes the flexibility of “real” wages. In our baseline analysis wages are measured in nominal terms and the effect of general price changes has been controlled by using the growth rate of the consumer price index as one of the explanatory variables. In an alternative analysis the consumer price is replaced by the (implicit) price of the real valued added of the manufacturing sector, which had only a minor effect on the results.

In addition, we have also applied another approach that is based on the decomposition of real wage growth. This is done by converting the wages of the individuals in the initial year into next year’s prices (i.e. prices of the end year) by use a deflator of consumer prices, or alternatively, of the real value added prices in the manufacturing.[24] The entry and exit components, instead, are totally independent of the price index. This can be seen from Equation (6) (and Equation (2)) which

[24] It is should be noted that this is in practice the same as to deflate the aggregate wage growth and the within component with a price index.

shows that the components of entry and exit are solely based on contemporary wages and therefore price index figures will cancel out. In practice also the between component is independent on the price index.[25] Regression analyses similar to those in Table 4 that are made with the decomposition of real wages (deflated by consumer prices) yielded essentially very similar results about the cyclicality of aggregate wage growth and wage growth of the job stayers (and about the cyclicality of the restructuring components, of course). However, when wages are deflated by the price of value added the coefficients for the aggregate wage growth and wage growth of the job stayers become statistically insignificant.

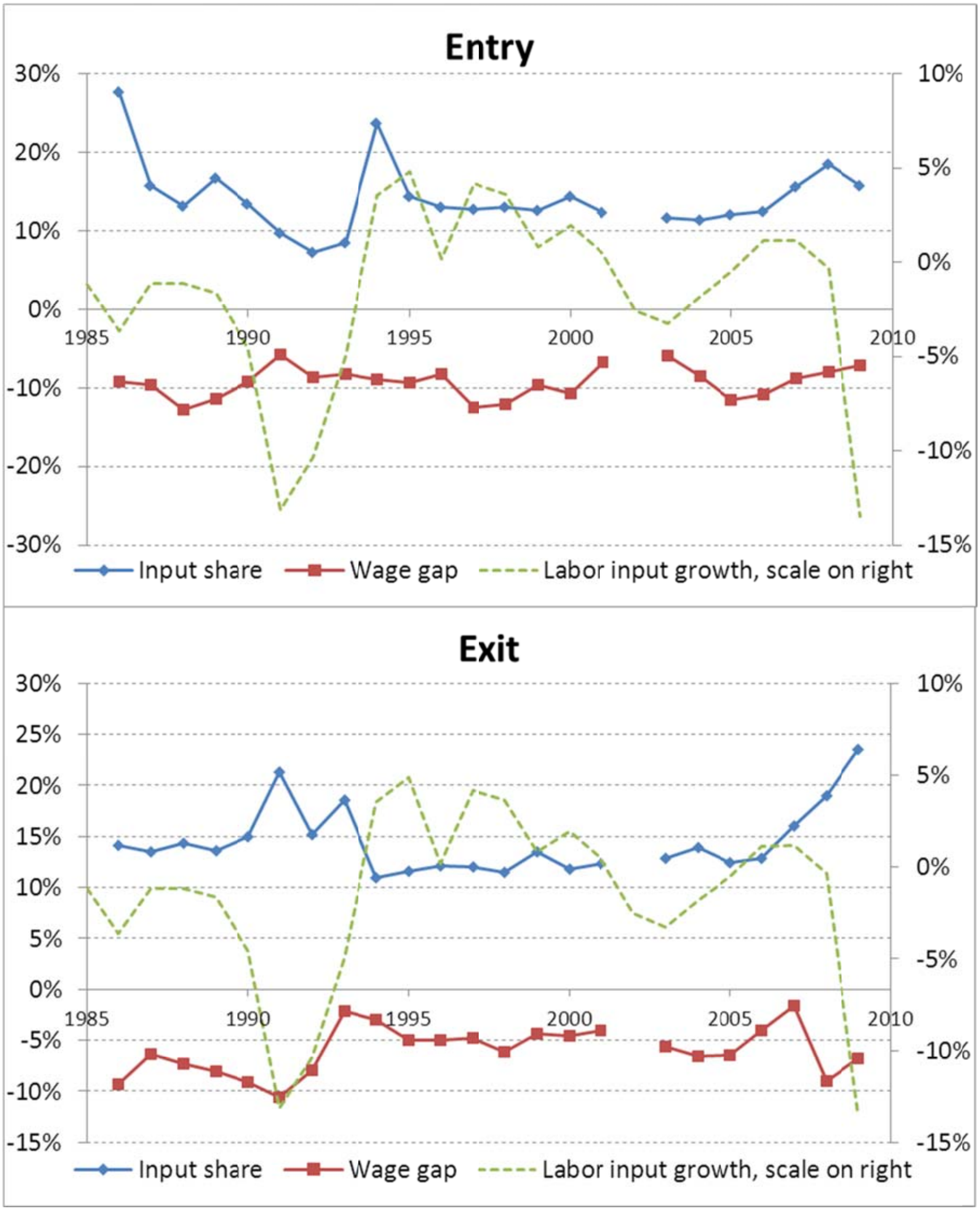
Elements of contribution of the non-job movers

Since the effects of the non-job movers were found to have particularly strong cyclical patterns they merit a closer attention. Figure 8 provides a further break-down of the factors underlying their effects. As shown in in Equation (6.b), the entry effect of the non-job movers is a product of two factors, 1) the aggregate wage gap to the job stayers (i.e. $\frac{W_t^{NM} - W_t^{C(j)}}{W_t^{C(j)}}$) and 2) the labor input share of those who have entered labor markets in the end year (i.e. $\sum_{j \in N(j) \cap \Omega_{NM}} s_{jt}$). The exit effect of the non-job movers is determined in an analogous manner as a product of 1) their wage gap (i.e. $\frac{W_s^{C(j)} - W_s^{NM}}{W_s^{C(j)}}$) and 2) labor input share ($\sum_{j \in X(j) \cap \Omega_{NM}} s_{js}$) in the initial year. As shown in Figure 8 the relative wage level is particularly low and the input share is high during the upturns that together explain why the entry effect is particularly negative in those times. The exit effect, on the other hand, is less positive during the upturns since the wage level of the exiting workers is less negative and the input share smaller than during the downturns. It is also worth noting that, on average, the relative wage level of those entering labor markets (which includes young

[25] Our empirical decompositions with nominal wages and real wages (deflated with consumer prices) indicate that the absolute difference in the annual between components is always less than 0.008%-points.

workers) is lower than that of those leaving (includes retiring workers), which illustrates the negative effect of the labor turnover on aggregate wage growth in the long run.

Figure 8. Components of non-job switchers



Note: Figures for labor input growth (change in hours worked) in the manufacturing are obtained from the National Accounts of Statistics Finland. Wage gap indicate the wage difference to that of the job stayers in accordance of Equation (6.b).

6.4. The cyclicality of contractual increase and wage drift

In economies where collective bargaining has an important role to play in wage setting the actual wage increase is the sum of contractual wage increase and so-called wage drift[26]. The wage drift is typically calculated as the difference between an index of wage earnings and the contractual increase (see e.g. Holden 1989). As such it is prone to various composition effects. A measure of wage drift that is free from composition bias would be important for the parties engaged in collective bargaining, but also as an input for macroeconomic models.

In Table 5 we show the sensitivity of wage increases of job stayers, the contractual increase, the wage drift for job stayers, and the "official" wage drift to three measures of business cycles. In panel A, business cycles are measured by change in the log GDP. From the third column it is seen that the wage drift for job stayers is strongly procyclical. As shown earlier, the wages of job stayers are cyclical, whereas it is seen from the second column that the contractual increase is not related to GDP growth. Comparison the third and fourth columns show that the "official" wage drift is much less cyclically sensitive than the wage drift for job stayers. This of course reflects the impact of restructuring on aggregate wages as shown above. These results show that wage drift plays an even larger role in Finnish wage setting than previously thought.

[26] Wage drift has been analyzed for many European countries, including the Nordic countries (Holden 1989 , Hibbs and Locking 1996 , Holden 1998) and Spain (Palenzuela and Jimeno 1996).

Table 5. Cyclical sensitivity of the wage drift

	Panel A: GDP			
	Δ wage of job stayers	Contractual wage increase	Wage drift (job stayers)	Wage drift (official)
ΔlnGDP	0.286***	0.087	0.200***	0.113**
	0.085	0.085	0.037	0.048
ΔlnCPI	0.670***	0.579**	0.091	0.280**
	0.216	0.216	0.094	0.122
Observations	23	23	23	23
R-squared	0.639	0.334	0.764	0.660
P-value				0.000372
	Panel A: Hours worked			
	Δ wage of job stayers	Contractual wage increase	Wage drift (job stayers)	Wage drift (official)
ΔlnHours	0.221***	0.072	0.148***	0.079**
	0.064	0.064	0.029	0.037
ΔlnCPI	0.763***	0.610**	0.154	0.314**
	0.215	0.217	0.097	0.125
Observations	23	23	23	23
R-squared	0.647	0.341	0.751	0.645
P-value				1.58e-05
	Panel C: Unemployment rate			
	Δ wage of job stayers	Contractual wage increase	Wage drift (job stayers)	Wage drift (official)
ΔlnUnemployment	-0.688***	-0.413**	-0.275**	-0.172
	0.158	0.155	0.105	0.106
ΔlnCPI	0.594***	0.532**	0.062	0.262*
	0.194	0.190	0.128	0.130
Observations	23	23	23	23
R-squared	0.711	0.488	0.559	0.614
P-value				0.0312

Notes: P-value refers to test of equality of the first row coefficients in the third and fourth columns in each panel. The official wage drift is calculated as the difference between index of wage earnings in manufacturing and the contractual wage increase. Time trend is included.

6.5. *The cyclicality of wage growth of job-to-job movers*

By means of Equation (6.b) the wage growth rate of the job-to-job movers can be measured as the sum of the within component of the job stayers, i.e. $\sum_{j \in C(j)} \bar{s}_{jt}^{C(j)} \left(w_{jt} - w_{js} \right) / \bar{w}_{jt}$, the between component of the job stayers, i.e. $\sum_{j\in C(j)}\left(s_{jt}^{C(i)}-s_{js}^{C(i)}\right)\left(\overline{w}_{jt}\middle/\overline{W}_{t}^{C(j)}\right)\left(W_t^{JM}-W_t^{C(j)}\right)\Big/W_t^{C(j)}$, minus the wage gap of the job-to-job movers in the initial year, i.e. $\left(W_s^{C(j)}-W_s^{JM}\right)\Big/W_s^{C(j)}$.[27]

We have performed similar regression analyses as above but now for the wage growth of the job stayers (that now includes also the between component) and the corresponding measure for the job-to-job movers.

Table 6 Cyclicality of wage growth among job stayers and job-to-job movers

	Δ wage among job stayers	Δ wage among job movers	Δ wage among job stayers	Δ wage among job movers	Δ wage among job stayers	Δ wage among job movers
ΔlnGDP	0.270***	0.366***				
	0.093	0.106				
ΔlnHours			0.213***	0.288***		
			0.069	0.078		
ΔUnemployment					-0.711***	-0.976***
					0.165	0.171
ΔlnCPI	0.747***	0.879***	0.837***	1.001***	0.668***	0.770***
	0.236	0.270	0.233	0.265	0.203	0.210
Observations	23	23	23	23	23	23
R-squared	0.604	0.625	0.619	0.644	0.710	0.776
P-value		0.00413		0.00135		2.97e-08

Note: Here the wage growth rate of the group (job stayers or job-to-job movers) also the between component. P-value refers to test of equality of the coefficients of the business cycle variable for job stayers and job movers. Time trend is included.

The results reveal that in addition to the fact that wages of the job stayers exhibit procyclical pattern (thanks to wage drift) wages of the job-to-job movers are even more flexible. These results are similar to e.g. Shin (1994) and Devereux and Hart (2006) even though the methods to reach the results are quite different.

[27] It should be noted that here we include the between component of the wage growth of the job-to-job movers for sake of comparability between the groups of job stayers and job-to-job movers. Note that, for example, the figure 0.270 for the wage growth among job stayer (obtained with GDP measure) in Table 6 is, by definition, the sum of the figures 0.286 and -0.016 in Table 4 for the within and between component, respectively.

7. Conclusion

We have proposed an approach for measuring and analyzing dynamics of the standard aggregate wage growth of the macro statistics with micro-data. We present a decomposition of the standard aggregate wage growth which includes explicit expressions for various composition effects with clear interpretations whereas earlier literature has only implicitly shown the role of various compositional changes in explaining the behavior of aggregate wages (see Shin 1994 , Solon et al. 1994 , Abraham and Haltiwanger 1995 , Devereux 2001). One advantage of our approach is that it allows examining several key research questions of the modern macro literature consistently in a coherent framework. On top of that our approach opens opportunities for a deeper analysis of various micro-level mechanisms.

Application of our decomposition method to linked longitudinal employer-employee data provides numerous micro-level components that capture various distinct micro-level mechanisms underlying the standard aggregate wage growth numbers that all are highly relevant from the point of view of the macroeconomic literature. They include the effect of wage growth of the job stayers alongside different effects of compositional changes associated with job and worker flows in the labor markets. Appropriate measurement of these effects is crucial for understanding wage growth in the long run as well as its cyclical variation in the short run. Besides showing analytically and illustrating graphically attractive features of our decomposition method, we demonstrate empirically the usefulness of our method for addressing topics such as the effect of job restructuring on efficiency of labor input, cyclical variation in wage growth of the job stayers and job movers, cyclical variation in the effect of worker composition changes (i.e. worker restructuring), the role of the wage drift as an adjustment mechanism in the collective bargaining system and the magnitude and temporal patterns of the log-bias caused by aggregating log-wages instead of use normal wages in accordance of the standard aggregate measure of wages.

Closer inspection of the components of aggregate wage growth in the Finnish manufacturing sector indicates, first, that growth of labor efficiency via job restructuring at the level of occupations and firms has a sustained positive (around 0.5 %-points per year) impact on aggregate wage growth and therefore constitutes an important source of economic growth in the long run. Second, wage growth of the job stayers is higher than aggregate wage growth and, third, it exhibits significantly stronger procyclical fluctuation than aggregate wages. Fourth, we find that wage growth of the job movers is, on average, even higher and exhibits stronger procyclical fluctuation than that of the job stayers. Fifth, the effect of compositional changes in worker structures instead has a strong countercyclical pattern, which can be attributed almost entirely to worker flows in and out of labor markets. Sixth, the wage drift when defined as a difference in wage growth of the job stayers and contractual wage growth has a strong procyclical pattern. This implies that wage drift constitutes an important adjustment mechanism in the collective bargaining system. Typically analyses based on our wage decompositions provides statistically and economically more significant results than more traditional counterparts that do not properly identify the effect of various compositional changes. All in all wage formation in the labor markets turns out to be much more flexibility over business cycles than it appears on the basis of the standard aggregate wage growth figures.

In future research we plan to extend these analyses beyond the manufacturing sector that will allow us considering sectoral differences in aggregate wage formation. This is interesting as the disparity in the development of industries can be expected to show up in the differences of the micro-level patterns of wage growth between industries. Similarly the approach can be applied to examine gender differences in the wage formation. Further, with slight modification our method can be applied to addressing numerous other interesting research questions. For instance, our approach appears to be useful for examining regional differences with an extension of distracting the contribution of migration as a part of regional job and worker restructuring.

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Appendix A. Derivation of the alternative formulation of the effect of the non-job entrants.

$$\textit{component in } (6.a) = \sum_{j\in N(j)\cap\Omega_{JM}} s_{jt} \frac{\left(w_{jt} - W_t^{C(j)}\right)}{W_t^{C(j)}} =$$

$$\sum_{j\in N(j)\cap\Omega_{JM}} \frac{h_j}{\sum_{j\in N(j)\cup C(j)} h_j} \frac{w_{jt}}{W_t^{C(j)}} - \sum_{j\in N(j)\cap\Omega_{JM}} \frac{h_j}{\sum_{j\in N(j)\cup C(j)} h_{jt}} \frac{W_t^{C(j)}}{W_t^{C(j)}} =$$

$$\frac{\sum_{j\in N(j)\cap\Omega_{JM}} h_j}{\sum_{j\in N(j)\cup C(j)} h_j} \sum_{j\in N(j)\cap\Omega_{JM}} \frac{\dfrac{h_j}{\sum_{j\in N(j)\cup C(j)} h_j}}{\dfrac{\sum_{j\in N(j)\cap\Omega_{JM}} h_j}{\sum_{j\in N(j)\cup C(j)} h_j}} \frac{w_{jt}}{W_t^{C(j)}} - \sum_{j\in N(j)\cap\Omega_{JM}} \frac{h_j}{\sum_{j\in N(j)\cup C(j)} h_{jt}} \frac{W_t^{C(j)}}{W_t^{C(j)}} =$$

$$\frac{\sum_{j\in N(j)\cap\Omega_{JM}} h_j}{\sum_{j\in N(j)\cup C(j)} h_j} \sum_{j\in N(j)\cap\Omega_{JM}} \frac{h_j}{\sum_{j\in N(j)\cap\Omega_{JM}} h_j} \frac{w_{jt}}{W_t^{C(j)}} - \sum_{j\in N(j)\cap\Omega_{JM}} \frac{h_j}{\sum_{j\in N(j)\cup C(j)} h_{jt}} \frac{W_t^{C(j)}}{W_t^{C(j)}} =$$

$$\left(\sum_{j\in N(j)\cap\Omega_{JM}} s_{jt}\right) \frac{W_t^{JM(j)}}{W_t^{C(j)}} - \left(\sum_{j\in N(j)\cap\Omega_{JM}} s_{jt}\right) \frac{W_t^{C(j)}}{W_t^{C(j)}} =$$

$$\left(\sum_{j\in N(j)\cap\Omega_{JM}} s_{jt}\right) \left(\frac{W_t^{JM(j)} - W_t^{C(j)}}{W_t^{C(j)}}\right) = \textit{component in } (6.b)$$

Appendix B. Sectoral composition of the data.

	Frequency	Percent
Manufacture of footwear	52,952	0.7
Manufacture of glass and glass products	46,869	0.62
Plumbing	105,426	1.39
Manufacture of leather and related products	19,906	0.26
Wood industry (woodwork)	184,132	2.42
Manufacture of building materials	33,764	0.44
Manufacture of clay building materials	6,481	0.09
Manufacture of wearing apparel	183,700	2.42
Energy	297,194	3.91
Manufacture of textiles	220,669	2.91
Manufacture of beverages	59,369	0.78
Technology industries	1,767,151	23.27
Technology industries	1,716,696	22.61
Forest industry	8,644	0.11
Wood industry (saw mill etc.)	417,912	5.5
Manufacture of paper and paper products	1,264,288	16.65
Manufacture of chemicals and chemical products	289,358	3.81
Manufacture of refined petroleum products	83,550	1.1
Manufacture of basic chemicals, fertilisers and nitrogen compounds, p	353,290	4.65
Processing and preserving of meat and production of meat products	219,146	2.89
Manufacture of food products	208,124	2.74
Manufacture of rubber products	54,809	0.72
Total	7,593,430	100