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Minimum Wages and the Wage Distribution in Estonia*

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Abstract: This paper studies how changes in the statutory minimum wage have affected the wage distribution in Estonia, a post-transition country with little collective bargaining and relatively large wage inequality. The analyses show that the minimum wage has had substantial spill-over effects on wages in the lower tail of the distribution; the effects are most pronounced up to the 20th percentile and then decline markedly. The minimum wage has contributed to lower wage inequality and this has particularly benefitted low-wage segments of the labour market such as women and the elderly. Interestingly, the importance of the minimum wage for the wage distribution was smaller during the global financial crisis than before or after the crisis.

JEL codes: J31; J38; D31; P36

Keywords: Minimum wage; wage distribution; spill-over effects; inequality; Central and Eastern Europe; global financial crisis

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1. Introduction

This paper studies the effect of the minimum wage on the wage distribution in Estonia, a country from Central and Eastern Europe (CEE) that joined the European Union in 2004. Estonia is a particularly interesting case for such an analysis since the country has relatively unequal wage and income distributions compared to those in other EU countries, in part reflecting the virtual absence of collective bargaining, a modest social safety net, and a flat income tax system.¹

Concerns about the distribution of incomes and wages have increased after the global financial crisis and the resulting economic setback in many countries. Studies on the causes and consequences of inequality have become best-sellers and constitute the backdrop for debates in academics and policy-making (Piketty, 2014). International organisations have similarly entered the debate and have emphasised that distributional concerns should be taken into account when devising economic policies (Dabla-Norris et al., 2015). Wages and the distribution of wages have similarly become a key issue on the European policy agenda (Schulten, 2012).

The minimum wage is an instrument that can potentially influence the wage distribution. Policy-makers have seen the minimum wage as a means of reducing poverty and improving living standards for low-wage workers. Minimum wages were first adopted in New Zealand and Australia in the 1890s and later in numerous other countries. In 2014, in total 21 EU Member States had a national minimum wage (Schulten, 2014a). Some countries have a single national minimum wage, while others set minimum wages only at, say, the sectoral or occupational level.

The effects of the minimum wage on the wage distribution are not only important from a distributional viewpoint but also from a macroeconomic perspective. This can be the case if policy-makers are concerned that an increase in the minimum wage will increase the *average* wage level and hence possibly be detrimental to international competitiveness. The spill-over effects to wages above the minimum wage are important in this context as these higher wages have a larger weight in the average wage level than the wages below the minimum wage.

A rise in the minimum wage may affect the wage distribution in various ways. The rise is intended to lift wages for those directly affected by the minimum wage, who are those that initially earn wages below the new minimum wage, but it may also affect the wage distribution for those with wages above the new minimum wage. The latter effect is called the *spill-over* or *ripple* effect. A positive spill-over effect may occur because of employers substituting away from the low-income workers affected by the rise in the minimum wage to higher-paid workers. It may also result from the minimum wage being taken as a benchmark in wage setting above the minimum wage. Employers may

¹ The Gini coefficient of equivalised disposable income in Estonia is 0.35 which is substantially above the EU28 average of 0.31 (Eurostat: *tessi190*). The Gini coefficient of is also high in several other CEE countries as well as many post-Soviet countries.

also seek to maintain a given wage structure or “hierarchy” if the efforts of employees depend on their relative wage (Grossman, 1983, Akerlof & Yellen 1990).

It is generally challenging to determine the distributional impact of changes in the minimum wage because such changes typically apply to all wage earners. A number of empirical methods have been developed to address this identification problem of which the one by Lee (1999) is the most commonly used. The methodology proposed by Lee (1999) is applicable when the minimum wage exhibits little cross-sectional variation and it is the method used in most studies of spill-over effects. The underlying idea is that the effect of the minimum wage on the wage distribution will vary depending on the existing wage distributions in different well-defined labour markets. The *effective* minimum wage is thus the minimum wage relative to the median or another measure of centrality of the wage distribution in the given labour market. The effective minimum wage will exhibit substantial cross-sectional variation and hence facilitate the identification of the distributional effect of the minimum wage.

Section 2 provides a comparative survey of studies assessing the effects of changes in the minimum wage on the wage distribution in high-income, transition and developing countries. The conclusion is that there is generally some spill-over to wages above the minimum wage, but the extent appears to vary across countries, likely reflecting different institutional and economic environments.

This paper contributes to the literature in three main areas. First, the paper uses the method developed by Lee (1999) but adapts the identification strategy by depicting labour markets not only by their time and region but also by an additional dimension, either the sector of activity or the occupation of the wage-earners. This elaboration allows applying the Lee (1999) methodology also to small countries where the number of regions with sufficient size is limited. Second, the paper is one of the first to address the distributional effects of the minimum wage in an EU member from Central and Eastern Europe. Research on the effects of the minimum wage on wage inequality in the region is limited, which is surprising given that many post-transition countries have very unequal wage and income distributions (Schulten, 2014b). Finally, data are for the period 2001-2014 and this relatively long sample makes it possible to investigate whether the effect of the minimum wage on the wage distribution changes over the business cycle, in particular between the pre-crisis boom before the global financial crisis, the period of crisis, and the period of post-crisis recovery.

We estimate spill-over effects in Estonia using data for the full-time employed from the Estonian Labour Force Survey for the years 2001-2014. The analyses for the full sample show that there are substantial spill-over effects from the minimum wage to the lower percentiles of the wage distribution, but the spill-over effects decline markedly as the wage approaches the median wage. When the effects are aggregated to the macro level, the result is that an increase of the minimum wage of 1 euro is associated with an increase of

0.11 euro in the *average* wage of all full-time wage-earners. The spill-over at given percentiles of the wage distribution is larger for women than for men and also larger for older wage-earners than for younger ones. The analyses also show that the spill-over effects on the lower tail of the wage distribution were smaller during the global financial crisis than before or after the crisis. Notably, the results are very similar irrespective of whether the sector of activity or the occupation of the wage-earners is used to construct the individual labour markets or cells.

The rest of the paper is organised as follows. Section 2 discusses the related literature. Section 3 provides information on the Estonian labour market and the minimum wage. Section 4 discusses the methodology. Section 5 presents the data and summary statistics. Section 6 provides the main results in the paper including the effect of the minimum wage for different subgroups of the sample. Section 7 contains some robustness analyses. Finally, Section 8 discusses the results of the paper.

2. Review of empirical studies

The literature on the role of minimum wages and their spill-over effects focused initially on the USA and the issue of whether declines in the real value of the minimum wage contributed to increasing wage inequality. Spill-over effects have since been studied in the UK particularly but also in a number of emerging-market and transition economies. This allows for a comparative analysis of the results.

Early studies generally find substantial spill-over effects from changes in the minimum wage in the USA. Gramlich (1976) reaches this conclusion by simply inspecting the wage distribution before and after changes in the minimum wage and Grossmann (1983) includes the minimum wage in time series wage regressions.

Later studies confirm these results using increasingly complex identification methods. DiNardo et al. (1996) propose a semi-parametric Oaxaca-type methodology that decomposes differences in wage distributions over time into contributions stemming from changes in coefficients, changes in endowments and residuals. They study the role of supply and demand shocks and labour market institutions and find that the decline in the real minimum wage was a key factor behind the higher wage inequality in the USA from 1979 to 1988.

Lee (1999) estimates the effect of the minimum wage at different percentiles of the wage distribution by considering the minimum wage relative to the median wage across different labour markets. The conclusion is that declines in the real minimum wage played an important role in the increase in wage inequality observed for the USA in the 1980s. Autor et al. (2016) update and augment the study by Lee (1999) by including more data and by instrumenting the minimum wage to account for possible reverse causality and measurement errors. The result is smaller spill-over effects, especially for males,

suggesting that changes in the minimum wage may in part reflect other factors affecting the wage distribution.

Neumark et al. (2004) regress changes in the wage income of individuals on changes in the time and the minimum wage along with a number of control variables. The effect of the minimum wage is substantial for low-income earners, but since the employment is adversely affected, the net effect on total income is negative for low-wage earners.

In contrast to the results for the USA studies using UK data generally find no or rather small spill-over effects. Dickens & Manning (2004a) consider the effects of the introduction of the national minimum wage in 1999 by inspecting wage distributions before and after. The conclusion is that there are virtually no spill-over effects on wage-earners who have not been directly affected.

Dickens & Manning (2004b) use the methodology of Lee (1999) to estimate spill-over effects for wage-earners in UK care homes, a group of low wage earners. The result is that the effects on wages above the minimum wage are negligible. Stewart (2012) estimates the wage growth of individual wage-earners in different wage brackets, identifying the effects of the UK minimum wage using difference-in-differences and the size of minimum wage changes. There appear to be no spill-over effects.²

There are very few studies from other Western European countries, in part because many of these countries have not applied a statutory minimum wage. An exception is France; Aeberhardt et al. (2015) use data from this country and find that increases in the minimum wage affect the wage distribution up to the seventh decile, a surprisingly strong effect. The paper uses a unique method where a Mincer type regression is augmented with the minimum wage and estimated using unconditional quantile regression.

Minimum wages have been found to have strong equity-enhancing effects on the wage distribution in emerging-market countries. For Mexico, Bosch & Manacorda (2010) study the effect on income inequality of the minimum wage, which varies across municipalities, using the methodology by Lee (1999). They show that changes in the real minimum wage can explain a large part of the changes in wage inequality, especially at the bottom of wage distribution. Minimum wages have also had an important role in reducing wage inequality in Brazil (Lemos, 2009). Moreover, the wages of workers in the formal and informal sectors are equally affected, suggesting that the formal and informal sectors are very integrated.

Few studies have focussed on transition countries. Ganguli & Terrell (2006) study the impacts of minimum wages on the wage distribution in Ukraine for 1996-2003, using kernel density techniques. They find that increases in the

² Butcher et al. (2012) consider panel data models for the UK where wage changes at different percentiles are regressed on changes in the national minimum wage along with control variables. They find larger spill-over effects than in other studies for the UK, reaching the 10th percentile and in one particular specification the 25th percentile.

minimum wage have played an important role in lowering inequality, more so for women than for men. For Russia, Lukiyanova (2011) uses the methodology by Lee (1999) to study the effect of the threefold increase in the real value of the minimum wage between 2005 and 2009. The minimum wage can account for the bulk of the decline in the lower tail wage inequality, particularly for females. Laporšek et al. (2015) use a difference in differences methodology on Slovenian data and find changes in the minimum wage to have spill-over effects on wage earnings of up to 150 per cent of the minimum wage.

No studies have formally investigated the spill-over effects of the minimum wage in Estonia. Hinnosaar & Rõõm (2003) compare kernel estimations of the wage distribution in 1995 and in 2000 and conclude that the wage distribution remained unaltered despite increases in the minimum wage. Masso & Krillo (2008) provide data on the Estonian labour market and argue that changes in wage inequality are mainly attributable to factors other than the minimum wage.

3. The Estonian economy and labour market

Estonia is a small country in Northern Europe with around 1.3 million inhabitants. It regained its independence from the Soviet Union in 1991 and embarked immediately on far-reaching political and economic reforms (Staehr 2004). The reforms exhibited a strong market orientation and comparatively little emphasis on distributional issues.

The business cycle in Estonia could be likened to a rollercoaster. A boom from 2001 until 2007 produced growth rates of around 5-10 per cent. The global financial crisis affected the country disproportionately, with GDP declining by 5 per cent in 2008 and 14.3 per cent in 2009, and then increasing by 1.8 per cent in 2010. The period since 2011 has exhibited a recovery with moderate but positive growth rates. Developments in the labour market have evidently reflected the very strong business cycle, as unemployment declined during the pre-crisis boom, increased rapidly during the crisis and then declined gradually during the recovery.

At the beginning of our sample in 2001 the economic transition in Estonia was largely complete, but the country nevertheless features some particularities throughout the sample period. The country has a flat personal income tax with a modest tax-free deductible, implying relatively little redistribution through the tax system. The social welfare system is among the least generous in Europe and is in many ways comparable to the systems often associated with Anglo-Saxon countries (Pöder & Kerem, 2011). Moreover, the ability to implement counter-cyclical policies is severely limited by a policy of annually balanced budgets and by a strictly fixed exchange rate prior to 2011 when Estonia joined the euro area.

The 1990s was a period of rapid economic and structural change but the transition was largely completed by the end of the 1990s. Worker reallocation

had by the early 2000s fallen to levels comparable with those in Western European countries (Meriküll, 2016). The wage distribution is however very wide compared to the peers in Western Europe. Moreover, the wage gap that cannot be explained by standard controls such as education and labour market experience is very large across the genders (Meriküll & Mõtsmees, 2014). Estonia has become a country with a high degree of nominal wage flexibility in Europe (Druant et al., 2012) and external shocks appear in large part to be accommodated through adjustment in wage costs (Babetskii, 2006).

The market reforms introduced substantial regional differences in unemployment and wage levels. Like in other Central and Eastern European countries, internal migration has been low in spite of the sizable and persistent regional disparities. Paci et al. (2010) find the internal migration in the CEE countries to be below the OECD average and comparable to the levels of Southern Europe and Austria. They also find that internal migration is concentrated among individuals that are young, better-educated and single, while other individuals react little to regional inequality. Jurajda & Terrell (2009) posit that the internal migration of high-skilled rather than low-skilled workers is likely to reflect the higher opportunity costs of not working for the high-skilled. Only 1-2 per cent of economically active individuals change their place of residence each year in Estonia (Meriküll, 2016).

The job-to-job mobility rate in Estonia is also one of the lowest among OECD countries, as around 6-9 per cent of workers change their job within a year and fewer than 50 per cent of those that change their job within a year also change their field of activity or occupation (Meriküll, 2016; OECD, 2010). The low mobility of workers is consistent with the finding that overall labour productivity growth is almost entirely the result of productivity growth within sectors and only to a limited extent due to sectoral reallocation of labour (Kuusk et al., 2017).

The main institutional reforms in Estonia during our sample period were the introduction of an unemployment insurance system in 2002 and a major relaxation in employment protection legislation in 2009. The introduction of an unemployment insurance system increased replacement rates for separated workers and led to a lengthening of the tenure of unemployment (Lauringson, 2011). Reform of the employment legislation system also contributed to a reduction in job-to-job flows (Malk, 2014).

The institutional framework for setting the minimum wage has remained unchanged throughout the sample period. The system can be described as collective or tripartite bargaining where minimum wages are set in negotiations between employers, trade unions and the government. The pre-tax minimum wage was increased gradually from 102 euros in 2001 to 278 euros in 2008. The minimum wage was kept unchanged during the global financial crisis but was increased to 290 euros in 2012 and then to 320 euros in 2013 and 355 euros in 2014. If the minimum wage is changed, the new rate always comes into force from 1 January.

The Estonian minimum wage is relatively low and not binding for a very large share of the employed (Schulten, 2012). The share of employed earning the minimum wage or less has declined during the sample period and reached 3-5 per cent in 2005-2014. This may reflect the substantial bargaining power that employers have in tripartite negotiations. Unions are generally perceived to be of little importance as union membership is low and exhibits a declining trend (Kallaste & Woolfson, 2009).

4. Methodology

We use the methodology by Lee (1999) to estimate the effect of the minimum wage on different percentiles of the income distribution. The method has been used in key studies, as discussed in Section 2. There are some challenges in using the method in the case of Estonia because there is no cross-sectoral variation in the minimum wage and, more importantly, because the relatively small population limits the number of geographical locations applicable for the empirical analysis. We address these challenges by exploiting that the mobility between economic sectors (and between occupations) is relatively modest in Estonia.

The underlying idea in Lee (1999) is that the effect of the minimum wage will vary depending on the wage distribution in each individual labour market. In labour markets where wages are typically high, few workers will be affected and so the minimum wage will have little impact on the wage distribution. In contrast, labour markets with typically low wages will see many workers affected and the minimum wage will have a substantial impact on the wage distribution. In other words, the *effective* minimum wage varies across different labour markets and this makes it possible to identify the effect of the minimum wage even when there is little or no regional variation in the headline minimum wage.

Lee (1999) defines each labour market or “cell” in terms of its location and time. To attain a sufficient number of observation points we define each cell using its location, time and sectoral activity, and in some robustness analyses the occupation instead of the sector. As discussed in detail in Section 3 there is relatively little mobility in the Estonian labour market, not only geographically within Estonia but also across sectors and occupations. The low level of mobility low us to use the sectoral or occupational distribution as an additional margin of identification when estimating the effect of the minimum wage.

It is assumed that the *latent* log wage, w_{ijt}^* , the wage in the absence of a minimum wage, in a cell or labour market can be depicted by the cumulative distribution function $F((w_{ijt}^* - \mu_{ijt}) / \sigma_{ijt})$, where μ_{ijt} is a centrality measure and σ_{ijt} is a scale or dispersion measure. Subscript i indicates the region, j the sector and t the time. The p^{th} percentile of the log wage in a cell is denoted w_{ijt}^p , so for instance the 10th percentile is w_{ijt}^{10} and the median is w_{ijt}^{50} . Given the distributional assumption, the p^{th} percentile of the *latent* log wage for the particular cell or labour market can then be found as $w_{ijt}^{*p} = \mu_{ijt} + \sigma_{ijt} F^{-1}(p)$.

If it is possible to find a centrality measure μ_{ijt} that is independent of the scale measure σ_{ijt} , then the centrality measure and the wage distribution will also be independent since it is assumed that $F(\cdot)$ is the same across all cells. We follow Lee (1999) and assume that the log median wage of the *observed* distribution, w_{ijt}^{50} , is a good candidate. The argument is that the minimum log wage, \underline{w}_t , is typically so low that it is unlikely that it will affect the log median wage. This independence assumption implies that the following holds for any given cell:

$$\text{cov}(\sigma_{ijt} F^{-1}(p), \underline{w}_t - \mu_{ijt}) = \text{cov}(w_{ijt}^{*p} - w_{ijt}^{50}, \underline{w}_t - w_{ijt}^{50}) = 0 \quad (1)$$

The difference between the minimum log wage and the log median wage, $\underline{w}_t - w_{ijt}^{50}$, is the *effective* log minimum wage which reflects the “bindingness” of the minimum wage, the degree to which the minimum wage is binding in a given cell.

The implication of eq. (1) is that any covariation between the effective log minimum wage and the difference between the observed p^{th} percentile of the log wage and the log median wage must stem from the minimum wage affecting the *observed* p^{th} percentile or, alternatively, from some other factors that may be captured by control variables. The reason is that the covariance between the latent distribution and minimum wages is zero given the assumptions so that any non-zero covariance is related to the minimum wage or some control variable. The exact functional form of the relationship is of course unknown, but Lee (1999) suggests that the following empirical specification provides sufficient flexibility:

$$w_{ijt}^p - w_{ijt}^{50} = \beta_1 (\underline{w}_t - w_{ijt}^{50}) + \beta_2 (\underline{w}_t - w_{ijt}^{50})^2 + \text{controls} + \varepsilon_{ijt} \quad (2)$$

The terms β_1 and β_2 are the coefficients to be estimated and ε_{ijt} is a conventional error term. The control variables may include cell specific features, including the business cycle stance. The non-linear specification implies that the marginal effect of the effective minimum wage may depend on the level of the effective minimum wage.

Eq. (2) can be estimated for any percentile p , but given the assumption that the minimum wage has no effect on the median wage, the marginal effects for $p > 50$ must also be negligible. This provides a test of the assumption that the median wage is a centrality measure that is not affected by the minimum wage. We will generally compute the marginal effects for percentiles above the median and examine whether the effects are insignificant in statistical and economic terms.

Given the assumptions of the model and the way we estimate eq. (2) it is possible to pinpoint how the effect of the minimum wage on the wage distribution is identified. As discussed, there is no cross-sectional variation in the headline minimum wage in Estonia, so that type of variation does not contribute to the identification. Moreover, we always include year fixed effects

(FE) in eq. (2) and this implies that the rest of the changes in wage distribution from year to year that are not related to minimum wages will be absorbed by the year fixed effects. The upshot is that the effect of the minimum wage is identified from the variation in the effective minimum wage across regions and sectors and this variation stems only from different median wages across the regions and sectors.

Many studies relying on the methodology by Lee (1999) use data where there is some cross-sectional variation in the headline minimum wage, but this variation may not be very important given that there is typically substantial variation in the median wage. Moreover, some studies identify the effect entirely from the variation in the effective minimum wage afforded by the variation in the wage distributions across different cells. In fact, Lee (1999) carries out robustness analyses with a sample of the 36 US states that do not have a state-specific minimum wage and where the federal minimum wage is binding, and finds the results to be qualitatively similar to those obtained using all 50 states. Dickens & Manning (2004b) analyse the distributional effects within the home care sector in the UK and estimate the distributional effects within the negotiated common minimum wage for the sector.

5. Data

We use data for 2001 to 2014 from the Estonian Labour Force Survey (LFS) by Statistics Estonia.³ The LFS data follow the ILO definitions for the labour market statuses and are used as the main source of labour market statistics internationally and in Estonia. The LFS is a quarterly survey with a rotating panel and covers 15,000 to 20,000 individual-level observations each year (Statistics Estonia, 2013).

We consider full-time wage-earners who are Estonian residents, meaning we exclude those who work part-time, whose main employment status is self-employment, or whose current residence is abroad. The net wage has been used, which comprises the take-home pay after income tax, pension contributions and unemployment insurance contributions. Beyond the net wages, individual data on each person's sector of activity, occupation, gender and age are also used, resulting in 6,000-7,000 observations for each year.

While the net wage is self-reported by respondents, the minimum wage is set in gross terms and it has therefore been converted into net terms using the statutory income tax and unemployment insurance rates. The simple Estonian tax system with flat taxes makes the conversion from gross to net a relatively straightforward exercise.⁴

³ The LFS data for 2015 and 2016 are not available in the format of earlier data due to a change in the way Statistics Estonia makes data available for research organisations.

⁴ A minor source of measurement error arises from the Estonian pension system where some individuals pay contributions to a funded second pillar funds. It is not possible to identify the individuals that contribute to the second pillar and the second pillar contributions are therefore not deducted when the net minimum wage is computed from the gross minimum wage. However, as these contributions are very small compared to the income tax, it is

Figure 1 shows the ratios of the Estonian net minimum wage to the net average and median wages for full-time employees using data from the LFS.⁵ The ratios have been relatively stable except at the beginning of the pre-crisis boom in 2003-2005. Using LFS data, the Gini index for the wage distribution for full-time employees has remained relatively stable at around 0.3 over the years from 2001 to 2014 with only a small increase in 2011-2012 in the aftermath of the crisis.⁶



Figure 1: Ratios of the net minimum wage to the net average wage and the net median wage for full-time employees in Estonia, 2001-2014

Source: Authors' calculations based on the Estonian LFS.

The original individual-level data have been collapsed to an aggregate database with a year, region and sectoral dimension. As discussed in the methodology section, this dimension defines our individual labour market in this paper. The database covers 14 years, five regions at the NUTS3 level, and 11 sectors.⁷ The year \times region \times sector dimension has been used in the

unlikely that this omission will affect the findings of the paper.

⁵ The ratio of the minimum wage to the mean wage is somewhat higher than the ratio reported in the official statistics. There are two reasons for this. First, this paper reports the ratio of the minimum wage to the mean wage *net of taxes*. The tax-free minimum makes the minimum wage largely exempt from taxation, which the average wage is not, and this results in a higher ratio than if pre-tax wages had been used. Second, the Estonian LFS is used for the official unemployment and employment statistics, but *not* for the official wage statistics. The average wage in the LFS is somewhat lower than in the official statistics; the official statistics are based on a survey of employers and the missing observations have been imputed unlike in the LFS.

⁶ Table A.1 in Appendix A shows summary statistics for the minimum wage and the wage distribution for the data in the database before it is collapsed to cells using the year, region and sectoral dimensions.

⁷ The 11 sectors are defined according to NACE 2003: 1) primary sector; 2) manufacturing and electricity, gas and water supply; 3) construction; 4) trade; 5) hotels and restaurants; 6) transport and communication; 7) financial intermediation, and real estate and business

baseline specification, but we also test an alternative specification where occupation replaces the very last dimension. The minimum number of observations for each cell is set at 20 observations; if the cell is based on fewer than 20 observations, the cell is omitted from the analysis.

6. Estimation results

6.1 Estimations on the full sample

We use data from the Estonian LFS as discussed in Section 5 and let each labour market or cell be described by its year, region and sector. Using the full sample, a total of 742 cells out of the maximum 770 have 20 or more observations, and the distributional data from these cells are used to estimate eq. (2) separately for different percentages of the distribution.

For each of the estimations the dependent variable is the difference between the log wage of the percentage and the log median wage, while the explanatory variables are the difference between the log minimum wage and the log median wage in linear and squared forms in addition to control variables. The log differences of the wage expressions imply that there is no need to deflate the wage variable. For our baseline estimation we follow Lee (1999) and use only time fixed effects as a control variable. We examine the importance of this choice by including regional fixed effects and the annual growth rate of regional real GDP and the regional unemployment rate as additional control variables in some specifications.⁸ We have experimented with various other control variables and generally find that the qualitative results are not very sensitive to the choice of controls.⁹

In line with almost all other studies we estimate eq. (2) using OLS. Autor et al. (2016) argue that there may be measurement errors and possible endogeneity issues and therefore use instrumental variables estimation. We prefer to use OLS in our case as good instruments are rarely available, and invalid or weak instruments may lead to biased estimations or erroneous inferences.

Table 1 shows the results when eq. (2) is estimated with only year fixed effects as control variable. The estimates of the coefficients β_1 and β_2 become smaller as the dependent variable – the difference between the p^{th} percentile and the median – increases. The coefficient of determination similarly decreases in the percentiles increase, suggesting that the degree to which the

activities; 8) public administration; 9) education; 10) health; 11) other services.

⁸ Regional data on GDP growth and the unemployment rate are from Statistics Estonia (2017, tables RAA0053 and TT50).

⁹ We refrain from including control variables for region and sectoral activity, and occupation in some robustness analyses, partly so as to avoid having an excessive number of control variables. Sectors are correlated with the effective minimum wage and with the wage distribution and would seem like sound controls. However, these variables share features that cause the problem of too much control. As discussed by Angrist & Pischke (2015) variables such as occupation may not perform well as controls in wage equations, and the field of activity of the worker shares the same features.

minimum wage binds is disproportionately important for wages in the lower tail of the distribution.

Table 1: Estimations of eq. (2) for percentiles of log wages, full sample

	(1.1)	(1.2)	(1.3)
	(minw – p50)	(minw – p50) ²	R ²
p5 – p50	1.106*** (0.100)	0.375*** (0.085)	0.441
p10 – p50	1.161*** (0.089)	0.516*** (0.079)	0.575
p15 – p50	1.027*** (0.085)	0.519*** (0.075)	0.428
p20 – p50	0.819*** (0.076)	0.442*** (0.066)	0.316
p25 – p50	0.662*** (0.075)	0.363*** (0.065)	0.244
p30 – p50	0.488*** (0.064)	0.282*** (0.056)	0.182
p40 – p50	0.183*** (0.046)	0.091* (0.039)	0.087
p60 – p50	-0.160*** (0.046)	-0.116** (0.036)	0.035
p70 – p50	-0.178* (0.072)	-0.114* (0.056)	0.031
p80 – p50	-0.289* (0.082)	-0.189** (0.065)	0.036
p90 – p50	-0.260* (0.119)	-0.178 (0.094)	0.036

Note: Each row reports the results of a separate OLS regression of eq. (2) with the dependent variable being the difference between the percentile indicated in the first column and the median. Year fixed effects are included as the control variable. The number of observations is 742 in all cases. Robust standard errors are shown in brackets. Superscripts ***, ** and * denote that the effect is statistically significant at the 1, 5 and 10 per cent level respectively.

The model in eq. (2) is non-linear and to ease the interpretation of the results we compute the marginal effects at the means of the explanatory variables. Table 2 shows the marginal effects for models with different control variables. Column (2.1) shows the marginal effects for the baseline model with year fixed effects, for which the estimation results were presented in Table 1. The computed effect at the 5th percentile is 0.622, so an increase in the minimum wage of 1 per cent is associated with a wage increase of a bit more than 0.6 per cent at this percentile. The computed marginal effects are positive and statistically significant for wages up the 40th percentile, but the effects decline relatively fast and are modest for the 30th and 40th percentiles. The marginal effects are typically statistically or economically insignificant in the estimations above the 50th percentile.¹⁰

¹⁰ The marginal effects above the 50th percentile are typically statistically insignificant despite the often statistically significant coefficients in Table 1. Since the marginal effect is derived from the coefficients of the linear and quadratic terms, the standard error of the

Table 2: Marginal effects for percentiles of log wages, full sample

	(2.1)	(2.2)	(2.3)
p5 – p50	0.622*** (0.027)	0.605*** (0.028)	0.605*** (0.028)
p10 – p50	0.494*** (0.021)	0.478*** (0.024)	0.478*** (0.024)
p15 – p50	0.356*** (0.020)	0.342*** (0.023)	0.342*** (0.024)
p20 – p50	0.248*** (0.019)	0.240*** (0.021)	0.239*** (0.021)
p25 – p50	0.192*** (0.017)	0.196*** (0.021)	0.196*** (0.021)
p30 – p50	0.124*** (0.015)	0.130*** (0.017)	0.130*** (0.017)
p40 – p50	0.065*** (0.010)	0.074*** (0.012)	0.074*** (0.012)
p60 – p50	-0.010 (0.011)	0.005 (0.012)	0.005 (0.012)
p70 – p50	-0.031 (0.017)	-0.007 (0.019)	-0.006 (0.019)
p80 – p50	-0.045* (0.021)	-0.004 (0.024)	-0.004 (0.024)
p90 – p50	-0.031 (0.031)	0.040 (0.034)	0.040 (0.034)
Year FE	Yes	Yes	Yes
Region FE	No	Yes	Yes
Growth and unempl.	No	No	Yes
Obs.	742	742	742

Note: Each row reports the results of a separate OLS regression of eq. (2) with the dependent variable being the difference between the percentile indicated in the first column and the median. The included control variables are indicated in the table. Robust standard errors are shown in brackets. Superscripts ***, ** and * denote that the effect is statistically significant at the 1, 5 and 10 per cent level respectively.

Column (2.2) shows the effects when both year and region fixed effects are included as a control variable and Column (2.3) shows the effects when the control variables also include regional GDP growth and unemployment. The results are virtually indistinguishable from those for the baseline model in Column (2.1) with only year fixed effects.

Figure 2 provides a graphical representation of the effects of the minimum wage for the baseline model. The gradual decline in the effect for increasing percentiles below the median wage is evident and, as expected, there is virtually no effect for the percentiles above the median wage. The relatively large spill-over effects in Estonia place the country alongside the USA, and many emerging markets and transition economies where similarly large effects have been found, but it sets the country apart from the UK and some continental European countries where the effects have generally been small.

marginal effect will also comprise the non-zero covariance of these two coefficients.

We return to possible factors behind these findings in the final comments in Section 8.

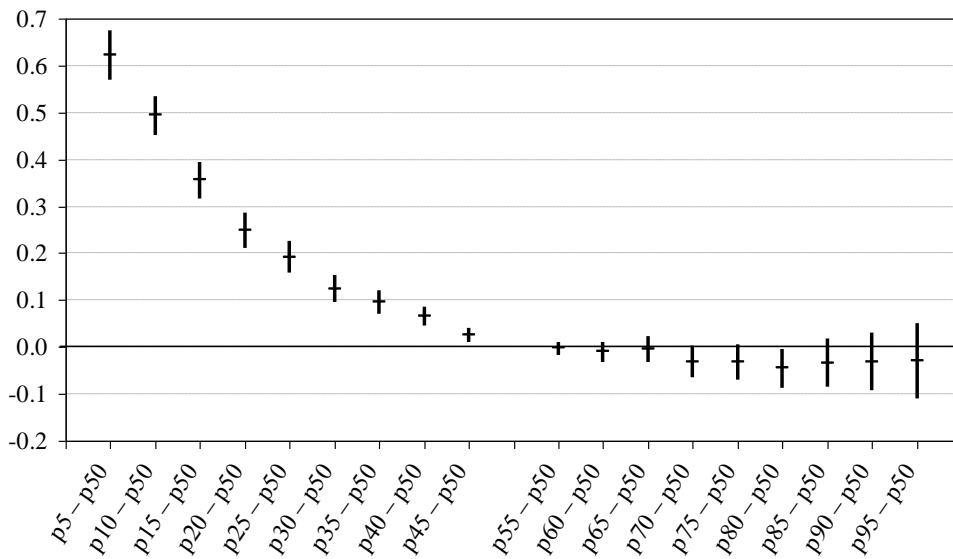


Figure 2: Marginal effects with confidence intervals for percentiles of log wages, baseline model

The marginal effects in Table 2 and Figure 2 are elasticities depicting the percentage increase in the wage at various percentiles when the minimum wage increases by 1 per cent. It may also be useful to consider the effect in monetary terms, i.e. the change in the wage in euros at various percentiles for an increase of one euro in the minimum wage. Table 3 shows the average wage in 2014 for various percentiles, the marginal effects from the baseline model in Column (2.1) and, finally, the marginal effects in euros for the corresponding percentiles given an increase of one euro in the minimum wage. The minimum wage in 2014 was 305.08 euros net of taxes, or just below the 5th percentile of the wage distribution.

Table 3: Marginal effects in euros for percentiles of log wages, 2014, baseline model

	(3.1)	(3.2)	(3.3)
	Average wage	Marginal effect	Marginal effect in euros
p5 – p50	319	0.605	0.631
p10 – p50	355	0.478	0.556
p15 – p50	398	0.342	0.446
p20 – p50	428	0.240	0.336
p25 – p50	460	0.196	0.296
p30 – p50	493	0.130	0.210
p40 – p50	550	0.074	0.134

Note: The marginal effect in euros depicts the change in the wage in euros given an increase of one euro in the minimum wage.

It is notable that the marginal effect is substantially below one euro even for those at the 5th percentile with wages just at or above the minimum wage. Moreover, although they clearly decline when the wages increase, the marginal effects in euros for, say, the 20th or 25th percentiles are not negligible. These relatively large marginal effects prove that the spill-over of the minimum wage to wages above the minimum wage is substantial, perhaps because the minimum wage is used as a benchmark or reference measure for wage setting at levels above the minimum wage.

Extending Table 3 by calculating the marginal effects in euros for every fifth percentile of the wage distribution makes it possible to derive a proxy wage distribution with and without the minimum wage increase. Comparing the average wages based on these distributions shows that a minimum wage increase of one euro in 2014 is related to an increase in the *average* wage of 0.11 euro. This back-of-the-envelope exercise demonstrates that although the rise in the minimum wage mostly affects workers in the lower part of the wage distribution, the effect on the average wage may also be non-negligible.

6.2 Gender and age

This subsection presents the results from estimations when the wage distributions of men and women are considered separately and when the wage distributions for different age groups are considered separately. Table 4 shows the results.

Table 4: Marginal effects for percentiles of log wages; gender and age groups

	(4.1)	(4.2)	(4.3)	(4.4)
	Men	Women	Age 45 or less	Age above 45
p5 – p50	0.548*** (0.048)	0.729*** (0.034)	0.542*** (0.038)	0.709*** (0.040)
p10 – p50	0.387*** (0.045)	0.607*** (0.025)	0.408*** (0.034)	0.570*** (0.029)
p15 – p50	0.272*** (0.041)	0.508*** (0.023)	0.298*** (0.027)	0.436*** (0.024)
p20 – p50	0.190*** (0.037)	0.390*** (0.022)	0.233*** (0.024)	0.334*** (0.022)
p25 – p50	0.133*** (0.032)	0.299*** (0.021)	0.173*** (0.021)	0.235*** (0.021)
p30 – p50	0.108*** (0.026)	0.214*** (0.018)	0.128*** (0.019)	0.170*** (0.021)
p40 – p50	0.068** (0.021)	0.105*** (0.012)	0.080*** (0.015)	0.072*** (0.015)
p60 – p50	0.042* (0.018)	-0.023 (0.012)	0.008 (0.014)	0.034* (0.016)
p70 – p50	0.062* (0.027)	-0.038 (0.018)	-0.019 (0.021)	0.056** (0.022)
p80 – p50	0.036 (0.036)	-0.014 (0.029)	-0.043 (0.028)	0.102*** (0.027)
p90 – p50	0.093 (0.059)	0.000 (0.038)	-0.027 (0.037)	0.091* (0.038)
Obs.	497	588	639	593

Note: Each row reports the results of a separate OLS regression of eq. (2) with the dependent variable being the difference between the percentile indicated in the first column and the median. Year fixed effects are included as a control variable. Robust standard errors are shown in brackets. Superscripts ***, ** and * denote that the effect is statistically significant at the 1, 5 and 10 per cent level respectively.

Columns (4.1) and (4.2) present the estimation results of equation (2) when the distributions for men and women are considered separately. The results demonstrate that the spill-over effects from the minimum wage are larger for women than for men up to the 30th percentile. The economic size of the difference is also sizeable in the lower part of the wage distribution; the difference in elasticity is roughly twice as large for women from the 10th percentile of wage distribution for example. These results are the consequence of the very different wage distributions for men and women in Estonia. The gender wage gap is very large in Estonia (Meriküll and Mõtsmees, 2014). This means that a man at, for instance, the 20th percentile of the wage distribution for men earn much more than a woman at the 20th percentile of the distribution for women.

The results demonstrate that the spill-over effects from the minimum wage are larger for women than for men up to the 30th percentile. The economic size of the difference is also sizeable in the lower part of the wage distribution; the difference in elasticity is roughly twice as large for women from the 10th percentile of wage distribution for example. The large

difference in elasticities corresponds to large differences in monetary returns; the marginal effects in euros are around 0.20 euro higher for women than for men between the 10th and the 25th percentiles in 2014. As expected, we find that an increase in the minimum wage benefits women more than men and contributes more to wage compression among women than among men. This also suggests that a rise in the minimum wage can help reduce the gender wage gap.

The large difference in elasticities corresponds to large differences in monetary returns; the marginal effects in euros are around 0.20 euro higher for women than for men between the 10th and the 25th percentiles in 2014. As expected, we find that an increase in the minimum wage benefits women more than it benefits men and contributes more to wage compression among women than among men.

Most studies on spill-over effects find that the wages of women are more affected by a rise in the minimum wage than are the wages of men.¹¹ Women usually earn lower wages than men and the minimum wage is therefore much more binding for women. The greater spill-overs for women are therefore typically a reflection of different wage distributions. The results for Estonia are in line with those from the literature and are consistent with the fact that the gender wage gap in Estonia is unusually large.

The wage distribution and the spill-over effects may also vary across different age groups. Columns (4.3) and (4.4) in Table 4 show the results when the sample is split along the age of the employees. The wage income for those under aged 45 years is higher than for those aged over 45 years. Given that the minimum wage is less binding for young workers, it is arguably not surprising that we find that the minimum wage affects the lower part of the wage distribution to a greater extent for older wage-earners than for younger ones.

6.3 Boom, bust and recovery

We examine in this subsection whether the effects of the minimum wage on the wage distribution differed across the different phases of the business cycle in Estonia as discussed in Section 3. We split the original year, region and sector level data between three subsamples, the boom years 2001-2007, the crisis years 2008-2010, and the recovery years 2011-2014. Table 5 shows the results when eq. (2) is estimated for the three subsamples separately.

¹¹ See for instance DiNardo et al. (1996) & Lee (1999) for the USA and Ganguli & Terrell (2006) and Lukiyanova (2011) for transition countries.

Table 5: Marginal effects for percentiles of log wages; before, during and after the global financial crisis

	(5.1)	(5.2)	(5.3)
	The boom period 2001-2007	The crisis period 2008-2010	The recovery period 2011-2014
p5 – p50	0.652*** (0.034)	0.482*** (0.086)	0.584*** (0.050)
p10 – p50	0.508*** (0.027)	0.360*** (0.046)	0.474*** (0.049)
p15 – p50	0.371*** (0.028)	0.247*** (0.048)	0.329*** (0.047)
p20 – p50	0.254*** (0.027)	0.175*** (0.039)	0.232*** (0.042)
p25 – p50	0.200*** (0.025)	0.127** (0.041)	0.202*** (0.040)
p30 – p50	0.123*** (0.022)	0.010* (0.037)	0.140*** (0.032)
p40 – p50	0.068*** (0.015)	0.048 (0.029)	0.089*** (0.020)
p60 – p50	0.006 (0.016)	0.013 (0.034)	0.005 (0.022)
p70 – p50	-0.001 (0.025)	-0.002 (0.048)	-0.012 (0.034)
p80 – p50	0.002 (0.034)	-0.062 (0.054)	0.020 (0.043)
p90 – p50	0.114* (0.046)	-0.109 (0.078)	0.029 (0.062)
Obs.	377	156	209

Note: Each row reports the results of a separate OLS regression of eq. (2) with the dependent variable being the difference between the percentile indicated in the first column and the median. Year fixed effects are included as a control variable. Robust standard errors are shown in brackets. Superscripts ***, ** and * denote that the effect is statistically significant at the 1, 5 and 10 per cent level respectively.

It follows from Table 5 that the spill-over effects are smaller and decay more rapidly across the lower percentiles for the crisis period 2008-2010 than for the boom and recovery periods, although the confidence intervals are relatively wide and largely overlapping. The smaller spill-over effects during the crisis period are consistent with the observation that nominal wages were declining across most of the wage distribution during the crisis years in spite of the headline minimum wage remaining constant. These results also apply if the GDP growth rate and the unemployment rate are included as additional control variables (not shown). The upshot is that the effects of the minimum wage on the wage distribution may vary across boom, crisis and recovery periods, in all likelihood reflecting changing wage setting behaviour across the business cycle.

7. Robustness

The estimations have so far considered labour markets or cells based on the year, region and sector. Although there is limited mobility of labour between sectors in Estonia, it is nevertheless advisable to assess whether the use of the sector as an additional margin of identification is appropriate. We have therefore repeated the estimations from Table 2 replacing the sector with the occupation in the definition of the cells. Data suggest that mobility between occupations is of broadly the same range as mobility between sectors, although it is even slightly lower between occupations. There are nine occupation groups at the ISCO 1-digit level of aggregation, which covers all occupations from elementary workers to managers but excludes the military. The change results in 590 cells with 20 or more individuals out of a maximum of 630 possible cells.

Table 6 shows the results when cells are formed from the year, region and occupation with different sets of control variables. When the results are compared with those in Table 2 it is clear that the change of identification margin is of very little importance. The results obtained are robust to the exact specification of the labour markets or cells in the aggregate dataset.

Table 6: Marginal effects for percentiles of log wages, occupation instead of sector

	(6.1)	(6.2)	(6.3)
p5 – p50	0.565*** (0.019)	0.555*** (0.019)	0.555*** (0.019)
p10 – p50	0.419*** (0.012)	0.416*** (0.013)	0.416*** (0.013)
p15 – p50	0.319*** (0.011)	0.316*** (0.012)	0.316*** (0.012)
p20 – p50	0.238*** (0.010)	0.238*** (0.011)	0.239*** (0.011)
p25 – p50	0.169*** (0.009)	0.168*** (0.010)	0.168*** (0.010)
p30 – p50	0.122*** (0.008)	0.123*** (0.009)	0.123*** (0.009)
p40 – p50	0.057*** (0.006)	0.056*** (0.007)	0.056*** (0.007)
p60 – p50	-0.006 (0.008)	-0.007 (0.008)	-0.007 (0.008)
p70 – p50	-0.026* (0.010)	-0.022* (0.011)	-0.022* (0.011)
p80 – p50	-0.032* (0.016)	-0.027 (0.016)	-0.027 (0.016)
p90 – p50	-0.055* (0.022)	-0.055* (0.023)	-0.056* (0.023)
Year FE	Yes	Yes	Yes
Region FE	No	Yes	Yes
Growth and unempl.	No	No	Yes
Obs.	590	590	590

Note: Each row reports the results of a separate OLS regression of eq. (2) with the dependent variable being the difference between the percentile indicated in the first column and the median. The control variables are indicated in the table. Robust standard errors are shown in brackets. Superscripts ***, ** and * denote that the effect is statistically significant at the 1, 5 and 10 per cent level respectively.

We have also implemented a number of other robustness checks. Until this stage cells with less than 20 observations have been dropped so that all cell have 20 or more individual observations. This relatively low number has been chosen to preserve observations in the aggregate dataset. We have examined the sensitivity of the results to this cut-off point and raised it to 50 but the results did not change in qualitative terms (not reported).

The monthly wage reported in the Estonian LFS is the most recent wage received by the individual interviewed. Temporary absence from work or overtime work may make the wage reported extraordinarily low or high and this may affect the tails of the wage distribution and also the results obtained. We can assess the robustness of the results to extraordinary fluctuations in wage income by using a question in the Estonian LFS in which the person interviewed is asked whether or not the wage reported is the “ordinary wage”. This question has been available in the LFS since 2007. We have repeated the estimations in Table 2 for the period 2007-2014 for the full sample with all

interviewed individuals and for a sample where we have excluded individuals whose reported wage is not the “ordinary wage”. The results for the two samples are virtually identical (not reported).

As a final robustness check we have run estimations where the median has been replaced as the centrality measure by the 40th percentile and by the 60th percentile (not reported).¹² The results are qualitatively in line with the results when the median is chosen as the centrality measure. In neither of the new specifications are there any statistically significant marginal effects above the new measure of centrality. This indicates that higher percentiles do not seem to be affected by the minimum wage, confirming the choice of the median as the centrality measure.

8. Discussion

This paper analyses the effect of the statutory minimum wage on the wage distribution of the full-time employed in Estonia using data from the Labour Force Survey from 2001 to 2014. The minimum wage in Estonia is uniform and this complicates the identification of the effect on the wage distribution. We use instead a modified version of the methodology developed by Lee (1999).¹³

The analyses for the full sample show that there are substantial spill-over effects from the minimum wage to the lower percentiles of the wage distribution. The effects are most pronounced up to the 20th percentile and then decline relatively fast as the wage approaches the median wage. The conclusion is that the minimum wage appears to have contributed to lower wage inequality in Estonia.

The marginal effect in monetary terms is less than the increase in the minimum wage at all percentiles, even at the 5th percentile of the wage distribution, just above the minimum wage. The estimated spill-over effects imply for 2014 that an increase of one euro in the minimum wage is associated with an increase of 0.11 euro in the *average* wage of all full-time wage-earners.

The spill-over at given percentiles of the wage distribution is larger for women than for men. The spill-over is similarly larger for wage-earners over 45 years than for those below 45 years. These results reflect that the wage distributions for men and women and for younger and older workers are very different. The spill-over effects at the lower tail of the wage distribution were

¹² The requirement is that the centrality measure must be independent of the scale measure, and this may not be satisfied if a very high percentile of the wage within the cell is chosen as the centrality measure. Lee (1999) uses the median as the centrality measure and this is customary in the literature.

¹³ The baseline results are derived using the sector of activity to construct the individual labour markets or cells, but the results are very similar if the occupation of the wage-earners is used.

smaller at the height of the global financial crisis in 2008-2010 than before or after the crisis.

In a comparative context, it is clear that the overall substantial spill-over effects for Estonia bear clear resemblance to those found in earlier studies for the USA, emerging-market economies in Latin America and some Eastern European transition countries, but are larger than those found for the UK and some continental European countries. The substantial effects in Estonia may be tied to a number of structural features of the economy and the role played by the minimum wage in wage and price setting in the country.

First, the absence of collective bargaining in Estonia makes the minimum wage the arguably most important institutional measure affecting wages and employment in Estonia. This is compounded by the flat income tax system which means that the marginal tax rate remains unchanged at higher income levels.

Second, changes to the minimum wage are announced in advance and take effect from 1 January of the following year. Survey evidence on wage setting in Estonia shows that when wages are changed on a regular basis, it typically occurs in January or one of the immediately following months (Dabušinskas & Rõõm, 2011). Changes in the minimum wage are thus typically known when the wage setting takes place and the information on the minimum wage is thus easy to take into account.

Third, a number of fees and prices are indexed to the minimum wage in Estonia; these include kindergarten fees, child support, and traffic fines. In this way changes in the minimum wage become very visible and directly affect the spending and wage expectations of many Estonians.

Finally, the level of wages is relatively low in Estonia in comparison to many Western European countries. It may therefore be quite affordable to raise wages at levels above the minimum wage and the incentive for employers to resist wage increases for these groups of employees may thus be limited if their productivity makes wage increases feasible.

This study could be extended in a number of ways. One direction would be to seek to validate or cross-check the results using other empirical methods, preferably incorporating possible effects on employment. The challenge in this context is to account for the lack of cross-sectional variability in the headline minimum wage in Estonia. Another interesting direction would be to produce similar analyses for other European countries with the aim of facilitating a direct comparison of spill-over effects across countries. We leave these questions for future research.

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Appendix A

Table A.1: Summary statistics, full time wage-earners

	Gross minimum wage	Net minimum wage	Median of net wage	Std. dev. of net wage
2001	102	92.12	192	155
2002	118	103.09	211	166
2003	138	117.74	224	163
2004	159	139.62	256	177
2005	172	155.57	288	220
2006	192	176.39	345	262
2007	230	206.48	447	307
2008	278	248.54	511	356
2009	278	246.03	511	365
2010	278	243.71	511	384
2011	278	243.71	510	483
2012	290	252.93	550	425
2013	320	277.98	600	447
2014	355	305.08	650	450

Note: The wages are expressed in euros per month. For 2001-2010 the wages have been converted from EEK to EUR using the fixed exchange rate 1 EUR = 15.6466 EEK

Source: Own calculations using data from the LFS (2001-2014).