Micro-components of aggregate wage dynamics[*]

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Abstract

We propose an approach for measuring and analyzing the dynamics of the standard aggregate wage growth of macro statistics with micro-data. We develop a method to decompose aggregate wage growth to wage growth of job stayers and various terms related to worker and job restructuring. This method produces explicit expressions, with clear interpretations, for the various restructuring components and thus opens new opportunities for a deeper analysis of various micro-level mechanisms and their cyclicality. The method also allows us to study simultaneously many topics that have previously been studied in isolation. Using comprehensive longitudinal employer-employee data over a long period of time we study how worker and job restructuring influence aggregate wage growth and its cyclicality. We show that wage formation is significantly more flexible than aggregate numbers suggest and indicate the micro-level mechanisms that explain this greater flexibility.

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1. Introduction

The statistics of the Bureau of Labor Statistics (BLS) for the US non-farm business indicate a substantial acceleration in growth of hourly real compensation from -0.4% to +2.1% between years 2008 and 2009. At the same time labor productivity growth accelerated from +0.6% to +2.3%. These numbers together would unambiguously convey a healthy picture on the economy unless the wage growth number were indicative of a strong counter-cyclical pattern in wage formation, that is because acceleration in wage growth coincided with a deceleration of the (net) decline in hours worked from -2.1% to -7.2%. On the other hand, the statistics of the BLS also provide evidence on incessant job restructuring beneath the figures of the net employment growth rates; the figures for business employment dynamics reveal that the average quarterly rates of gross job gains and losses in the US private sectors in years 2001-2010 were 6.8% and 6.8%, respectively.

Aggregate wage (productivity) growth means that wage bill in real terms (total real value added) per total number of hours worked has increased. This growth may be due to wage changes of job stayers (those who stay in the same occupation and firm) or changes in *worker composition* (i.e. worker restructuring) or changes in *job composition* (i.e. job restructuring).

To interpret the above figures properly we need to consider various micro-level mechanisms underlying aggregate wage growth. A sharp distinction between wage growth of the job stayers and the effect of compositional changes on aggregate wage growth is essential for understanding both long-run determinants and cyclical behavior of wage growth. For long-run economic growth, the distinction is essential because incessant changes in *job composition* (i.e., job restructuring) increase the productivity of the hours worked in the economy. For the cyclical aspect, there is a need to isolate 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). Neglecting these restructuring components leads to a distorted picture of aggregate wage growth. More generally, we need a rich account of the different aspects and dimensions of the composition effect. Importantly, this account should link different micro-level components consistently to the standard aggregate wage growth measure, such as that which is used in the empirical macroeconomic literature and can be read from the National Accounts.

We propose an approach for measuring and analyzing the dynamics of the standard aggregate wage growth of macro statistics with micro-data. We are the 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)[2]. One advantage of our approach is that it allows for the examination of several key research questions in the modern macro literature in a coherent framework. Moreover, our approach opens new opportunities for a deeper analysis of various micro-level mechanisms and their cyclicality.

Our approach utilizes a formula for average wages that is partially based on the Bennet (1920)[3] decomposition and is related to formulas used in the analysis of aggregate productivity growth (Maliranta 1997, Maliranta 2005, Böckerman and Maliranta 2007, Diewert and Fox 2009) and analysis of skill upgrading (Vainiomäki 1999). Our approach 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

[2] Daly et al. (2011) is an exception. They develop a decomposition for median weekly earnings, which provides an explicit expression for the worker restructuring component.

[3] For a more detailed description of the Bennet index, see Balk (2003) and Diewert (2005).

formula, the within component is a weighted average growth rate of the stayers measured in accordance with the divisia-index principle. Another key aspect of the decomposition is that the entry and exit components are mutually symmetric and 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 aspect of our method is that its aggregate wage growth rate is a very close approximation of the standard aggregate wage growth measure. This property derives from the fact that our method is based on the aggregation of the normal absolute wages rather than log wages. As a result, we avoid the typical log bias that is potentially troublesome in these types of analyses.

In our method, the formula is applied in a manner that allows us to distinguish 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 job restructuring as a determinant of nominal aggregate wage growth. Other important topics include the cyclical patterns in the wage growth of job stayers, in the effects of compositional changes, and in the wage drift between the wage growth of job stayers and contractual wage increases.

Earlier literature has not provided a suitable approach to identify and quantify the effects of job and worker composition together with true wage inflation (i.e. wage growth of the job stayers) on aggregate wage growth in a coherent framework. Probably the main reason for this is that such analysis requires rarely accessible, typically register-based, comprehensive linked employer-employee data that allow measuring the wages and input shares of the job stayers, job switchers and those how have entered or left the labor market over a relatively long time period. The lack of such data may have discouraged researchers to seek methods that are suitable to such purpose.

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

The second set of results concerns the effects of *job restructuring* (i.e., changing job composition) on aggregate wage growth. In our study, a unit refers to an occupation group in a firm and a job refers to 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 via the exit of the low-wage units and the expansion of the 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 effects of job restructuring on aggregate wage growth mirror the traditional estimates of labor quality change obtained with the standard growth accounting method very closely.

These results show that job restructuring and worker restructuring have opposite effects on aggregate wage growth, the negative effect of worker restructuring having a dominating effect Job restructuring has a positive effect because high-wage units expand and worker restructuring has a negative effect because new hires in the high-wage units receive lower wages than job stayers in those units. Thus, worker restructuring has a negative effect precisely because employees move to high wage units.

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

2. Related literature

Our paper is related to several strands of literature. It has direct links to the literature on micro-level sources of aggregate productivity growth. That literature 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 the productivity growth of firms. These analyses indicate the importance of analyzing aggregate productivity growth in the context of a heterogeneous firm framework.[4] This paper is similar in substance, but it applies these ideas to aggregate wages. Our formula differs from some popular alternatives proposed in the literature regarding the interpretation of the components,

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

particularly the within component (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 mainly because we need a measure of the wage growth of the job stayers that is distinct from that of the aggregate wage growth and its other micro-components.

The influence of job restructuring on aggregate wage growth turns out to have close links to growth accounting literature that examines the contribution of labor quality growth to aggregate productivity growth (Ho and Jorgenson 1999). The growth accounting approach is based on a cross-classification of hours worked on the basis of worker characteristics (usually gender, age, education and self-employment status).[5] Typically, these analyses find that labor quality grows about half of a percentage point per year, albeit 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. Additionally, in our approach, labor efficiency change consists of three distinct sub-components that measure job restructuring (the entry, exit and between components), which augments the interpretation of the underlying dynamics.

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

[5] 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).

Most directly our approach is linked to the large body of literature that examines 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 (as measured by earnings) varies over the business cycle due to the changing worker composition, thus leading to a smoother cyclical behavior pattern for aggregate wages. The second main finding is that the wages of job changers are more cyclical than those of job stayers (e.g. Shin 1994, Solon et al. 1994, Barlevy 2001, Devereux 2001, Devereux and Hart 2006, Carneiro et al. Forthcoming). The third finding is that movements between positions might be cyclical even within firms (Solon et al. 1997, Devereux and Hart 2006). Such cyclical job movements may affect the behavior of aggregate wages even though the wages in all jobs would be rigid.

Our approach extends these analyses by taking an accounting approach and illustrating analytically the link between aggregate wages and the various composition effects. The richness of the composition effects allows us to provide a more detailed picture of the composition bias than that which has previously been available. Our decomposition also allows us to study the previously mentioned three main findings simultaneously, and we can calculate their exact effects on aggregate wage fluctuations. Prior studies have examined these effects in isolation; for example, Solon et al. (1994) abstract away from changes in job composition, whereas Solon et al. (1997) and Devereux and Hart (2006) do not consider worker composition. Further, we empirically measure the magnitude of the worker restructuring effect and its subcomponents in the manufacturing sector over business cycles. By definition, the cyclicality of these components sum up to the cyclical changes in the standard measures of aggregate wages. This link has not been shown explicitly prior to this study.

Closest to our study is the paper by Daly et al. (2011). They develop a decomposition method to analyze how median wage growth depends on the wage growth of job stayers and worker restructuring. Their method also produces explicit expressions for the various restructuring components. The key differences to our approach is that they model the median weekly earnings, whereas we model a standard measure of aggregate wage growth (i.e. hours weighted average) and that they do not consider job restructuring, which plays an important role in our analysis. A further difference is found in the results. Their results show that unemployment margin plays only a small role for aggregate wage growth. This finding is in contrast to the previous literature using U.S. data (e.g. Solon et al. 1994, Mulligan 2011). Our results show that movements in and out of the labor market strongly affect aggregate wage growth.

Last, our results have implications for the theoretical macroeconomic literature. In that literature the cyclical flexibility of new hires vs. incumbents is an important question. Gertler and Trigari (2009) argue that most empirical studies cannot explore this because one must 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 by comparing incumbents and new hires. Our decomposition clearly shows the contribution of new hires to aggregate wage flexibility. Moreover, we distinguish between job-to-job hires and other hires in addition to separations.

3. Micro-level mechanisms and their measurement

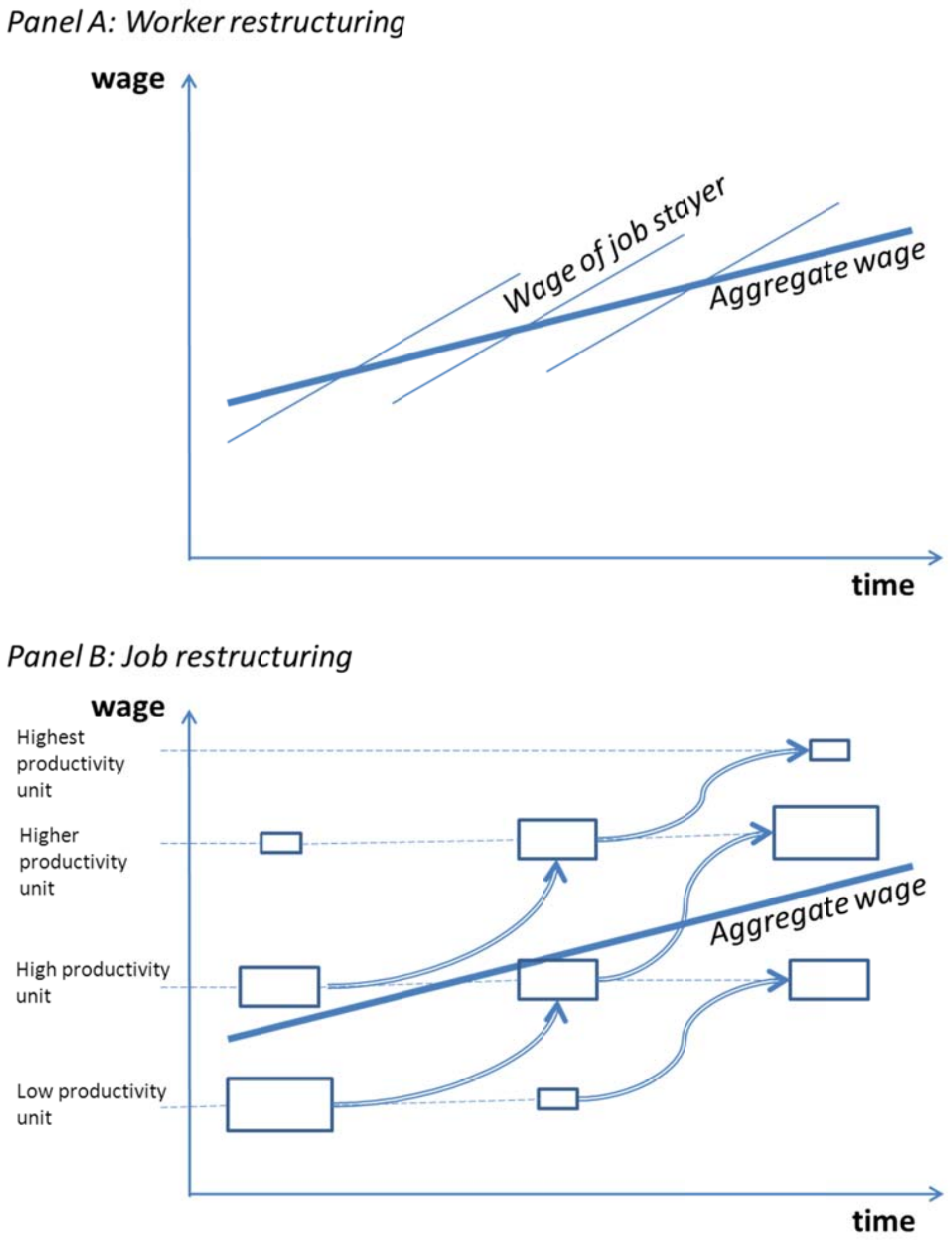
3.1. Illustrations of the mechanisms

Job and worker restructuring

This section provides the intuition for our decompositions and the next section gives the formal details. Panels A and B in Figure 1 illustrate the mechanisms underlying aggregate wage growth that we aim to measure and analyze. We need several key concepts for the analysis, which we define next. A *unit* refers to an occupation group in a firm, a *job* refers to 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 for two consecutive time periods. With these definitions in mind, we can examine Panel A in Figure 1, which illustrates a situation in which the wage growth of the job stayers continuously exceeds that of the 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 the aggregate wages, and we examine factors that drive a wedge between these slopes. In Panel A, aggregate wage growth is lower than the wage growth of the job stayers because of *worker restructuring* (older high-wage workers are replaced by younger low-wage workers). Panel B instead demonstrates a situation in which *job restructuring* has a positive impact on the aggregate wage (which is an average of the wages of the units weighted by the hours worked). In this example, there is job destruction in the low productivity/wage unit (it first shrinks and later exits) and job creation in the higher and highest productivity/wage units (either via expansion or entry). Curved double lines indicate that worker flow (these are job movers) between jobs 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 the aggregate wage growth. This happens 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 to note here is that job restructuring may have a sustained positive impact on aggregate wage growth when it involves the entry of new high-wage (and high productivity) units that replace older low-wage (and low productivity) units. As a result, this mechanism can be important for long-run growth.

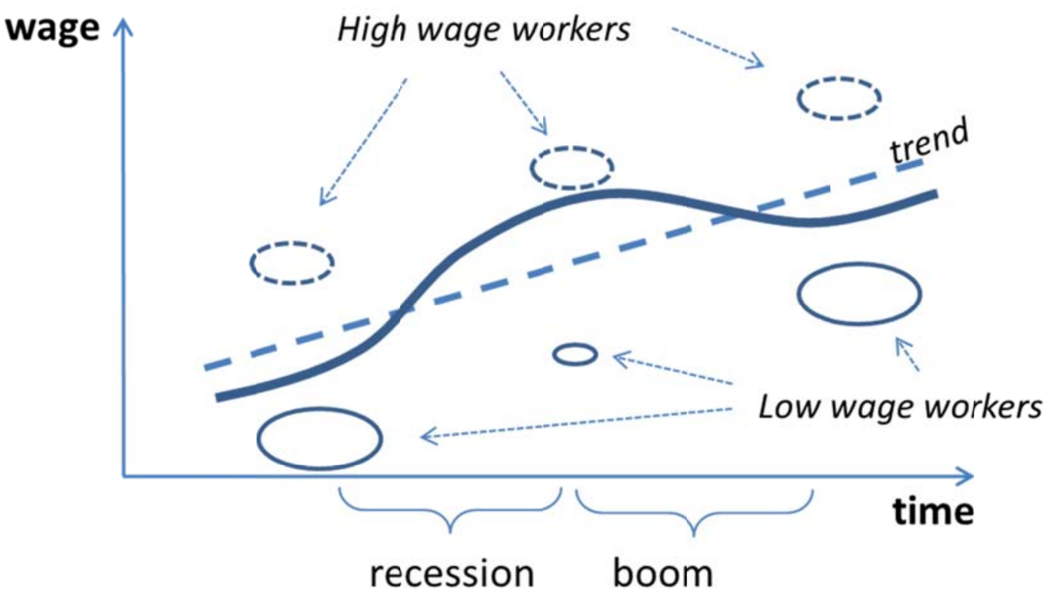
Figure 1. Graphical illustration of the roles of worker restructuring and job restructuring



Worker restructuring and business cycles

It is also important to examine the effect of worker restructuring because the structure and intensity of worker flows is expected to vary over business cycles; therefore, the cyclical patterns of aggregate wage growth may differ from the patterns of the 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, while during a boom it increases. However, the number of high-wage workers stays constant and the employment share increases. As a result, the aggregate wage growth exhibits a countercyclical pattern despite the stable wage growth of the job stayers.

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



3.2. The basic structure of decomposition

In this section, we present the basic idea behind our decomposition of aggregate wage growth, which will be used to identify and measure the mechanisms described above. To implement it we apply a formula that is particularly suitable for analyzing the wage growth of the job stayers as an integrated part of the standard measure of aggregate wage growth. For the sake of clarity, we will 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 includes a *within* component of the units, which is a weighted[6] average wage growth rate of the units. The following three components measure the different aspects of the inter-unit compositional changes, which indicate the role of job restructuring: 1) the changing input (hours worked) shares *between* the continuing units; 2) the *entry* of units; and 3) the *exit* of units. Moreover, the decomposition includes four cross terms, one for each of the four components described above. Cross terms make the decomposition to add up to the standard aggregate measure of wage growth. Additionally, they allow for a useful interpretation of all the components of 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 allows us to break down the within component of the units into four worker-level sources (see Figure 3). The first of these is the *within* component of the job stayers[7], which is the weighted[8] 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., newly hired workers) into the continuing units, and the fourth is the *exit* of workers (i.e., separation of workers) from the continuing units. Decompositions made for each of the continuing units are then aggregated using their labor input shares (again, using the average in the initial and the 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

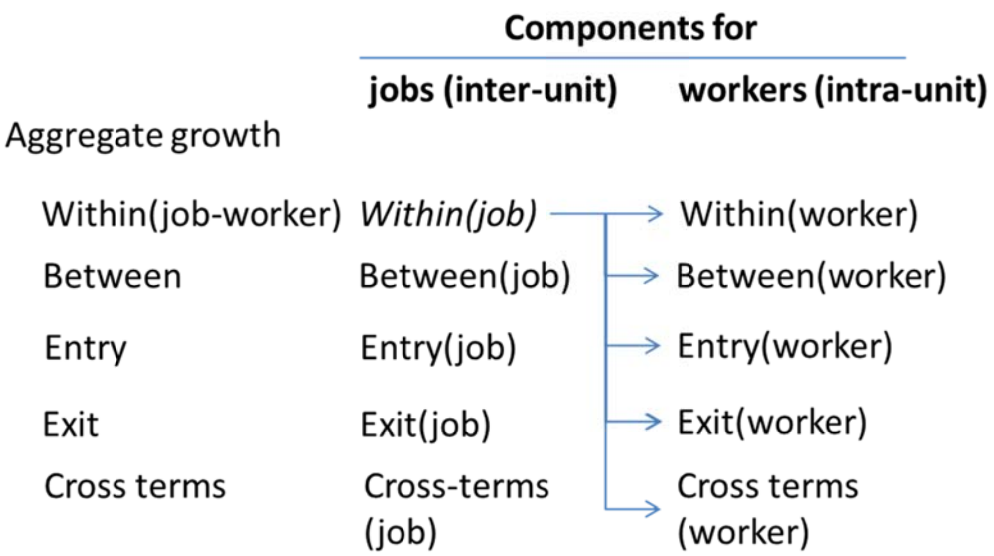
[6] Each unit is weighted by its average input share (among continuing units) in the initial and end year, in accordance with the divisia-index approach.

[7] 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 required for a consistent decomposition.

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

measures the wage growth rate of an average job stayer in an average continuing unit. Additionally, we have two sub-components for each of the three restructuring components (i.e., entry, exit and between components). The first refers to job restructuring and the second to worker restructuring. This decomposition also yields a cross term for each of the seven components. As shown below, some of these "correction components" have an economic interpretation.[9] Their economic importance is, however, an empirical matter that will be examined 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 the decomposition of aggregate wage growth



3.3. Decomposition formula

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

$$W_t = \frac{\sum_i \sum_j w_{ijt} \cdot h_{ijt}}{\sum_i \sum_j h_{ijt}} \qquad (1)$$

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

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

Our goal here is to measure the growth rate of the standard aggregate wage between years *s* and *t*. Typically, this is performed using a log difference; however, following the example of Davis and Haltiwanger (1992), we convert wage growth into a growth rate using the average wage as a denominator. This provides us with a very close approximation of the standard measure of growth rate (e.g., log-difference of the absolute aggregate wage levels between two consecutive years). A significant 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 (2012).

Step 1: Unit level decomposition

First, we will present the decomposition into unit-level sources, and later we will integrate the aspect of worker mobility into this. The aggregate wage growth rate can be decomposed into unit-level sources using 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 $s_{it}^{C(i)} = \frac{h_{it}}{\sum_{i \in C(i)} h_{it}}$, $\bar{s}_{it}^{C(i)} = 0.5\left(s_{is}^{C(i)} + s_{it}^{C(i)}\right)$, $W_t^{C(i)} = \frac{\sum_{i \in C(i)} w_{it} \cdot h_{it}}{\sum_{i \in C(i)} h_{it}}$, $\bar{W}_t^{C(i)} = 0.5\left(W_s^{C(i)} + W_t^{C(i)}\right)$,

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

The formula makes use of a Bennet (1920) type decomposition of the aggregate wage growth of the continuing units (see the second and third rows). This is an important aspect of our decomposition because 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 the wage growth rates of the units. It should be noted that a specific property of this decomposition is that $\sum_{i \in C(i)} \bar{s}_{it}^{C(i)} = 1$, which means that the within component indicates the growth rate of an average hour worked in the continuing units.[10] 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 a relatively high wage level, i.e., $\frac{\bar{w}_{it}}{\bar{W}_t^{C(i)}} > 1$, 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 fourth row indicates the entry component of the units, and the fifth

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

row indicates the exit component (i.e., the 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 the exiting units is lower (higher) than in the 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).

The decomposition can be applied to either real or nominal wages. The restructuring components are unaffected by the choice of deflator because they measure wage levels relative to an average. Naturally, the difference (i.e. growth) terms, e.g. aggregate wage growth and wage growth of job stayers, are affected by the choice of the deflator.

The cross terms

These components are purposely derived in these forms to allow for useful interpretation. As a consequence, this decomposition also includes a set of "correction" components that are called "cross terms":

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

In addition to making all components to add up very closely to the standard aggregate measure of the wage growth rate, these components also have economic interpretations. This is true especially for the first component in the second row of Equation (3), which is associated with the within component (we refer to this as 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 type of "β-convergence" in wage levels among continuing units), then 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 that has a lower wage level makes a smaller contribution to the standard aggregate wage growth. Put differently, if low-wage units have higher wage growth rates, then the within component, as measured by the weighted average growth rate of the units, overrates the contribution of wage growth of the units to the standard aggregate wage growth.

Numerical illustration

We illustrate the mechanics of the decomposition in Table 1, which is borrowed from a study by Fox (2011). Each unit uses one labor input. Therefore 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, and thus 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% ($= 0.5 \times 163.6\% + 0.5 \times 5.1\%$). The within component exceeds the aggregate wage growth rate because Unit 1 has a high wage growth rate, but its wage level is low. Thus, in this example there is a decline in wage dispersion between units, which is reflected by the negative cross term of the within component. Because the amount of labor input does not change in either unit in this example, the between component is zero. Additionally, because there are no entrants or exiting units, the entry and exit components are zeros as well.

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

	Example 1			Example 2				
	Unit 1 y1	Unit 2 y2	Aggregate (y1+y2)/2	Unit 1 y1	Unit 2 y2	Unit 3 y3	Unit 4 y4	Aggregate (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; however, we have added an exiting unit (Unit 3) and an entering unit (Unit 4). It should be noted that the 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). Stated differently, our formula measures the wage growth rate of the continuing units with a suitable index that is not confounded by other micro-level mechanisms such as entries and exits of units.

Because 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 the continuing units in period 0, i.e., $1/3\times(18-15)/15 = 1/15 \approx 6.67\%$. The cross terms of the entry and exit components are also reported in Table 1. Due to these terms, the entry and exit components have a useful interpretation because 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 the 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 wage growth of the job stayers. An important insight achieved from our decomposition is that job stayers can be found only in the continuing units, and the contribution of the job stayers to the wage growth of the unit can be measured in the same way that the contribution of the continuing units to aggregate wage growth is measured. Formally, this can be written as follows:

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

where $s_{ijt}^{C(j)} = \dfrac{h_{ijt}}{\sum\limits_{j\in C(j)} h_{ijt}}$, $\bar{s}_{ijt}^{C(j)} = 0.5\left(s_{ijs}^{C(j)} + s_{ijt}^{C(j)}\right)$, $\bar{w}_{ijt} = 0.5\left(w_{ijs} + w_{ijt}\right)$, $w_{it}^{C(j)} = \dfrac{\sum\limits_{j\in C(j)} w_{ijt}\cdot h_{ijt}}{\sum\limits_{j\in C(j)} h_{ijt}}$,

$\bar{w}_{it}^{C(j)} = 0.5\left(w_{is}^{C(j)} + W_{it}^{C(j)}\right)$, *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, which is a weighted average wage growth rate of the job stayers. Note that we now have the 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 the hourly wage earned by an average job stayer in the continuing firms. The third row is the between component of workers, which 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, which is positive when newly hired workers have a higher wage level on average than the job stayers in the unit into which they have been hired. The fifth row is the exit component of workers, which is positive when separating workers have a lower wage level on average than the job stayers in the unit from which they have separated.

Similar to the decomposition of the unit-level sources, the components that measure the worker-level sources of wage growth also include cross terms. They are as follows:

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

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 refer to this as Version 1.

3.4. Decomposition with a breakdown by worker type

Similar formulas can be applied to examine the role of worker composition in greater detail. In what follows, we ignore the job-restructuring dimension and in exchange, we classify workers into three separate worker groups. The first group is the familiar "job stayers" whose wage growth indicates, again, the rate of wage inflation. The second group is the "job-to-job movers" who worked in both the initial and end year, although they worked in different units. We denote this group of workers by Ω_{JM} . The third group is called the "non-job movers" who did not work either in the initial or the end year (i.e., they have either entered or exited the labor markets). This group is denoted by Ω_{NM} .[11]

We next present Equation (6.a), which is a modification of Equation (2) in two major respects. First, unit indicator *i* is replaced by worker indicator *j*. Second, both the entry and exit components are split into two sub-components; one of these is for job-to-job movers, and the other is for non-job movers. The second row shows the within component of the workers, which is a weighted[12] 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 the changing composition of hours worked between the job stayers. The fourth row presents the entry component of workers, which consists of the separate effects of job movers (on the left-hand side) and non-job movers

[11] A more detailed breakdown by worker type can also be applied. For instance, the job-to-job movers can be split into those who have moved between firms and those who have moved between occupations within a firm.
[12] Each job stayer is now weighted by the average hours worked in the initial and end year.

(on the right-hand side). The fourth row shows the exit components, which also include the effects of the job movers and the non-job movers.

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

Using some algebra, Equation (6.a) can be derived in an alternative but equivalent form as shown in Equation (6.b).[13] This presents the entry and exit effects of the job movers and non-job movers in a different form[14]:

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

[13] A derivation for the entry effect of the job movers is presented in Appendix A.

[14] Similar alternative formulations can be given for the Equations (2) and (4).

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 year *t* refers, by definition, to the same group of 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 the years s and t are computed, again by definition, with completely different groups of workers.

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

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

Taken together, Equations (6) and (7) provide us with a decomposition formula that ignores the role of job restructuring but allows a more detailed analysis of worker restructuring due to a breakdown by worker flow type. We refer to this as Version 2, which complements Version 1 in the empirical analysis. Version 2 is particularly useful for performing 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[15]. 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, which may be in absolute amounts, percentages or more typically, some combination of these. The increase applies not only to tariff wages but also to current wages. Typically, 3/4 of the total wage increase has been an across-the-board increase, which means that wages for each individual in all sectors increase similarly. These contractual wage increases have been, on average, approximately 1/3of the actual wage increase. This difference is called “wage-drift”.

The contractual increase sets the floor for the wage increases of the job stayers. For other workers (e.g., those who have changed jobs), the contractual increase has an effect through increased tariff wages. Thus, although the contractual increases chiefly affect wage increases 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 organization of employer associations. The main industries covered by the data are

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

manufacturing, construction, energy and transportation. The member firms of the EK employ the majority of employees in manufacturing, and this amounts to roughly every third Finnish employee. The wage data are based on an annual survey of employers, and with the exception of the smallest firms, a response from member firms is mandatory. The data cover the years 1985-2009. Wage data are used in collective bargaining and form the basis for the private sector wage structure data maintained by Statistics Finland, the country's statistical authority. Thus, the information that we use here comes from the wage records of firms and is highly reliable. We concentrate on the manufacturing sector, and the sectoral composition of the data is given in Appendix B. On average, the data contain approximately 250 000 persons and 1100 firms annually.

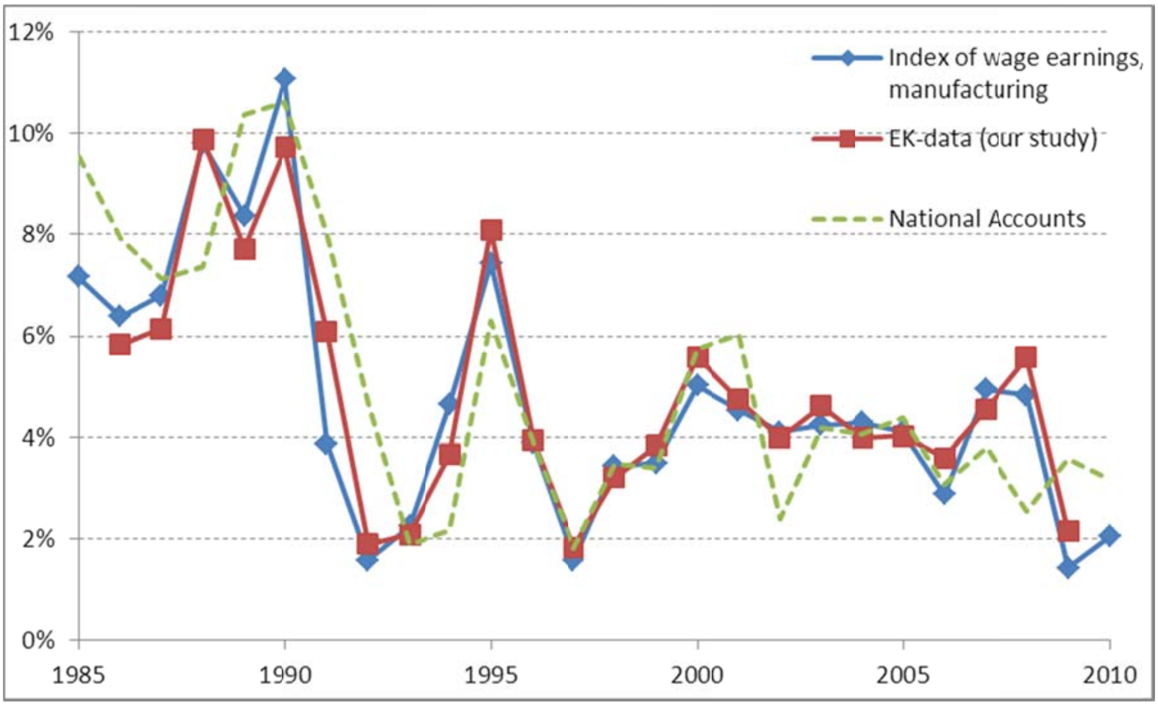
The data include detailed information on wages and job titles as well as unique person and firm identifiers. Thus, it forms a linked employer-employee panel that allows people to be followed over time, possibly throughout different firms. These data contain all the necessary information to implement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

Wage variables differ for blue- and white-collar employees. For blue-collar employees, the data include three separate measures of hourly wages (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 and 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-collar employees are uniform throughout the various industries. Prior to 2002, there were 75 job titles in use. There are now 56 titles in use since the titles were reformed in 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 throughout the whole period of observation. The weighted[16] average number of job titles for white-collar and blue-collar employees in a given firm from 1995-2009 is 40 (17) and 6(4), respectively.

Because the data source does not cover the whole manufacturing sector (not all firms are members of the 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 (from Statistics Finland) that is presented in Figure 4 indicate that our data give a highly representative picture of the standard aggregate wage growth in the manufacturing sector.

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



[16] Values are weighted by hours worked in a firm. The figures in parenthesis give the unweighted numbers.

6. Results

6.1. General patterns

Table 2 presents the average annual nominal aggregate wage growth rate and its components separately for the years 1995-2009 and the years 1985-1995. Four main findings presented in this 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 the years 1995-2009)[17]. A major part of this difference can be attributed to the restructuring components (-0.22% in the years 1995-2009); however, the cross terms also play a role. Second, job restructuring has an important effect on aggregate wage growth (0.57% in the years 1995-2009). This mainly 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 effect is due to the large negative effect of worker entry, indicating that newly hired workers typically earn less than the job stayers of the unit. On the other hand, the exit effect of the workers is positive, which means that separating workers currently earn less than the job stayers of the unit on average. However, the net entry effect (the sum of the entry and exit effects) is clearly negative (-0.77% in the years 1995-2009). Fourth, the basic patterns in the components are quite similar over the years 1995-2009 and 1985-1995.

[17] It should be noted that, because 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, for the job stayers, the effect of accumulated human capital through increased experience is expected to be limited. For example, Manning (2003, chap. 6) points out that much of the returns of experience materialize via job mobility. This is an issue that will be examined in Section 6.5.

Table 2. Decomposition of aggregate wage growth in the manufacturing sector by Version 1: annual averages and percentage 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: The 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 temporal patterns of the components. The upper panel of Figure 5 shows how the effect of job restructuring (the sum of between, entry, and exit components) has evolved over time. To more clearly show the trends in this effect, we have added a smoothed trend (thick line) computed with a Hodrick-Prescott filter.[18] The figure shows that job restructuring has an important but somewhat countercyclical role in the growth of aggregate wages. The middle panel of Figure 5 plots also the part of the productivity growth in manufacturing that is attributable to restructuring (or "creative destruction") and its smoothed trend. This series is obtained from the study by Maliranta et al. (2010). In fact, it is computed in a manner that is pretty analogous to the approach applied here; creative destruction effect is the

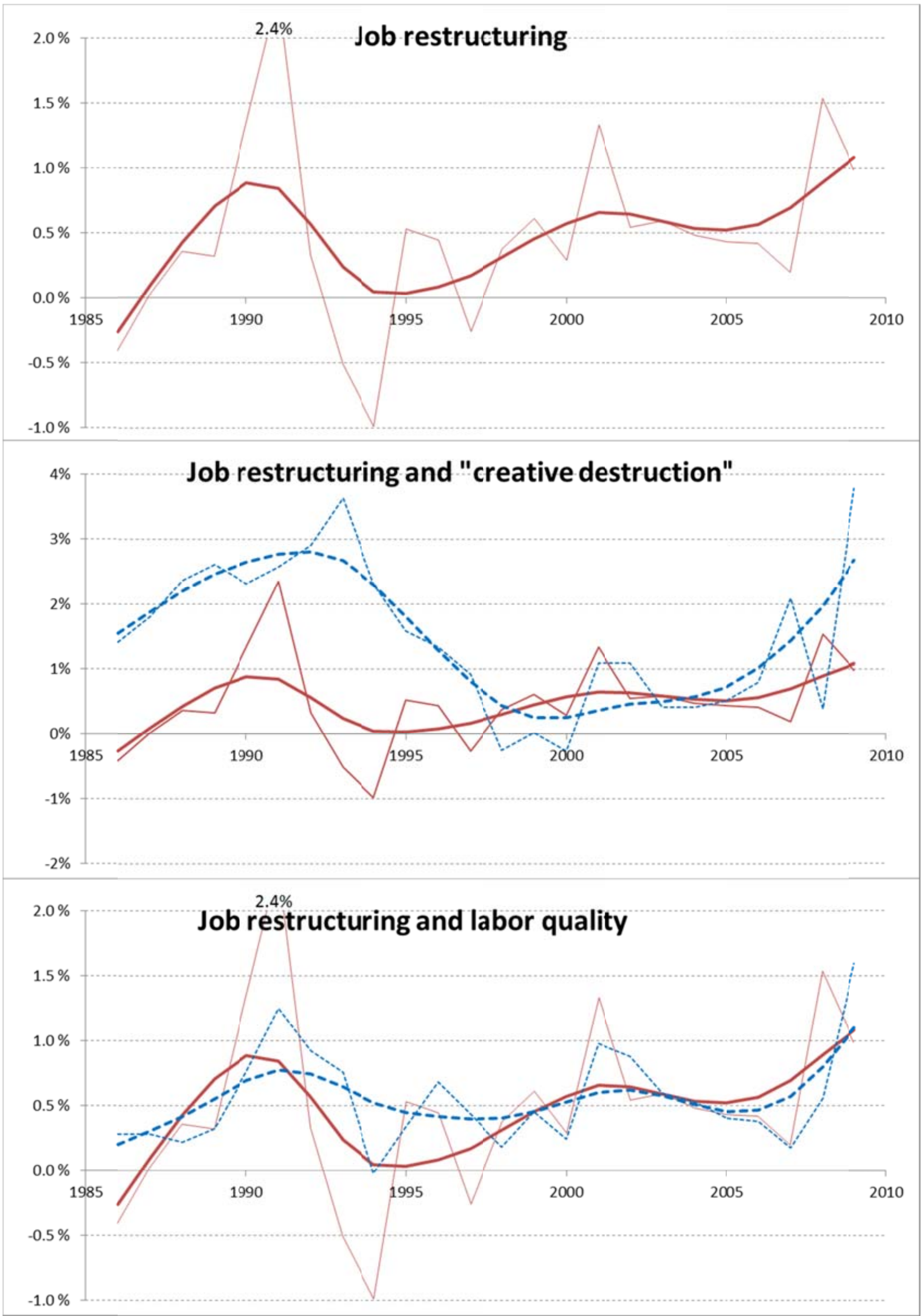
[18] We have used a lambda parameter value of 6.25, as proposed by Ravn and Uhlig (2002).

difference between aggregate labor productivity growth and the weighted average labor productivity growth of staying plants, and thus includes productivity-enhancing effects of the entrants, exiting plants and reallocation of resources between the staying plants. It is seen that both series broadly share similar time patterns except that "creative destruction" effect of labor productivity growth is generally larger. In the bottom panel of Figure 5, we have included the growth of labor quality (as calculated by the growth accounting approach) and its smoothed trend.[19] The striking similarity between the series, both in short-run variation and in long-run trends, as seen in the bottom panel of Figure 5 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). Overall, Figure 5 provides an empirical confirmation that the components of job restructuring in our wage decomposition capture micro-level mechanisms that are essential for the long-run growth of labor productivity.[20] 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.

[19] 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 with the annual numbers of the growth accounting computations by Statistics Finland.

[20] A graphical illustration of these mechanisms is presented in Figure 1, panel A.

Figure 5 The wage effect of job restructuring (solid line), “creative destruction” effect and labor quality effect (dashed lines)

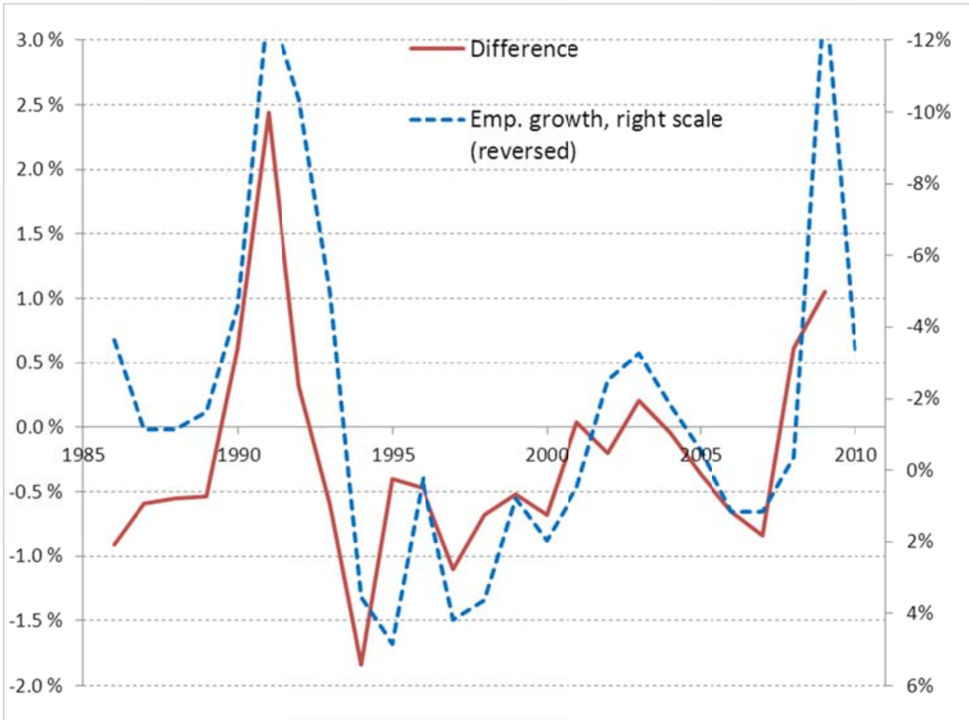


Notes: Annual figures for labor quality estimates in the manufacturing sector are obtained from Statistics Finland. Computations are based on the cross-tabulations of labor input into 18 groups (by age, education and gender). The numbers for the effect of job restructuring are from this study. Both time-series are smoothed using the 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, the role of business cycles, that our decomposition method is able to identify. Earlier literature has shown that aggregate wages exhibit less cyclicality than the wages of individuals (e.g. Solon et al. 1994, Devereux 2001, Devereux and Hart 2006). Figure 6 shows the difference in the standard aggregate wage growth and the wage growth of job stayers over time. By definition, this difference consists of two main parts: 1) both job and worker restructuring components 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 the 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. Because it is presented on a reversed scale, the close co-movement of the two series indicates a strong countercyclicality in the difference between aggregate wage growth and job stayer wage growth. This countercyclicality indicates that compositional changes in the labor market smooth out aggregate wage changes compared to the wage changes of job stayers. This result corroborates earlier findings in the literature.

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



Notes: Figures for the growth of hours worked in the manufacturing sector are obtained from the National Accounts of Statistics Finland. Note that the right-hand 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 timing is likely to explain some of the discrepancies between the series in certain years.

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

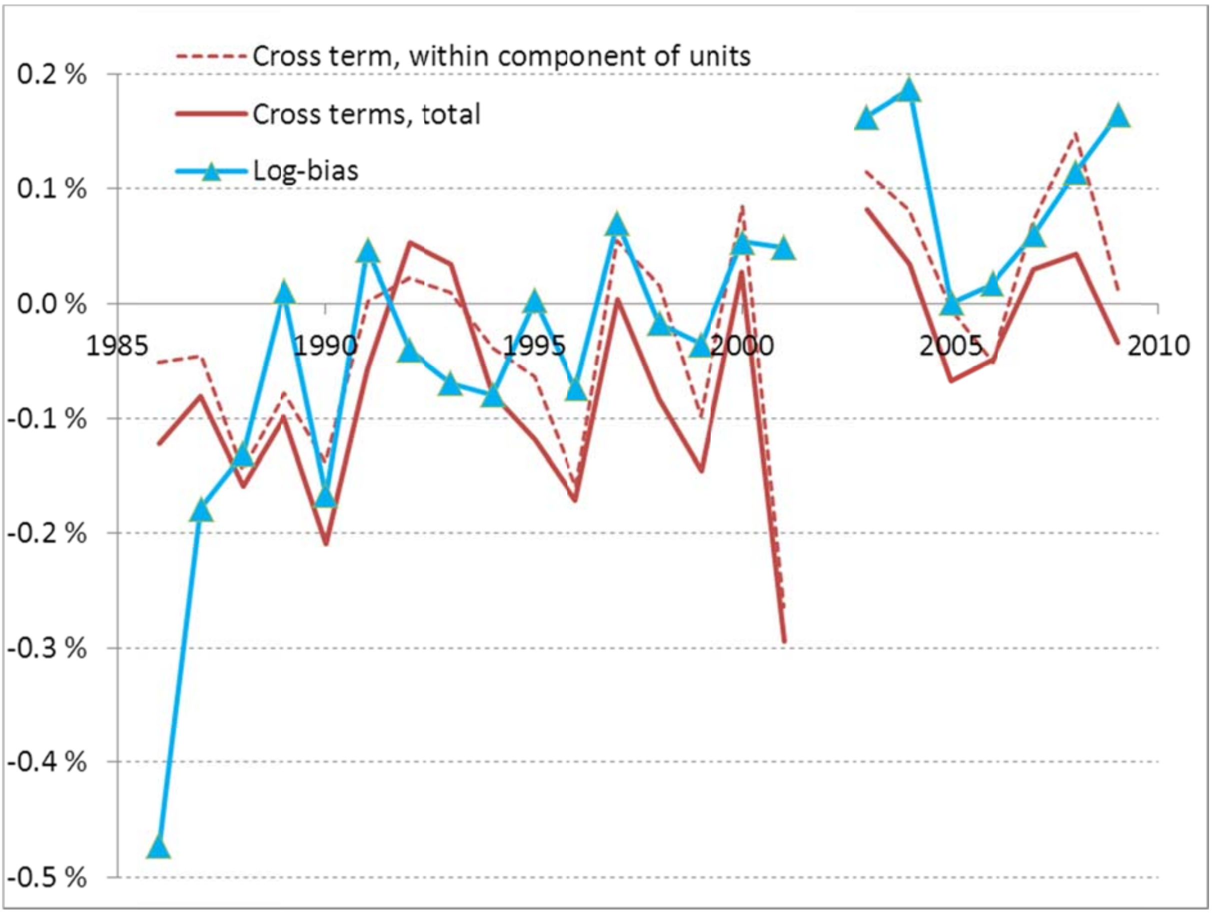
Patterns in the log-bias of aggregation

Figure 7 illustrates the log-bias in the aggregate measure of wage growth. This is the difference between the standard aggregate wage growth and the aggregate wage growth that is obtained by aggregating the log wages of workers (using shares of hours worked).[21] As we can see, on average, the log-bias is not very large but nonetheless has a non-trivial amount of temporal variation (some annual fluctuation and an upward-sloping trend). Interestingly, the figure shows that the log-bias

[21] All computations have been made with the same data following procedures analogous to those used in other computations.

is strongly correlated with the sum of all the cross terms of Version 1. The main exceptions to this are the years 1986 and 2001.[22] 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 due to its somewhat complicated structure, but a negative value may provide an indication of the tendency of low-wage units to have higher wage growth rates compared to high-wage units. Table 1 provides a demonstration of such a situation.

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



[22] Note that there is a break in our data in the year 2002; 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 using regression models. To examine the aspects of worker restructuring in greater detail, we now apply Version 2 of our decomposition, which takes into account the type of worker flow (i.e., job-to-job and non-job flow). However, before discussing 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

The main results obtained with Version 2 of our wage decomposition are presented in Table 3. First, the average wage growth rate of job stayers was 4.15% in the years 1995-2009, which slightly differs from that obtained with Version 1 as presented in Table 2 (4.24%). The gap is due to the use of a slightly different weighting structure in each method.[23] However, these two series are extremely similar (correlation is 99.2%). The aggregate wage growth rate (3.97% in the years 1995-2009) is identical by definition. Second, worker restructuring has a negative effect (-0.19 percentage points from 1995-2009) on aggregate wage growth. Third, this negative effect is due to the negative entry effect (-.66 percentage points). Fourth, the negative entry effect is solely contributed to by the non-job movers, a group which includes worker flows from unemployment or education. This negative effect (-1.24 percentage points) indicates that these entrants have a wage level that is lower than that of the job stayers in the manufacturing sector in the year of entry. Fifth, the exit effect is positive (0.33 percentage points), which comes from the contribution of non-job movers (those who did not appear in our data in the next year because of

[23] In Version 1, weighting is based on the input share of the continuing units, which 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 a drawback.

unemployment or retirement, for example).[24] The positive contribution indicates that these workers earned less than the job stayers in the manufacturing sector before they left the labor markets. In a later section, we will examine the time patterns of the relative wage levels and input shares of the non-job movers in greater detail (Figure 8). Sixth, the effects of the cross terms are generally of minor importance.

Table 3. Decomposition of aggregate wage growth in the manufacturing sector by Version 2: annual averages and percentage points

	Years 1995-2009				Years 1985-1995			
	Total	Job stayers	Job movers job-to-job	Job movers non-job	Total	Job stayers	Job movers job-to-job	Job movers 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: The year 2002 is excluded from these calculations due to a change in the occupational titles.

Regression analysis of the components

Next, we will examine the cyclicality of the components of worker restructuring using simple OLS regressions. The dependent variable is the nominal aggregate wage growth rate or one of its micro-level components. In total, we have 22 different dependent variables in the analysis. We use

[24] It should be noted that non-job movers are those who are found in our data 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. However, according to Napari (2009), such transitions are relatively rare. Because these flows are nonetheless a less-than-perfect measure of the transitions between employment and non-employment, our empirical analysis is expected to mitigate the role of these transitions as a source of worker restructuring.

the 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 manufacturing or unemployment) as explanatory variables; the coefficient of the latter is of particular 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 using the growth rate of the gross domestic product (GDP), and a number of interesting findings are illustrated here. First, we note that there is a positive relationship between the standard aggregate wage growth and GPD growth (the coefficient is 0.101), indicating some procyclical flexibility in the aggregate wages. However, this relationship is not statistically significant. Instead, the coefficient of the within component is highly statistically significant, giving an indication of procyclical flexibility in the wages of the job stayers. The coefficient implies that a deceleration of GDP growth by one percentage point leads to a decline in the wage growth of the job stayers by 0.29 percentage points. This result shows that aggregate wages are smoothed out by job and worker restructuring. This finding is similar to what was found by Solon et al. (1994) and Shin (1994). Moreover, our finding that the wages of job stayers are about twice as cyclically sensitive as the aggregate wages is similar to their finding regarding the difference between results from aggregate data and micro data. Our finding that the wages of job stayers are quite cyclically flexible is similar to what was found by Devereux and Hart (2006). However, our results show less cyclical sensitivity than their results for the UK.

Second, the difference in the aggregate wage and the job stayer wage flexibility can be entirely attributed to the countercyclical pattern of the restructuring effect (-0.17). This result explicitly shows the magnitude of the composition bias that was identified in 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 when low-wage workers enter the labor market in upturns and exit in downturns, as illustrated in Figure 2. However, job-to-job movers do not contribute to the restructuring component. In fact, this is not a surprising finding considering that 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 the wage growth of job-to-job movers is a different issue that will be discussed later. Fourth, when business cycle fluctuations are measured by a sector-specific indicator, such as 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, although their general patterns are quite similar. The use of the unemployment rate as an indicator of business cycles leads to similar conclusions concerning the cyclicality of the wage growth of the job stayers and the effect of restructuring (not reported here).

Table 4. Regression coefficients of business cycle indicators and 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 the 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. 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 for 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 value added from the manufacturing sector, which had only a minor effect on the results.

Additionally, we have utilized another approach that is based on the decomposition of real wage growth. This is performed by converting the wages of the individuals in the initial year into next year’s prices (i.e., the prices of the end year) using a deflator of consumer prices, or alternatively, of the real value added prices in manufacturing.[25] The entry and exit components, instead, are completely independent of the price index. This can be seen in Equation (6) and

[25] In practice, this is the same as a deflation of the aggregate wage growth and the within component with a price index.

Equation (2), which show that the components of entry and exit are solely based on contemporary wages, and therefore, the price index figures will cancel out. In practice, the between component is also independent of the price index.[26] 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 regarding the cyclicality of aggregate wage growth, the wage growth of the job stayers and the cyclicality of the restructuring components. However, when wages are deflated by the price of value added, the coefficients for aggregate wage growth and the wage growth of the job stayers become statistically insignificant.

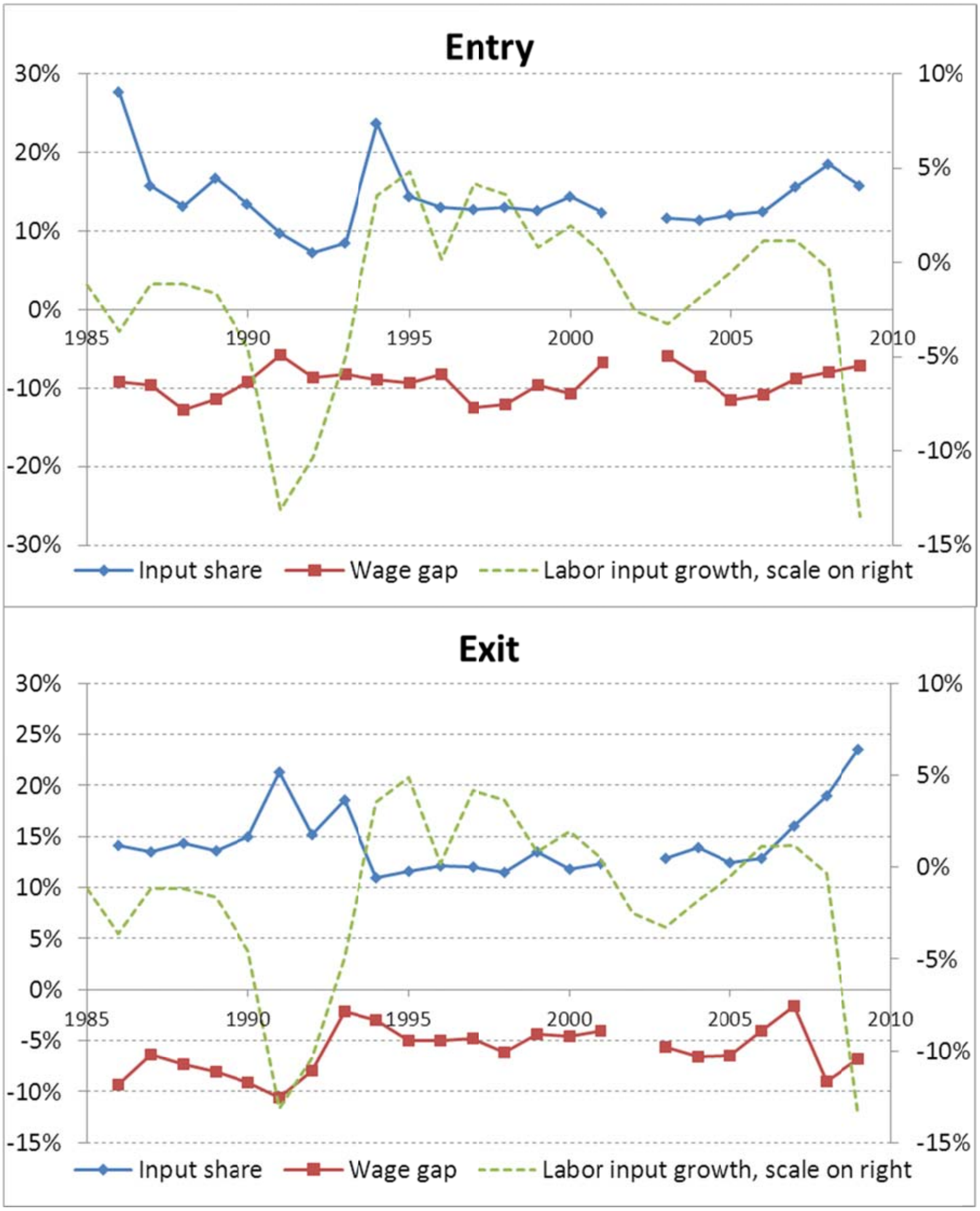
Elements of contribution of the non-job movers

Because the effects of the non-job movers were found to have particularly strong cyclical patterns, they merit closer attention. Figure 8 provides a further breakdown 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 the 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 their wage gap (i.e., $\frac{W_s^{C(j)} - W_s^{NM}}{W_s^{C(j)}}$) and their 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. Taken together, these results explain why the entry effect is particularly negative during these times. The exit effect, on the other hand, is less positive during the upturns because the wage level of the exiting workers is less negative and the input share is smaller than during the downturns. It is also worth noting that, on average, the relative wage level of those

[26] 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 percentage points.

entering labor markets (including young workers) is lower than that of those leaving (including retiring workers), which illustrates that labor turnover has a negative effect on aggregate wage growth in the long run.

Figure 8. Components of non-job switchers



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

6.4. The cyclicality of contractual increase and wage drift

In economies where collective bargaining plays an important role in wage setting, the actual wage increase is the sum of the contractual wage increase and the so-called wage drift[27]. 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 parties engaged in collective bargaining and also serves as an input for macroeconomic models.

In Table 5, we illustrate the sensitivity of the 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 the change in the log GDP. Based on the third column, we can see that the wage drift for job stayers is strongly procyclical. As shown earlier, the wages of job stayers are cyclical, whereas the second column shows that the contractual increase is not related to GDP growth. A comparison of the third and fourth columns shows 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 illustrate that wage drift plays an even larger role in setting wages in Finland than previously thought.

[27] 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: The P-value refers to a 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 the index of wage earnings in manufacturing and the contractual wage increase. Time trend is included.

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

Using 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., $\sum_{j \in C(j)} \left(s_{jt}^{C(i)} - s_{js}^{C(i)} \right) \left(\bar{w}_{jt} / \overline{W}_t^{C(j)} \right) \left(W_t^{JM} - W_t^{C(j)} \right) / W_t^{C(j)}$, minus the wage gap of the job-to-job movers in the initial year, i.e., $\left(W_s^{C(j)} - W_s^{JM} \right) / W_s^{C(j)}$.[28]

We have performed regression analyses similar to those shown above using the wage growth of the job stayers (which now includes the between component as well) 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) includes the between component. The P-value refers to a 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 a procyclical pattern due to wage drift, the wages of the job-to-job movers are even more flexible. These results are similar to results obtained by Shin (1994) and Devereux and Hart (2006), although the methods to achieve these results are quite different.

[28] Here, we include the between component of the wage growth of the job-to-job movers for the sake of comparison 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 stayers (obtained with the 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 components, respectively.

7. Conclusion

We have proposed an approach for measuring and analyzing the dynamics of the standard aggregate wage growth of macro statistics with micro-data. We present a decomposition of the standard aggregate wage growth that 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 us to examine several key research questions of the modern macro literature in a coherent framework. Additionally, our approach provides the opportunity for a deeper analysis of various micro-level mechanisms.

The 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, which all are highly relevant from the point of view of the macroeconomic literature. These include the effect of the wage growth of the job stayers alongside the different effects of compositional changes that are associated with job and worker flows in the labor markets. The appropriate measurement of these effects is crucial for understanding wage growth in the long run and its cyclical variation in the short run. In addition to analytically demonstrating and graphically illustrating the attractive features of our decomposition method, we empirically demonstrate the usefulness of our method for addressing topics such as the effect of job restructuring on the aggregate wage growth, cyclical variation in the wage growth of the job stayers and job movers, cyclical variation in the effects of worker composition changes (i.e., worker restructuring), the role of 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 using normal wages in accordance with 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 (approximately 0.5 percentage points per year) impact on aggregate wage growth and therefore constitutes an important source of economic growth in the long run. Next, the wage growth of the job stayers is higher than aggregate wage growth and exhibits significantly stronger procyclical fluctuation compared to aggregate wages. We also find that the wage growth of the job movers is, on average, even higher and exhibits stronger procyclical fluctuation than that of the job stayers. On the other hand, the effect of compositional changes in worker structures has a strong countercyclical pattern, which can be attributed almost entirely to worker flows in and out of labor markets. The wage drift, when defined as the 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 provide results that are more statistically and economically significant than their more traditional counterparts, which do not properly identify the effects of various compositional changes. Overall, wage formation in the labor markets is much more flexible over business cycles than it appears to be on the basis of the standard aggregate wage growth figures.

In our future research, we plan to extend these analyses beyond the manufacturing sector, which will allow us to consider sectoral differences in aggregate wage formation. This is interesting because the disparity in the development of industries can be expected to show up in the differences of micro-level patterns of wage growth between industries. Similarly, this approach can be utilized to examine gender differences in wage formation. Further, with slight modifications, our method can be utilized to address numerous other interesting research questions. For example, our approach appears to be useful for examining regional differences because we can effectively study 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.

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

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

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

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

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

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

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