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The role of firms in the gender wage gap

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Abstract: Recent research suggests that firm-level factors play a significant role in the gender wage gap. This paper adds to this literature by analysing the role of sorting between firms and bargaining within firms using the methodology of Card et al. (2016). We employ linked employer-employee data for the whole population of firms and employees from Estonia for 2006–2017. Estonia is a country with the highest gender wage gap in the EU with about two-thirds of that unexplained by conventional factors. The results show that firm-level factors are important determinants of the gender wage gap, explaining as much as 35% of the gap. We find that within-firm bargaining plays a larger role in the gender wage gap than similar prior papers. This could be related to lenient labour market institutions, as reflected in low minimum wages and union power, and to lower bargaining skills of women. Further, the role of firm-level factors in the gender wage gap have increased over time, and these are especially important at the top of the wage distribution and among workers that are more skilled. There is a heavy penalty for motherhood in wages, 4–9 log points, but this is not related to firm-specific time-invariant productivity premiums.

JEL codes: J31, J71, J16, D22

Key-words: Gender wage gap, firm-level productivity premiums, sorting and bargaining, distribution of wages, skills, motherhood penalty

1. Introduction

A substantial proportion of the gender wage gap remains unexplained by the standard individual level characteristics traditionally used by labour economists (Goldin 2014, Beaudry and Lewis 2014, Bertrand 2010). The unexplained gender wage gap is greatest for the top of the wage distribution, where the gap diminishes more sluggishly than across the remaining wage distribution (Blau and Kahn 2017). This points to different mechanisms behind the wages for men and women at various skill levels and the incentives of firms in many high-performance requiring contexts to reward disproportionally highly the employees who can offer more flexibility in excessive working hours (Goldin 2014). Recent research suggests that firm-level productivity premiums play a significant role in the aggregate gender wage gap (Card et al. 2016). The segregation between

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employers has been found to be more important for the gender wage gap than segregation between occupations (Cardoso et al. 2016, Jewell et al. 2019, Gallen et al. 2019. The role of firm-level factors is especially important at the top of the wage distribution (Cardoso et al. 2016, Jewell et al. 2019). The likely importance of firm-level factors also follows from the well-documented wide distribution of productivity across the companies (Andrews et al. 2016, CompNet Task Force, 2014).

This study investigates the role of firm-level productivity premiums in the gender wage gap using employer-employee level data from Estonia, the country with the highest gender pay gap in the EU. We disentangle the role of the sorting of employees into high-productivity and high-wage firms (the sorting channel) and the within-firm gender wage gap (the bargaining channel) using the decomposition methodology of Card et al. (2016). First, the role of firm-level productivity premiums in the gender wage gap is investigated in respect to various measures of skill. We ask whether the role of productivity premiums varies in respect to the distribution of wages, the level of education or occupation categories. Second, we investigate the role of parenthood in the gender wage gap, disentangling here again the role of firm-level factors working through the sorting and bargaining channels. We ask whether the gender wage gap varies in respect to age and parenthood, and whether the motherhood penalty comes from women sorting to lower-wage firms or earning lower wages within the same firms after childbirth.

The contribution of the paper is twofold. First, we contribute to recent literature on the role of firm-level factors in the gender wage gap, disentangling the role of sorting and bargaining in an institutional environment characterised by low unionisation, relatively low minimum wages and very high gender wage gap. There are only a few papers that have applied this approach (Card et al. 2016, Coudin et al. 2018, Bruns 2019, Casarico and Lattenzio 2019), and highlight the importance of the institutional environment in the findings. For example, Card et al. (2016) and Casarico and Lattenzio (2019), using Portuguese and Italian data, show that the role of bargaining accounts for one-third of the effect of firm-level productivity premiums on the gender wage gap, while Coudin et al. (2018) and Bruns (2019), using French and German data, find that bargaining plays almost no role. The Portuguese labour market is characterised by more lenient labour market institutions and wide wage distribution, while Coudin et al. (2018) and Bruns (2019) link their findings to very high minimum wages in France and the strong role of unions and collective bargaining in Germany. Minimum wages and unions affect the lower part of the wage distribution, contributing to the gender wage gap within firms in the lower part of the wage distribution. We extend the set of empirical evidence available on the role of firm-level factors in the gender wage gap using Estonian data—focusing on a case with an institutional environment with low minimum wages and essentially very limited role of unions in wage setting and a wide wage distribution (see e.g. Masso et al. 2018).

Second, we contribute to the literature on the role of parenthood in the gender wage gap. Event studies show that the motherhood penalty is around the size of 7–10 log points (Kleven et al. 2019). There is usually a very small gender gap in wages when young people enter the labour market, while by the age of 40 it is already 15–20 log points (Goldin 2014, Card et al. 2016, Coudin et al. 2018, Bruns 2019, Jewell et al. 2019). There are only a few studies on the role of firm-level factors in the motherhood penalty. Coudin et al. (2018) find that the sorting of women into lower-wage lower-performance firms is activated especially after the birth of a child. Bruns (2019) shows that firm-level productivity premiums explain 20–30% of the increase in the gender wage gap after

childbirth (Bruns 2019).

The paper estimates wage regressions of the type proposed by Abowd et al. (1999) with individual and firm fixed effects. We use the whole population based panel of linked employer-employee data from 2006–2017. This is the great value of our paper, as papers so far have had to exclude a substantial share of firms due to matching of employee and employer level data or to impute a substantial part of trimmed employee level data (see e.g. Card et a. 2016, Card et a. 2013). Our data is less prone to limited mobility bias, which can originate from small subsamples of the population (Card et al. 2018). The data are from Estonia, which is an excellent case to study the drivers of the gender wage gap. It has the largest unconditional and conditional gender gap in the European Union and the 2nd highest in the OECD, and stands out with a high share of the gap unexplained, two-thirds of the gap remains unexplained by the standard often-used determinants (see e.g. Christofides et al. 2013, Anspal 2015). The institutional environment with low minimum wages, low union density and high-wage inequality provides an insightful case for analysis.

Firm-specific wage or productivity premiums have been shown to affect the gender pay gap through the bargaining and sorting channels (Card et al. 2016). Card et al. (2016) show that women in Portugal are less likely to be employed at high-productivity firms paying high wages—the sorting channel. In addition, they are paid lower wages than men within the same firms—the bargaining channel. Card et al. (2016) show that the role of the sorting and bargaining channel in the gender wage gap is different for low- and high-skilled workers, the sorting channel has a dominant role for low-skilled and the bargaining channel, for high-skilled workers. The firm-specific productivity premiums explain 21% of the gender wage gap in Portugal, of which two-thirds originate from the effect of sorting and one-third from the effect of bargaining.

There are only a few studies following the approach proposed by Card et al. (2016). The firm-level productivity premiums explain a much smaller share of the gender wage gap in France, 8%, and the sorting effect displays a dominant role (Coudin et al. 2018). The authors assign the low importance of bargaining to high minimum wages that shield low-wage workers. Bruns (2019) finds that firm-level productivity premiums explain 11–26% of the gender wage gap in Germany and again with the sorting effect having a dominant role. He assigns the low importance of bargaining to union power and collective wage setting.[4] The largest role of firm-level productivity premiums in the gender wage gap has been found for Italy, where they explain 30% of the gap (Casarico and Lattenzio 2019). As in the original study of Portuguese data, they assign two-thirds of the effect to sorting and one-third of the effect to bargaining.

Some studies have applied the approach from Card et al. (2016) without disentangling the bargaining effect and just test the role of sorting between firms in the gender wage gap (Sorkin 2017 for the US, Jewell et al. 2019 for UK, Gallen et al. 2019 for Denmark). The limitation of these studies has been that they cannot link their firm-level fixed effects to firm-level data on productivity. This does not allow them to normalise the firm fixed effects and disentangle the role of the bargaining channel. Finally, there are studies that analyse the role of the employer simply by controlling for the mean establishment earnings (Goldin et al. 2017). All these studies conclude that firm-level factors and sorting between firms are important in explaining the gender gap in

[4] We would, however, note that the union power and collective agreements coverage have significantly decreased in Germany during the recent decades: while in 1990 collective agreements coverage was still at 85%, it fell by 2019 down to 59% in West Germany and 48% in East Germany (Bosch 2019).

wages.

There are many channels that show how the more high-performance and knowledge intensive work environments affect the gender wage gap. Some of the effects may work through Becker's (1957) taste-based discrimination channel, with the ability of firms to discriminate depending on the performance of the firm. At the same time, the adoption of more knowledge intensive technologies, such as IT technologies and other non-physical skill-intensive technologies has been shown in some past studies to act to complement female labour and thus likely contribute to lowering the gender pay gap (Weinberg 2000).

Other types of effects may work in exactly the opposite direction. Recent studies by Goldin (2014) emphasize the role of lesser temporal flexibility for job purposes and more work interruptions in lowering women's wages relative to men, clearly showing the importance of this mechanism in the US. Goldin (2014) studies the impact of temporal flexibility or the lack of this in shaping the gender pay gap within different occupations. The channel of the effects that she outlines is the disproportionate size of rewards in some occupations and organisations for working longer hours, continuous hours or particular hours. This linked with the on average higher ability or willingness of men to provide this temporal flexibility (or the perception of the firm that this is the case), can lead to a higher gender wage gap in organisations and occupations where temporal flexibility (24/7 availability for job purposes) of workforce matters a lot and where substitutability between individual employees is limited. These tend to be disproportionally the high-performance workplaces and jobs. Classical examples of such occupations or sectors would be lawyers and management consultants, and business occupations in general. Ben Yahmed (2013) further outlines in her Melitz-based (2003) heterogeneous producer trade model the complementarities between 'advanced technology' adopted at the firm and the consequent higher level of commitment (here seen as temporal flexibility) needed as input from its employees. These complementarities induce firms that have more advanced technology to hire more "committed" employees and, as a result, have a higher gender wage gap among employees. The net effect of investments in knowledge capital or the productivity of firms on gender wage gap depend on which type of effects dominate.

Our findings suggest a larger gender wage gap in high-performance firms. The firm-level productivity premiums explain 35% of the gender gap in wages, of which half originate from men sorting to high-performance high-wage firms and half from women bargaining lower premiums within a firm. The large role of within-firm bargaining in the gender wage gap can be related to institutions such as low minimum wages and low union power. The role of firm-level productivity premiums have been increasing over time, and are much more important for the top wage earners and for high-skilled white collars. These findings support the story that segregation between firms (Cardoso et al. 2016) and increase in the productivity dispersion of firms (Bruns 2019) are behind the persistently high gender wage gap among top earners. However, we do not find that parenthood is activating the effects of firm-level productivity premiums on the gender wage gap. This is different from the findings of Coudin et al. (2018) using French data and Bruns (2019) using German data. Our results suggest that the gender wage gap due to firm-level productivity premiums is increasing with the individual's level of wages and skills, but is not related to parenthood.

The paper is organised as follows: the next section discusses data and methodology, the third section tests the key assumptions of the two-way fixed effects estimation and presents the results, and the last section summarises.

2. Methods and data

2.1. Methods

We apply the methodology proposed by Card et al. (2016). They analyse the role of firm-specific wage premiums in the gender wage gap and use the two-way fixed effects model of Abowd et al. (1999). Wage setting is defined as follows:

$$w_{it} = \alpha_{it} + \gamma^{M,F} S_{iJ(it)t}, \quad (1)$$

where w_{it} denotes the logarithm of the real wage of worker i at time t; α_{it} denotes a worker's outside options which can be a job in self-employment or unemployment benefits; $S_{iJ(it)t} \geq 0$ is the surplus for worker i from working for firm J at period t; $\gamma^{M,F}$ denotes the gender-specific surplus for men, M, and women, F. $S_{iJ(it)t}$ or the worker surplus from working for firm J consists of three parts:

$$S_{iJ(i,t)t} = \bar{S}_{J(it)} + \phi_{J(it)t} + m_{iJ(it)} \quad (2)$$

Here the first component on the right hand side, $\bar{S}_{J(it)}$, captures the time- and worker-invariant surplus from working for firm J; the second component, $\phi_{J(it)t}$, captures the time-varying and worker-invariant surplus from working for firm J; and the last component, $m_{iJ(it)}$, captures the time-invariant and worker-specific surplus from working for firm J. The outside option α_{it} consists of the following components:

$$\alpha_{it} = \alpha_i + X_{it}^{'} \beta^{M,F} + \varepsilon_{it}, \quad (3)$$

where α_i is a permanent component of wages capturing individual fixed effects; $X_{it}^{'}$ is the time-varying component of characteristics such as tenure, education; $\beta^{M,F}$ are gender-specific coefficients showing returns to characteristics; and ε_{it} captures the transitory component of wages. Substituting equations (2) and (3) into the wage setting equation (1) yields:

$$w_{it} = \alpha_i + \psi_{J(it)}^{M,F} + \square_t + X_{it}^{'} \beta^{M,F} + r_{it}, \quad (4)$$

where $\psi_{J(it)}^{M,F} \equiv \gamma^{M,F} \bar{S}_{J(it)}$(firm-specific wage premiums for men and women), $r_{it} \equiv \gamma^{M,F}\left(\phi_{J(it)t} + m_{iJ(it)}\right) + \varepsilon_{it}$; and $\square_t$ refers to time fixed effects. Equation (4) will be estimated separately for men and women and gives individual fixed effects, gender-specific firm fixed effects and gender-specific coefficients for characteristics. We apply the *felsdvreg* command in Stata to estimate the two-way fixed effects model in equation (4) (the command by Cornelissen 2008). Estimating equation (4) with OLS assumes that the exogenous mobility condition holds. However, the error term in equation (4) has a complicated structure. It contains the time-varying surplus from working for the firm, $\phi_{J(it)t}$, the worker-specific surplus from working for the firm, $m_{iJ(it)}$, and the transitory wage shock, ε_{it}. In order for the erogeneity to hold, three conditions should be satisfied. Workers should not have a systematic drop in wages before leaving a firm and should not have systematic gains after joining a firm. Workers joining high-wage firms should have similar gains compared to the losses for workers joining low-wage firms. Prior to a job switch, workers moving towards high-wage firms should not have different trends in wages from those moving towards low-wage firms.

Card et al. (2016) test all these assumptions using the simple tests suggested by Card et al. (2013). We follow these tests and present the findings in the beginning of the Results section.

Next step in the analysis is to normalise the firm effects. The firm-specific wage premiums are identified only if there is a reference set of firms. We proceed from the approach of Card et al. (2016) and take as a reference the firms that offer no wage premiums compared to outside option for workers in equation (1). To obtain this reference category, the wage premium of low-surplus firms is set to zero. The two-step approach is used, where first, the gender-specific firm fixed effects are estimated, and then the firm-specific fixed effects are normalised by setting the fixed effects equal to zero below the threshold of labour productivity where no wage premium is paid.

Equation (4) can be used to decompose the variation in wages into effects from persons, firms, covariance of person and firm effects, individual characteristics and residuals. There are several papers performing these estimates. Card et al. (2018) summarise that 20% of the variation in wages can be assigned to variations in firm-specific wage premiums. This implies that workers with an equal set of characteristics can get substantial premiums from working for high-wage firms compared to low-wage firms. This paper focuses on how the firm-specific wage premiums contribute to the gender wage gap. Card et al. (2016) propose a decomposition of gender-specific firm fixed effects, which splits the gender gap in the average wage premium for men, $\overline{\psi^{M}_{J(\iota t)}}$, and women, $\overline{\psi^{F}_{J(\iota t)}}$, into two components: sorting and bargaining effects. The decomposition is:

$$\overline{\psi^{M}_{J(\iota t)}} - \overline{\psi^{F}_{J(\iota t)}} = \left(Share^{M}_{J(it)} - Share^{F}_{J(it)}\right)\psi^{M}_{J(it)} + \left(\psi^{M}_{J(it)} - \psi^{F}_{J(it)}\right)Share^{F}_{J(it)} \quad (5)$$

Where $Share^{M}_{J(it)}$ denotes the share of men in firm J and $Share^{F}_{J(it)}$ the share of women in firm J; $\psi^{M}_{J(it)}$ firm fixed effects for men and $\psi^{F}_{J(it)}$ firm fixed effects for women. The decomposition follows the general logic of Oaxaca-Blinder decomposition, except that instead of gender gap in wages the gender gap in firm-specific wage premiums is decomposed. The first term on the right hand side captures the usual endowment effect; that is, how large the gap was if men and women worked for different firms but had the firm-specific wage premiums of men. This part is denoted as sorting effect by Card et al. (2016), showing how much the firm-specific wage premiums of men and women differ because men and women work for different firms. The last term on the right hand side captures the effect of the usual coefficients; that is, how large was the gap if men and women had different firm-specific wage premiums but the same share of women. This part is denoted as bargaining effect by Card et al. (2016), showing how much the firm-specific wage premiums of men and women differ for the same firm. As usual, the results of the decomposition are sensitive to the reference group of coefficients, men in equation (5). We use female coefficients as a reference for the robustness test.

Finally, we discuss some restrictions on the data from this methodology. The two-way fixed effects models can only be estimated for a connected set of firms; that is, for firms that have some worker mobility within the covered period. As we estimate separate models for men and women, the connected set condition has to be satisfied for both of the samples (Card et al. 2016). Another data restriction is that we can decompose the gender-specific firm fixed effects for only those firms that have had worker mobility from both genders during the covered period (Card et al. 2016).

Otherwise, the counterfactual firm fixed effect for a worker of the opposite sex cannot be constructed. This implies that we have to exclude the firms with employees of only one gender from the analysis and also all other firms where at least one of the genders has not had any mobility. There are 2–3% of workers in single-gender firms in our sample. The following section on data demonstrates how these restrictions affect the final outcome.

2.2. Institutional environment of the sample country and the data

We use data from Estonia—the country with the largest gender wage gap in the EU. The unconditional gender wage gap is around 25% and a large part of the gap remains unexplained by conventional controls (see e.g. Christofides et al. 2013). This background enables us to find new explorative findings from the environment of a very wide gender wage gap where discriminatory factors have potentially an important role.

We briefly summarise the main characteristics of the labour market in our sample country. There is very little institutional intervention in the wage setting in Estonia—union density is negligible (6% according to ILO IRData), and employment protection legislation is less strict than on average in OECD countries (OECD Stat Extracts; employment protection was relatively strict till 2009 but that was reduced due to its imperfect enforcement). Minimum wages have not been very binding, but have contributed to the lowering of the gender wage gap (Ferraro et al. 2018). As a result, the wage distribution is quite wide. The ratio of the ninth and first earnings decile is close to four, which is at the high end of wage inequality in the EU (Eurostat series earn_ses_hourly). Wages have also proven to be very flexible and respond significantly to market forces. For example, nominal wages were widely adjusted down during the Great Recession (Branten et al. 2018).

At the same time, labour market flexibility in terms of temporary contracts and working hours is limited. The role of temporary contracts is negligible, and there is no evidence of a gender gap in temporary employment. Only about 3–4% of men and women work with temporary contracts (Eurostat series lfsa_etpgan, in 2018). The majority of workers work full time, and whereas working part-time is more common among women than men, it is rather low even among them—15% of women and 7% of men have part-time jobs (Eurostat series lfsa_eppga, in 2018). Labour market participation is high, especially for women. On the basis of this characteristic, Estonia ranks second after Sweden in the EU. Employment rate among women is 71% and among men is 78% in the age group of 15–64 (Eurostat series lfsa_ergan, in 2018).

This background is also relevant for understanding the quality of our data. The data covers the whole population of wage earners from the Registry of the Tax and Customs Board with monthly frequency and the whole population of business sector employers from the Business Registry with yearly frequency. The timespan is from 2006 to 2017. The information about occupation, education, household structure and children originates from the Census in 2011 and is time-invariant. The advantage of our data is that the whole population of employees and employers is covered, and that we can link employee and employer data using their unique identifiers. The former implies that our data is less prone to limited mobility bias, which can originate from small

subsamples of the population (see the discussion in Card et al. 2018).[5] Many similar studies proceed only from the subsample of employees (e.g. Jewell et al. 2019, Bruns 2019) or the employer data cannot be directly linked with employee data and is matched using variables such as firm size, field of activity, among others (see e.g. Card et al. 2016). We use monthly worker-level wage data from January for each of the sample years and link it with the yearly firm-level balance sheet and profit/loss statements data.

The limitation of our data is that there is no information on working hours nor whether a person had a full- or part-time job. Women are more likely to work part-time and this may bias the gender gap up in our data. We take a number of initiatives to address this shortcoming. First, we exclude all persons who earn less than the statutory national minimum wage. Second, we exclude all observations where wages are below 50% of the median wage in particular 2-digit ISCO and 2-digit NACE cell. Appendix 1 describes the sample before and after the treatment of outliers. It can be observed that after eliminating these low wage earners, the sample mean wages become very close to the official estimates of mean wages. The gender wage gap is overestimated before trimming the outliers and is slightly underestimated afterwards, but it is close to the gap in hourly gross wage according to official wage statistics. Finally, we argue that the rather limited part-time work even among women in Estonia (as discussed above) limits the potential problems caused by the lack of working hours in our data.

Table 1 reports the descriptive statistics. Men are slightly younger than women in our sample, they have more frequently primary and secondary education and less frequently higher education. There are more men from the industrial north-east region and more women from the capital region in the north. Men work for smaller firms, but in firms with higher productivity. This finding is known from other studies as well (Card et al. 2016). Our data points to high segregation of men and women in the labour market: the share of female co-workers is 31% for men and 72% for women. This is a striking difference between men and women. However, it is not significantly different from other studies, this gap has found to be of similar magnitude in the US, UK and Portugal (see discussion in Card et al. 2016). We also find that men are more likely to work for firms that pay high wages: the mean wage of an individual's co-workers is 14% higher for men compared to women. This cannot explain the whole difference in unconditional gender wage gap and amounts only to half of the total gap. However, it suggests that segregation across firms has an important role for the gender gap in our sample country. There is further evidence of strong occupational segregation in our data: only 27% of men work in female dominated occupations and 27% of women in male dominated occupations.

[5] They discuss that using small samples of the population can produce samples with low worker mobility between firms, whereas the switches between employers that are not captured by the data are left out of the analysis. As a result, between firm worker mobility is underestimated, which leads to downward biased estimation of the correlation between firm and worker fixed effects (Card et al. 2018) While we cover the whole population of workers employed by the business sector, we omit, however, the workers of the public sector. The data shows that most of the worker mobility takes place within the private or public sector in Estonia (see e.g. Masso and Espenberg 2013 for an analysis of labour flows in the private and public sector). Only a small fraction of the mobility takes place between the private and public sector. The latter type of mobility is not captured by our data, but as it is a small fraction of total mobility, it causes a very limited downward bias of mobility in our sample.

Table 1. Descriptive statistics by gender, 2006–2017

	Men		Women		Mean men / mean women
	Mean	St. dev	Mean	St. dev	
Real monthly wage, EUR	558.0	386.8	437.6	280.9	1.275
Age, years	41.6	12.9	43.2	12.7	0.962
Education primary (dummy)	0.160	0.367	0.078	0.269	2.045
Education secondary (dummy)	0.599	0.490	0.545	0.498	1.099
Education tertiary (dummy)	0.241	0.428	0.377	0.485	0.640
Region North (dummy)	0.320	0.466	0.354	0.478	0.903
Region Central (dummy)	0.068	0.253	0.069	0.253	0.999
Region North-East (dummy)	0.084	0.277	0.058	0.235	1.435
Region West (dummy)	0.079	0.270	0.082	0.275	0.965
Region South (dummy)	0.449		0.437		1.027
Firm size, no. of employees	3.870	1.864	4.442	1.999	0.871
Mean wage of co-workers, EUR	504.4	269.6	444.5	226.3	1.135
Value added per employee, EUR	34714.4	61198.6	29071.7	64516.2	1.194
Share of women among co-workers	0.311	0.259	0.720	0.230	0.432
Mainly female ISCO 3-digit occupation	0.270	0.444	0.797	0.402	0.338
Mainly male ISCO 3-digit occupation	0.812	0.391	0.271	0.444	3.001

Note: the total sample consists of 5,095,244 observations, of which 2,923,893 are men and 3,136,220 women.
Source: Registry of Tax and Customs Board and Business Registry.

Figure 1 shows that firms employing more women have lower productivity and lower wages. The share of women in a firm starts to decline after the 60th wage percentile and is roughly 7% percentage points lower for above the 60th wage percentile than below this threshold. A similar negative relationship is observed between labour productivity and the share of women. High-productivity firms employ in general less women. However, unlike the relationship between wages and the share of women in the firm, the relationship with labour productivity has interesting non-linear swings. The share of women starts to increase in firms above the 85th productivity percentile, but it is still lower than for low-productivity firms. One possible reason for that increase could perhaps be the higher educational attainment of women in Estonia and the fact that the highest-productivity firms are employing relatively more employees with higher levels of education.These descriptive results provide the first hint that sorting of men and women to different firms has a role in the gender wage gap.

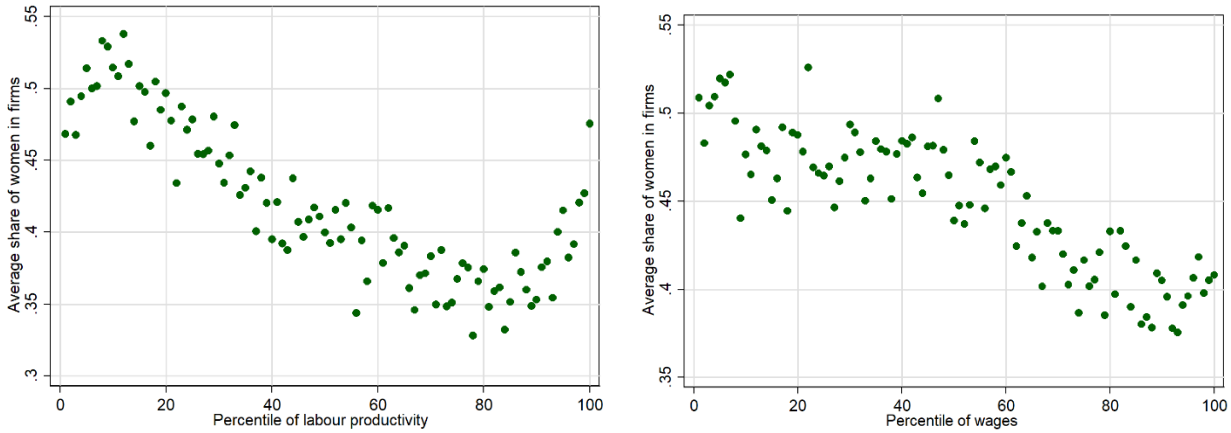

Figure 1. Productivity and wages across the share of female employees

Source: Registry of Tax and Customs Board and Business Registry.
Note. Each dot in the figure corresponds to one percentile of the distribution of labour productivity (left) or wages (right).

3. Results

3.1. The exogenous mobility assumption and gendered mobility gains

The key assumption of the two-way fixed effects approach used in this paper is that worker mobility is exogenous, otherwise firm and worker fixed effects estimates would be biased (see e.g. discussion by Card et al. (2018) and Section 2.2 of our paper). The idea is that "worker mobility is uncorrelated with the time-varying residual components of wages" (Card et al. 2018, p. 31).

Card et al. (2013) provide indirect tests for the exogenous mobility assumption. They plot the wage dynamics of the co-workers of job switchers two years before and two years after the switch. They split the co-worker wages into four quartiles and compare the wage dynamics of transitions between quartiles. Figure 2 presents the dynamics in our data. The first condition for exogenous worker mobility is that co-worker wages should not have a systematic drop before leaving the firm and should not have systematic gains after joining a new firm. This condition is clearly satisfied; there are no systematic developments in co-worker wages before or after the switch. The second condition states that workers joining high-wage firms should have similar gains compared to the losses of workers joining low-wage firms; that is, the gains and losses from moving should be symmetrical. This assumption seems to hold well for male job switchers, but is less clear for female job switchers. Women tend to gain a bit less than men from moving to high-wage firms, but they tend to lose a lot less from moving to low-wage firms.

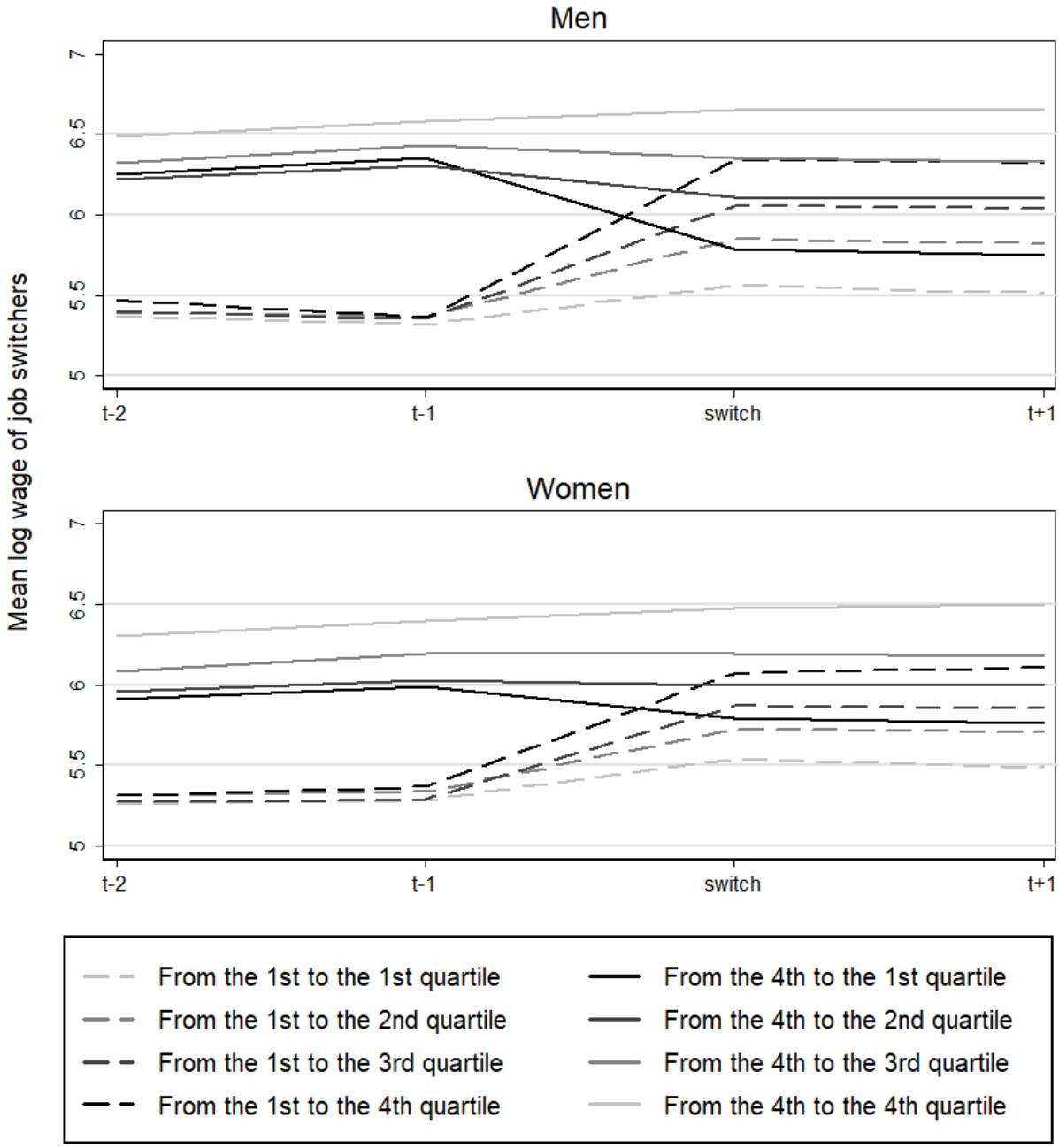

Figure 2. Log real wages of the co-workers of job switchers two years before and one year after the switch, for men and women

Note: Job switchers are divided into four wage quartiles based on the wage of their male and female co-workers. For example, the switch from the first to the fourth quartile means that the worker switched from a company paying 25% of the lowest wages to the company paying 25% of the highest wages. The figure plots the average wage of all the switchers from the first and the fourth quartile of co-worker wage groups; Appendix 2 shows descriptive data for all the quartiles.

Source: Registry of the Tax and Customs Board and the Business Registry.

Lastly, prior to the job switch, workers moving towards high-wage firms should have the same trends in wages as those moving towards low-wage firms. This assumption is rather satisfied for both genders and the wage growth of the co-workers is more-or-less the same for those switching to high-wage firms or to low-wage firms. We conclude that the exogenous mobility assumption is quite well satisfied in our sample. Men and women gain from moving towards higher wage firms and lose from moving towards low-wage firms. While there is evidence that women are more risk averse in their job switch, they gain somewhat less than men from moving to high-wage firms and loose substantially less from moving towards low-wage firms. Women make safe choices in the job switch, they do not sort to the highest paying firms and they do not sort to the lowest paying firms. Similarly, like sorting by occupation (see the discussion in Bertrand 2010), gender differences in risk aversion, attitudes towards competition and negotiations can have a role in sorting by firm.

3.2. Estimating two-way fixed effects model

The two-way fixed effects model of equation (4) is estimated separately for men and women. The results are presented for the dual-connected set of men and women; that is, for our final sample of firms that are connected by the mobility of men and women. See Appendix 3 for the relative sample size and the unconditional gender wage gap of the dual-connected set. This shows that although almost half of the firms are not connected by the job mobility of men and women, the sample of the dual-connected set represents as many as 89% of the person-years of the original sample after trimming. The firms that are not connected by worker mobility are very small firms, and these are left out of the analysis. The majority of the workers are covered by the dual-connected set.

Table 2 presents the results of the two-way fixed effects model for the dual-connected set. The only time-varying explanatory variables are the age squared and age cubic terms, these are defined at the personal level. The time fixed effects are also added for the 11 sample years. The linear term of age cannot be added, as it is perfectly collinear with time fixed effects. Omitting the linear age term implies normalisation of the age profile at age 0. This can lead to some overestimation of the role of time-varying characteristics and the person fixed effects in the variation of wages (Card et al. 2018). The quadratic term for age shows a concave relationship between age and wages, which is a well-known regularity for the Estonian labour market (Meriküll and Rõõm 2016). The curvature of the concave relationship is stronger for men than for women, so young working-age men earn relatively more than old men do, while earnings for women are flatter over their age.

The variance decomposition shows that the time-varying characteristics explain most of the variation in wages for men and women, while the role of person fixed effects is stronger for women and the role of firm fixed effects is stronger for men. The firm-level productivity premiums or firm fixed effects explain roughly 20% of the variation in wages internationally (Card et al. (2018)), which is similar to what we find. It is surprising that we find large differences between men and women – firm-level productivity premiums explain 22% of the variation in wages for men and 15% of the variation in wages for women. Which firms they work for matters more for the wages of men than for the wages of women.

Table 2. Estimation results for the two-way fixed effects model for men and women, 2006–2017

	Men	Women
Age^2	-0.242***	-0.142***
	(0.002)	(0.002)
Age^3	0.001***	0.001***
	(0.00002)	(0.00001)
Year fixed effects	Yes	Yes
No of year fixed effects	11	11
Person fixed effects	Yes	Yes
No of person fixed effects	350 400	378 266
Firm fixed effects	Yes	Yes
No of firm fixed effects	26 626	26 700
No of person-years	2 128 756	2 421 764
Variance decomposition:		
Time-varying characteristics (Cov(lrwage, xb)/Var(lrwage)	44.3%	38.1%
Person effects (Cov(lrwage, FE^{person})/Var(lrwage)	10.2%	25.6%
Firm effects (Cov(lrwage, FE^{firm})/Var(lrwage)	22.2%	15.2%
Residuals (Cov(lrwage, Res)/Var(lrwage)	23.3%	21.1%

Notes: The estimation sample refers to the dual-connected set, i.e. to the set of firms that are connected via the mobility of men and women. ***. **, * refer to statistical significance at 10%, 5%, 1% respectively. The variable "lrwage" in the table denotes "log of real wage".

The quality of the estimates of firm fixed effects depends on the number of movers per firm. The more movers per firm there are, the better the quality of the estimates of firm fixed effects. Table 3 presents the statistics on movers per firm in the baseline estimation sample of the dual-connected set. The majority of the firm fixed effects are estimated based on firms that have six or more movers per firm during the timespan of our sample; a quarter to one-third of firm fixed effects are estimated based on 20 or more movers per firm. Again, the gender differences stand out. It seems that the firm fixed effects are estimated more precisely for men than for women. While the differences are similar among men and women in terms of job mobility, 51% of men and 49% of women changed firms in the sample period. It seems that women tend to move to firms where relatively few other women are moving.

Table 3. Movers per firm in the dual-connected set of firms, 2006–2017

Movers per firm	Men	Women
1-5	37.6%	46.5%
6-10	15.6%	14.4%
11-20	14.8%	12.4%
21-30	7.7%	6.2%
31-50	8.1%	6.1%
51-100	7.7%	5.9%
>100	8.6%	8.4%
Total	100%	100%

Notes: The estimation sample refers to the dual-connected set, i.e. to the set of firms that are connected via the mobility of men and women. The number of firms in the estimation sample refers to that of Table 2.

Source: Registry of the Tax and Customs Board and the Business Registry.

3.3. Normalising firm fixed effects with productivity

The estimated firm fixed effects do not have an easily interpretable economic meaning, they just show the average firm wage premiums relative to the firm in the base category. In order to compare the firm fixed effects for men and women, the firm fixed effects have to be placed on a meaningful and comparable scale. Card et al. (2016) suggest a normalisation of firm fixed effects using firm labour productivity. This implies that the meaningful firm fixed effects can only be derived for those firms for which the labour productivity is known. Labour productivity is not available for the public sector: this is an additional reason on top of the missing data for us to exclude that sector from our analysis. We also lose a substantial part of the firms because of the missing observations in labour productivity. Luckily this does not bias our sample in terms of the unconditional gender wage gap (see Appendix 3).

The idea of the normalisation of firm fixed effects is based on a set of low-productivity firms that do not share the productivity premiums with workers. Card et al. (2016) call these no-surplus or zero surplus firms. They divide firms into 100 percentiles on the basis of their average real labour productivity over the timespan and calculate the average firm fixed effect for each productivity percentile. This shows that the productivity and firm fixed effects are positively related after some no-surplus threshold. The data of our sample country shows the same regularity (see Figure 3). The log labour productivity starts increasing approximately linearly with firm fixed effects around the threshold of 9.5. This threshold refers to 13,600 euros in 2010 prices and roughly 20% of workers are employed in these no-surplus firms. The productivity premiums increase faster for men than for women and the difference in the slopes for men and women is larger in our data for Estonia than for Portugal (Card et al. 2016), France (Coudin et al. 2018) or Germany (Bruns 2019). This regularity is evidence of the strong role of bargaining in determining the gender wage gap in our Estonian data.

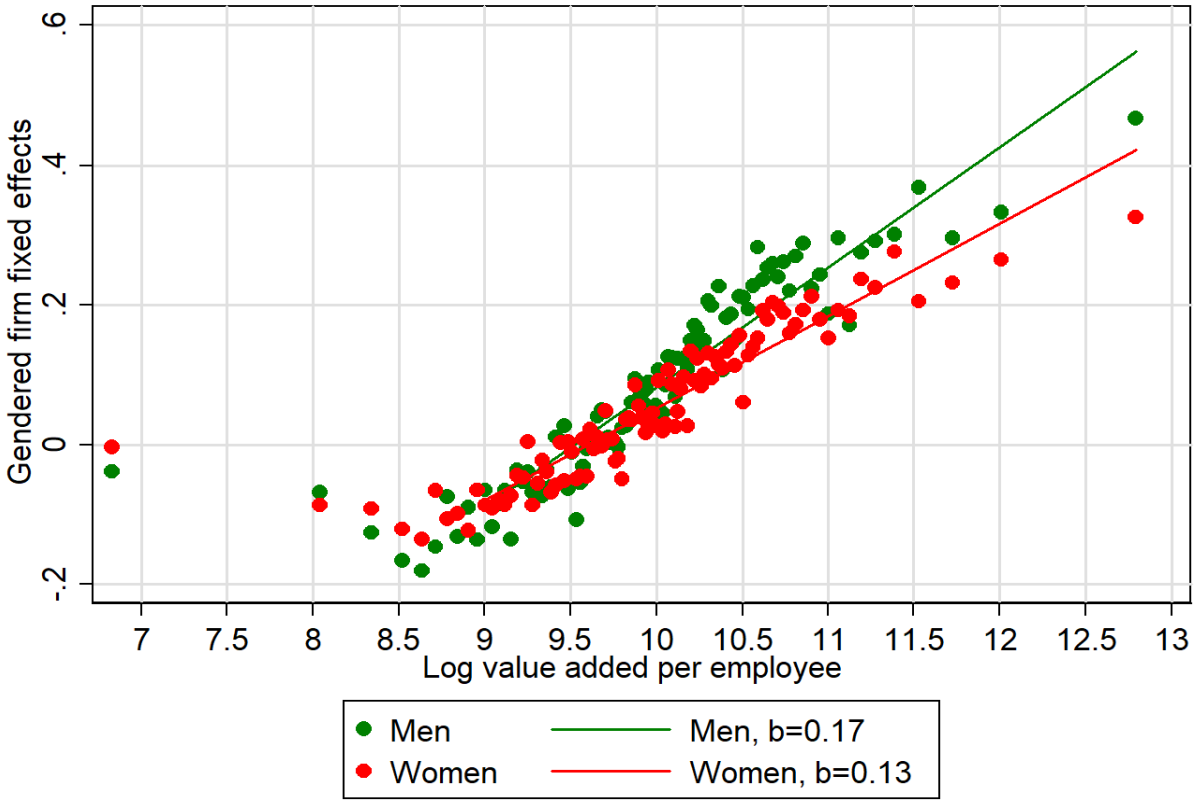

Figure 3. Firm labour productivity and firm fixed effects, 2006–2017
Source: Registry of the Tax and Customs Board and the Business Registry.
Note. Each dot in the figure corresponds to one percentile of the value added per employee distribution.

3.4. Baseline results and the role of skills

This sub-section formally derives the role of sorting and bargaining in the gender wage gap. The results of the decomposition in equation (5) are reported in Table 4. The raw wage gap is 24 log points in our final sample and the contribution of firm-level productivity premiums is 8.5 log points. This implies that the firm-level productivity premiums account for 35% of the total raw gap in wages. The average productivity premiums for men and women are "interpreted as estimates of the average rents received by men and women relative to jobs at no-surplus firms" (Card et al. (2016), p. 666). Men receive on average premiums with a size of 20 log points, while women receive on average only 12 log points. A core result of our paper is the finding that the role of productivity premiums in the gender wage gap is larger in Estonia than in other countries for which similar estimations have been conducted. The productivity premiums explain 35% of the raw gap in Estonia, 11% in France (Coudin et al. (2018)), 21% in Portugal (Card et al. (2016)), 26% in Germany (Bruns (2019)), and 30% in Italy (Casarico and Lattenzio (2019)).

Splitting the contribution to the effect of sorting and bargaining, shows that the role of bargaining is much larger in Estonia. The bargaining effect has almost no contribution to the gender gap in firm premiums in France (Coudin et al. (2018)) and Germany (Bruns (2019)), while it accounts for one-third of the gap in Portugal (Card et al. (2016)) and Italy (Casarico and Lattenzio (2019)). The

absence of the bargaining effect in France and Germany implies that it is conditional on personal characteristics and person fixed effects, there are no wage differences between men and women within the firm. Coudin et al. (2018)) and Bruns (2019) assign their low bargaining effect to labour market institutions, as high minimum wages and the strong role of unions do not allow much wage variation within an establishment. Our opposite finding of large differences in conditional wages within an establishment fit the Estonian institutional environment well, since it has low minimum wages and the role of unions is weak (see also Section 2.2). There is also evidence that women ask for lower wages than men in one on-line job portal in Estonia, which can reflect their worse bargaining skills (Meriküll and Mõtsmees 2017).

The choice of the counterfactual group of coefficients affects the relative size of bargaining effect. Using male firm effects as a counterfactual results in a smaller role of bargaining than using female firm effects as counterfactual: explaining correspondingly 45 or 60% of the gender gap in premiums. The sensitivity of the results to the choice of the counterfactual is quite common in any decomposition exercises. This is similar in the original paper by Card et al. (2016). They explain the larger role of bargaining using the counterfactual of female firm effects with the regularity that men usually work for firms where the gender gap in firm productivity premiums is small. Given that it has been found that bargaining plays a greater role in the Estonian sample using either group as counterfactual, we proceed by showing the results only for the counterfactual of male firm effects.

Table 4. Decomposition of firm fixed effects into sorting and bargaining, 2006–2017

	(1)	(2)	(3)	(4)	(5)	(6)
	Raw gap	Average male premiums	Average female premiums	Contribution of firm-level premiums to raw gap = (2)-(3)	Contribution from sorting	Contribution from bargaining
All workers: Base male firm effects (endowments) and female distribution of jobs (coefficients)						
Log points	0.243	0.202	0.117	0.085	0.047	0.038
In %	100			35.1	19.3	15.8
All workers: Base female firm effects (endowments) and male distribution of jobs (coefficients)						
Log points	0.243	0.202	0.117	0.085	0.034	0.051
In %	100			35.1	14.0	21.1
Primary education: Base male firm effects (endowments) and female distribution of jobs (coefficients)						
Log points	0.276	0.180	0.100	0.080	0.051	2.9
In %	100			28.9	18.5	10.4
Secondary education: Base male firm effects (endowments) and female distribution of jobs (coefficients)						
Log points	0.314	0.215	0.108	0.107	0.065	0.042
In %	100			34.1	20.8	13.3
Tertiary education: Base male firm effects (endowments) and female distribution of jobs (coefficients)						
Log points	0.258	0.258	0.154	0.104	0.053	0.051
In %	100			40.4	20.6	19.7

Source: Registry of Tax and Customs Board and Business Registry.

We go on by checking whether the role of productivity premiums differs over skills and the distribution of wages. It has been found that the role of bargaining is more important for high-skilled workers (Card et al. 2016, Coudin et al. 2016) and for top wage earners (Casarico and Lattenzio 2019). The share of potential rents in total wages from high-performance could rather naturally be expected to be larger in higher wage groups. Table 4 reports the decomposition results by level of education, and Figures 4 and 5 by ISCO main groups of occupation and the distribution of wages. We confirm earlier findings that the role of bargaining or gendered within-firm wage differences are more important for workers with tertiary education and for top wage earners. The results are more mixed across the ISCO groups, where it is clear that the productivity premiums are more important for high-skilled white collars, especially for professionals. White-collar professional men earn higher productivity premiums than women from the same occupation and the gap originates mostly from men sorting to high-premium firms.

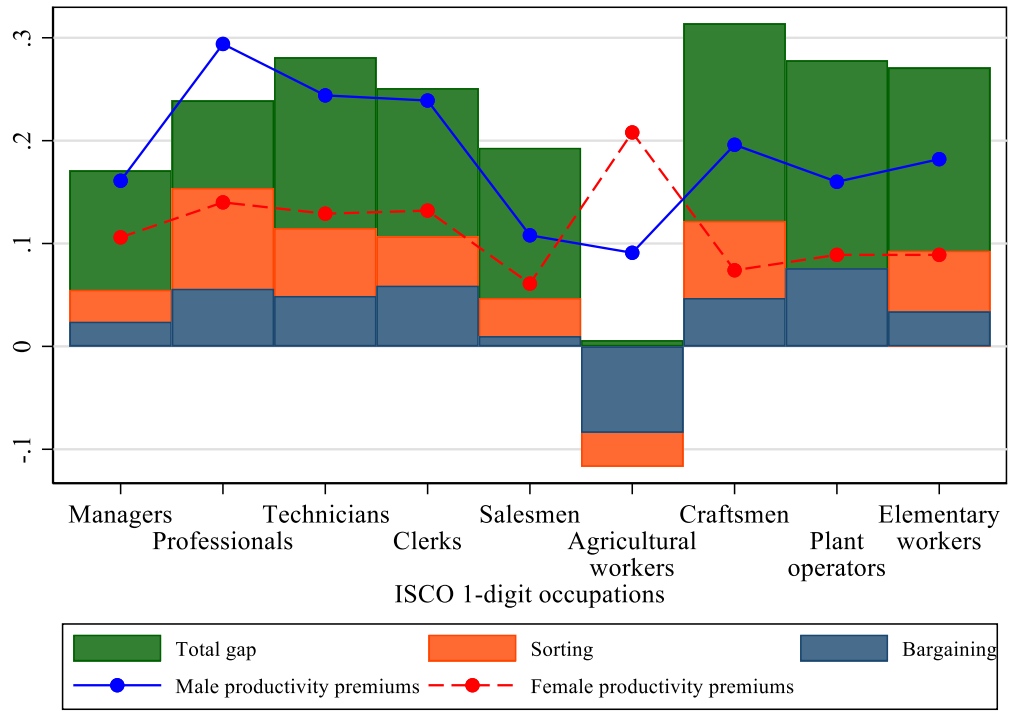

Figure 4. The unconditional gender gap (Total gap) and the role of firm productivity premiums in it (Bargaining + Sorting), 1-digit ISCO occupations
Source: Registry of Tax and Customs Board and Business.

The gender gap over the distribution of wages deserves further attention. We find that the raw gender gap in wages is increasing over the wage distribution. It approaches 30 log points around the 60th percentile and stays at a similar level for the upper part of the wage distribution. This shape of distribution is similar to the results from Christofides et al. (2013) and Meriküll and Mõtsmees (2017). Therefore, there is no evidence of a sticky floor or glass ceiling effect (wage gap

especially low at the very bottom or top of the wage distribution). As in Casarico and Lattenzio (2019), we find that the gender gap in productivity premiums is negative at the lower part of the wage distribution. However, unlike their Italian sample, we find this because of women sorting to higher premium firms at the lower part of the wage distribution. The sorting and bargaining effects both increase over the wage distribution, and they both contribute to the higher importance of firm-level productivity premiums at the upper part of the wage distribution. For the top wage earners, it matters more which firm they work for than the low wage earners. This is not the case in Italy, where the firm's contribution to the gender wage gap was found to decline after the 30th percentile (Casarico and Lattenzio 2019). The Estonian labour market could be considered to resemble the US more, where extra and unconventional working hours or commitment get proportionally more rewards (Goldin 2014). One earlier finding illustrating the contribution of the bargaining channel to the gender gap, especially in certain companies in Estonia, is that the gender wage gap is much larger in multinational than domestically owned firms in Estonia (Vahter and Masso 2019). Multinationals pay higher wages and are more exposed to international competition. Therefore, we could expect them to attract more committed workers and to pay higher premiums for commitment.

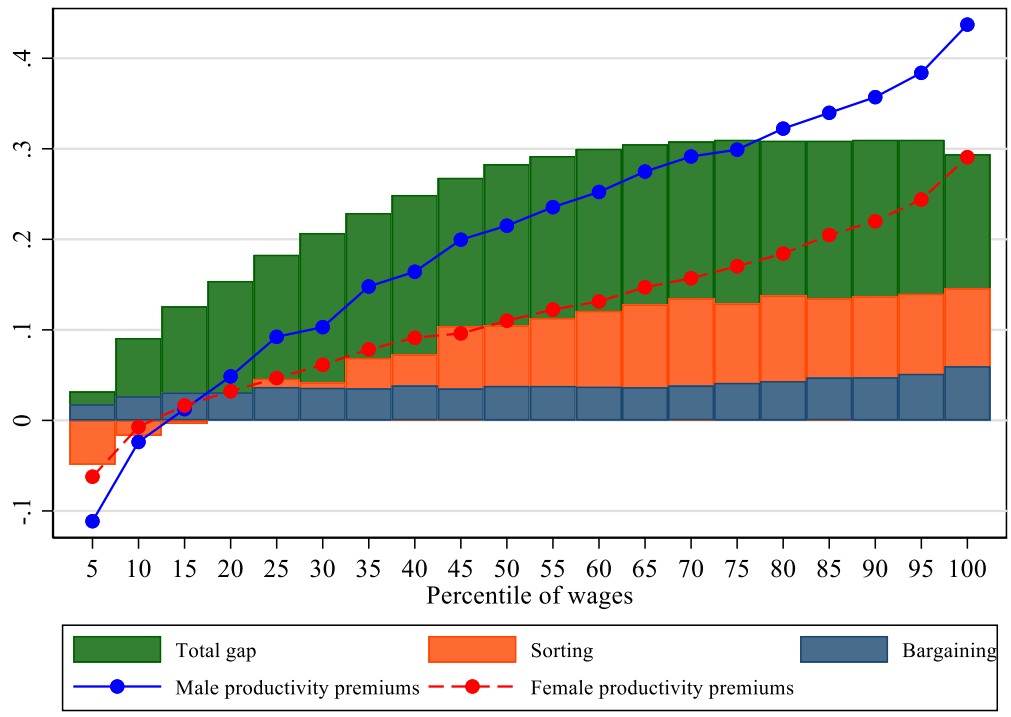

Figure 5. The unconditional gender gap (Total gap) and the role of firm productivity premiums in it (Bargaining + Sorting), percentiles of the wage distribution

Note: 5 refers to wages less than equal to the 5th percentile, 10 to wages larger than 5th percentile and less than equal to 10th percentile and so on.

Source: Registry of Tax and Customs Board and Business.

3.5. The role of parenthood

There is a substantial amount of empirical evidence about the age profile of the gender wage gap and the role of parenthood in it. See, for example, Goldin (2014), Barth et al. (2017) or Gallen et al. (2019). The gender wage gap is usually low when people enter the labour market. It expands until they enter their 40s and plateaus or declines later on (Card et al. 2016, Coudin et al. 2018, Bruns 2019, Jewell et al. 2019 and Goldin 2014). Firm-level productivity premiums have an important role in the expansion of the gap: firm-level productivity premiums explain as much as 25–30% of the expansion of the gap in Germany (Bruns 2019) and are important also in other countries such as Portugal, France and the UK (Card et al. 2016, Coudin et al. 2018, Jewell et al. 2019). It has been shown that the sorting effect is the main driver of the expansion of the gap before the 40s (Card et al. 2016, Coudin et al. 2018). The main explanation for these age differences are the different effects of parenthood on the wages of men and women. In this sub-section, we seek to understand how parenthood contributes to the gender wage gap and whether it is related to the sorting and bargaining effects.

Figure 6 presents the unconditional gender wage gap and the role of sorting and bargaining effects in it. We compare our findings to those available for Portugal, France and Germany (Card et al. 2016, Coudin et al. 2018, Bruns 2019). The unconditional gender gap in wages is 16% for the youngest cohorts, which is higher than in other countries where it is usually close to 5% at the time when people enter the labour market. The unconditional gap climbs towards the 40s in Estonia as in other countries. Unlike other Western European countries it does not plateau but declines afterwards. Similar dynamics can be observed also in the US (Goldin 2014). The unconditional gender gap in wages is almost the same for the youngest and the oldest labour market participants in Estonia. This is related to the common hump-shaped wage distribution on the basis of age in Post-Communist countries (see e.g. Meriküll and Rõõm 2016). Wages are often lower for older people because the old cohorts obtained their education during the Communist era and their human capital is valued less nowadays.

Another dissimilarity with other countries is that the gender gap in firm-specific productivity premiums is highly similar over age groups in Estonia. The gender gap in premiums grows from 8 to 10 log points as age increases with a growing importance of bargaining, but there is no evidence that the increase in the unconditional gender gap in a person's 30s and 40s is related to the increase in the gender gap due to productivity premiums. This is something different – observed in other countries. There is no evidence in our data that the gender gap in firm-level productivity premiums increases for the age groups when children are born (as in Card et al. 2016, Bruns 2019) or that the birth of a child is related to women sorting to low-premium firms (as in Coudin et al. 2018))

We cannot observe the exact time of the birth of a child to a household in our data. However, we know the household structure of our whole population at the time of the Population Census in 2011. We can conduct the decomposition for this year using the estimated firm fixed effects for the whole timespan. We observe the age of the youngest child in each household and the number of children in each household (see Figures 7 and 8). These results repeat the key results for the different age groups. The unconditional gender gap in wages increases substantially after childbirth. It is the highest for parents with young children and declines over the age of the youngest child. It is also evident that each additional child has a parenthood penalty for women compared to men; the unconditional gender gap increases with the number of children. The gap is two times larger for

men and women with three children than for men and women without children. The size of the penalty per child in our cross-sectional data is similar to that estimated using panel data and an event study (Kleven et al. 2019): around 7–10 percentage points per child

However, there is no evidence of the gender gap in firm-level productivity premiums increasing with the birth of a child. The gender gap in firm-level productivity premiums is similar, around 9 log points, for people with young and old children or without children; and for people with no children or with many children. This result is somewhat different from the results of Coudin et al. (2018) and Bruns (2019) and deserves further discussion.

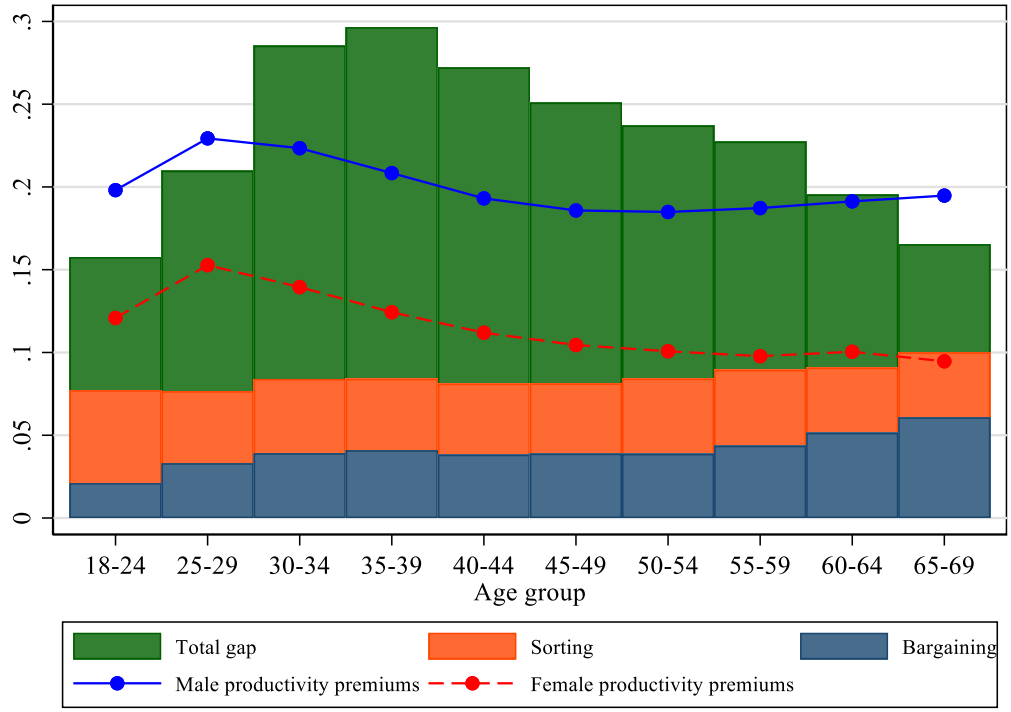

Figure 6. The unconditional gender gap and the role of firm productivity premiums in it, by age groups

Source: Authors' calculations from the Registry of the Tax and Customs Board and the Business Registry.

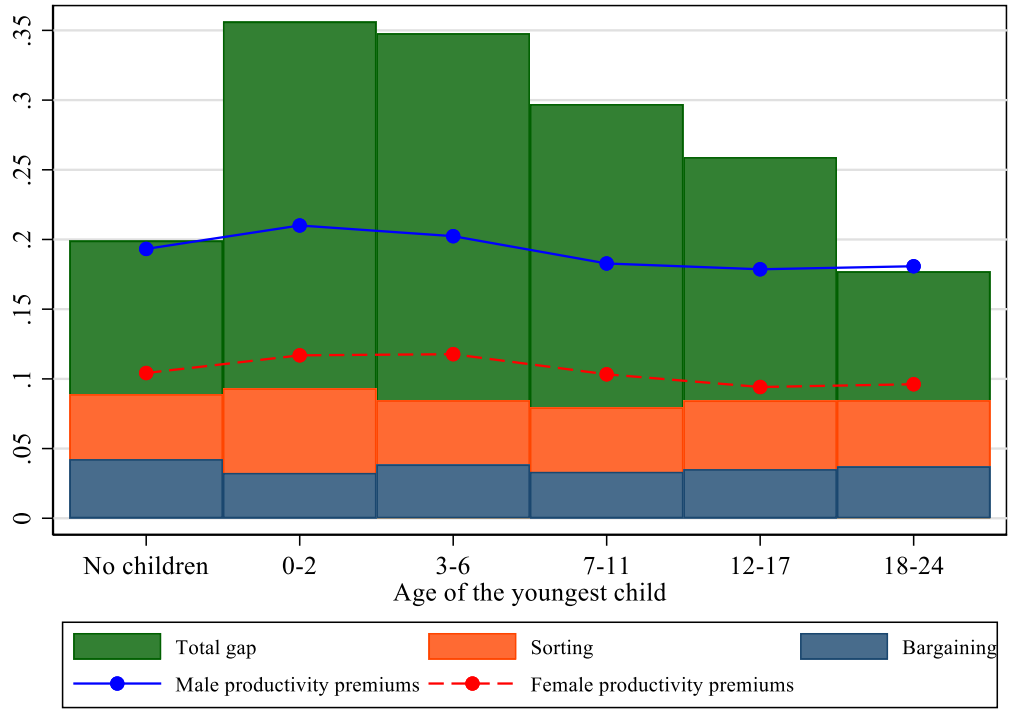

Figure 7. The unconditional gender gap (total gap) and the role of firm productivity premiums in it (bargaining + sorting), age of the youngest child in household
Source: Authors' calculations from the Registry of the Tax and Customs Board and the Business Registry.

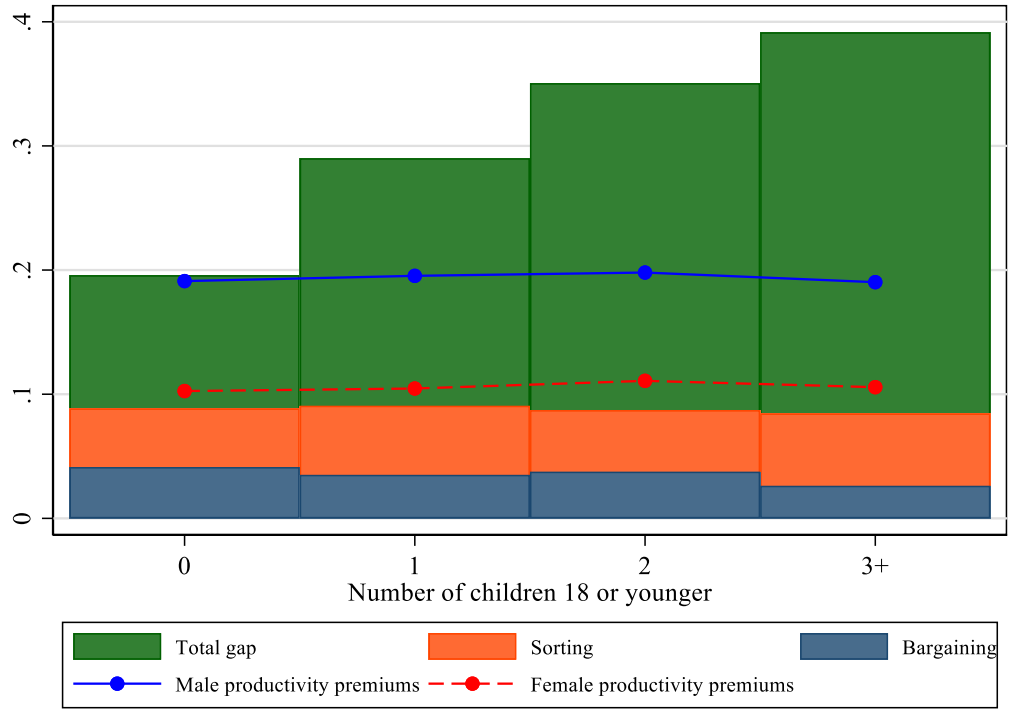

Figure 8. The unconditional gender gap (total gap) and the role of firm productivity premiums in it (bargaining + sorting), number of children aged 18 or younger in household
Source: Authors' calculations from the Registry of the Tax and Customs Board and the Business Registry.

The first explanation for the limited role of firm-level productivity premiums could arise from our data. We cannot observe the working hours and this could lead to the situation whereby the relative decline in the working hours of women after parenthood is picked up by the unconditional gender gap but not by the firm-level productivity premiums in our data. We do exclude cases where we suspect that the person is not working full time; for example, excluding wages below the minimum wage. However, there is prior evidence from Denmark that having children decreases the income of women by 20%, of which labour market participation, working hours and wages each explain around an equal part (Kleven et al. 2019). Given our data about the wages of labour market participants, we could expect that up to half of the increase in the unconditional gender wage gap is related to the reduction of working hours by women. However, this is clearly an upper limit of this estimate, as we exclude part-time observations using indirect filters and in general, part-time work is not common in Estonia (see Section 2.2). There is also evidence that 30% of the gap in working hours between men and women can be explained by women working for low working hour firms (Gallen et al. 2019), which could show up in more active sorting by women to low-wage firms around the time of childbirth in our data. However, we observe only a very small increase in the sorting effect for workers with young children. Thus, we would argue that this first potential explanation does not fully account for our results.

The second explanation for such a regularity is that factors other than firm-level fixed factors are responsible for the potentially large child penalty on wages in Estonia. One explanation could be the occupational sorting or within occupation enlargement of the gender wage gap. There is ample evidence that in many occupations the relationship between the hourly wage and working hours is non-linear; that is, working for extra or non-regular hours is rewarded at a disproportionally high rate (Goldin 2014). Goldin (2014) shows based on the example of lawyers and MBA graduates how women in these occupations with a non-linear relationship between their wage and working hours work less hours, earn disproportionally less than men and that this is mostly related to child-rearing. In other occupations, such as in the US in the case of pharmacy employees, such non-linear effects do not exist, resulting in a much lower gender wage gap and motherhood penalty in wages (Goldin 2014). Therefore, there may be occupation specific fixed effects rather than firm-specific fixed effects that matter in the context of explaining the motherhood penalty on wages.

The third explanation lies in the institutional setting. The labour market is not heavily regulated in Estonia and competitive forces have a much larger role in wage setting than in countries with similar studies. For example, the minimum wages are relatively low, there is almost no union power and the employment protection legislation allows companies to fire workers with low employment termination costs. At the same time, the job market is small with low regional mobility for workers (see e.g. Meriküll 2011 for calculations), which can raise the monopsonic power of employers. Firms can apply taste-based discrimination in such an environment and pay women lower wages than under perfect competition.

In sum, we observe that people with the youngest child under the age of six have as much as 15 log points greater unconditional wage gap than people without children, while this enlargement of the gender gap in wages is not related to firm-level productivity premiums. Even taking into account the possible shortcomings of our data, the majority of the child penalty in Estonia is likely related to factors other than firm-level productivity premiums.

4. Conclusions

The aim of this paper is to estimate the role of firm-level factors in the gender wage gap. We use the methodology of Card et al. (2016) and disentangle the sorting effect, due to men sorting into high-wage firms and women into low-wage firms, and the bargaining effect of women earning lower wage premiums than men within the same firm. We use the whole population of linked employers-employees from Estonia from 2006–2017. We extend the knowledge about the role of firm-level factors in the gender wage gap in an environment of very high gender inequality in wages. The labour market of our sample country, Estonia, is characterised by a very high gender wage gap, wide distribution of wages, low minimum wages, and low union density and collective bargaining. We ask, first, whether the firm-level factors can explain the larger and more persistent gender wage gap among top wage earners and among more skilled workers. Second, we ask whether the effect of firm-level productivity premiums in the gender wage gap are activated by parenthood.

Our results show that firm-level productivity premiums, due to women sorting less to high-productivity firms (sorting effect) and due to women receiving lower wages within the same firm (bargaining effect), can explain as much as 35% of the gender wage gap, which is the largest proportion found in similar studies using the approach from Card et al. (2016). This large proportion originates especially from the larger role of bargaining than in other countries. The bargaining effect (within-firm effect) explains around half of the gender gap in firm-level premiums. We argue that this finding can be related to the lenient labour market institutions in our sample country and to women being less effective wage negotiators. The remaining contribution of firm-level productivity premiums to the aggregate gender wage gap is due to women sorting less to high-productivity firms, a common finding also in several other papers.

We further find that firm-level factors have a potentially important role in explaining the wider and persistent gender wage gap at the top of the wage distribution. The role of firm-level factors has increased over time and firm-level factors explain 50% of the gender wage gap among the top 5% of wage earners. This finding fits well with two pieces of empirical evidence from the related literature: that the productivity dispersion between firms has increased over time (Andrews et al. 2016) and that the gender gap in wages has closed much more sluggishly at the top of the wage distribution. Lastly, we find that the motherhood penalty is as large in our sample country as in similar studies. However, we do not find that the motherhood penalty is related to mothers sorting to work for lower-wage and lower-performance firms, or being paid lower premiums within firms. Our findings suggest that the motherhood penalty is related to other factors than firm-specific fixed effects, such as potentially the amount of working hours or differences in educational and occupational tracks.

Our finding of a large within-firm gender wage gap (the bargaining effect) suggests the significant importance of policies that increase the transparency of wages in firms. For example, measures such as compulsory reporting and monitoring of gender disaggregated wage statistics by firms can be especially useful for lowering the gender pay gap in countries where the 'bargaining channel' makes up a significant proportion of the aggregate gender wage gap, such as in Estonia. Such compulsory reporting of wages has been, for example, introduced in Denmark in 2006. That reform resulted in a lower gender wage gap, in particular due to the post-regulation lower wage growth of male employees compared to women (Bennedsen et al. 2018). Similarly, the introduction of a compulsory requirement for firms to monitor the wage gap has been found to lower the gender wage gap in Switzerland (Vaccaro 2017).

One measure that could in theory affect both the selection of women to high-productivity firms and the within-firm gender wage gap could be increasing the share of female managers by imposing the requirements for gender quotas on boards of firms. However, Bertrand et al. (2019) found that the requirement in Norway to have at least 40% of women on the boards of public limited liability companies did not have any wider reducing effect on the within-firm wage gap. For Italy, Casarico and Lattenzio (2019) found that the step-wise increase of women on the boards of public and state owned enterprises since 2011 has led to more hiring of highly qualified women and sharing the productivity premiums with them, while there was no effect on the wages of the previously hired employees. In the case of the same reform, Maida and Weber (2019) found, similar to Norway, that the resulting higher representation of women on corporate boards did not spill over to the higher representation of women in other top positions. This evidence shows that the results of measures to reduce the gender pay gap at firm level have been mixed and one measure alone is not likely to solve all the issues related to the firm-level gender pay gap.

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Appendix 1. Sample before and after outlier treatment and comparison to official wage statistics

			Our data		Statistics Estonia	
	Year	No of obs.	Mean gross wage	Mean men / mean women	Mean gross wage	Mean men / mean women
Raw sample	2006	537593	501	1.414	601	
Raw sample	2007	560745	594	1.446	725	
Raw sample	2008	567549	705	1.405	825	
Raw sample	2009	531373	756	1.359	784	
Raw sample	2010	468420	708	1.333	792	
Raw sample	2011	470524	725	1.340	839	1.297
Raw sample	2012	494151	777	1.359	887	1.327
Raw sample	2013	502940	816	1.359	949	1.330
Raw sample	2014	507441	872	1.329	1005	1.307
Raw sample	2015	516717	934	1.319	1065	1.285
Raw sample	2016	513734	992	1.295	1146	1.263
Raw sample	2017	518715	1055	1.288	1221	1.264
Final sample after eliminating outliers	2006	444757	570	1.312	601	
Final sample after eliminating outliers	2007	446544	688	1.319	725	
Final sample after eliminating outliers	2008	463005	805	1.297	825	
Final sample after eliminating outliers	2009	461069	827	1.280	784	
Final sample after eliminating outliers	2010	406688	781	1.272	792	
Final sample after eliminating outliers	2011	409433	796	1.275	839	1.297
Final sample after eliminating outliers	2012	411841	874	1.300	887	1.327
Final sample after eliminating outliers	2013	407970	933	1.290	949	1.330
Final sample after eliminating outliers	2014	411104	1001	1.268	1005	1.307
Final sample after eliminating outliers	2015	414541	1073	1.256	1065	1.285
Final sample after eliminating outliers	2016	407944	1144	1.243	1146	1.263
Final sample after eliminating outliers	2017	410348	1214	1.229	1221	1.264

Source: Authors' calculations from the Registry of the Tax and Customs Board, the Business Registry and Statistics Estonia series PA001 and PA5335.

Appendix 2. Log real wages of co-workers of job switchers two years before and one year after the switch, men and women

Gender	No of obs.	Quartiles of co-workers	Percent–age of mobility between wage quartiles	Log real wage (-2)	Log real wage (-1)	Log real wage	Log real wage (+1)	Wage change before mobility	3 year wage change (%)
Men	4444	1 to 1	33.52	5.371	5.319	5.561	5.513	-0.052	0.142
Men	3273	1 to 2	24.69	5.388	5.366	5.850	5.820	-0.021	0.432
Men	3045	1 to 3	22.97	5.403	5.351	6.056	6.042	-0.052	0.639
Men	2497	1 to 4	18.83	5.473	5.362	6.340	6.324	-0.110	0.851
Men	2555	2 to 1	16.32	5.672	5.717	5.675	5.627	0.045	-0.045
Men	4941	2 to 2	31.55	5.759	5.808	5.921	5.904	0.049	0.145
Men	4682	2 to 3	29.9	5.835	5.846	6.115	6.096	0.010	0.261
Men	3481	2 to 4	22.23	5.854	5.892	6.375	6.362	0.038	0.508
Men	1815	3 to 1	7.66	5.951	6.007	5.717	5.694	0.055	-0.257
Men	3911	3 to 2	16.51	5.968	6.015	6.004	5.970	0.046	0.001
Men	10116	3 to 3	42.71	6.091	6.130	6.192	6.178	0.038	0.086
Men	7843	3 to 4	33.11	6.127	6.197	6.400	6.404	0.069	0.276
Men	1295	4 to 1	4.2	6.255	6.356	5.786	5.746	0.100	-0.510
Men	2094	4 to 2	6.8	6.220	6.301	6.112	6.097	0.081	-0.123
Men	7358	4 to 3	23.88	6.320	6.431	6.355	6.326	0.111	0.006
Men	20065	4 to 4	65.12	6.485	6.587	6.655	6.657	0.101	0.172
Women	7645	1 to 1	35.44	5.259	5.285	5.541	5.489	0.026	0.230
Women	7945	1 to 2	36.83	5.315	5.335	5.724	5.705	0.020	0.391
Women	3934	1 to 3	18.24	5.271	5.288	5.872	5.858	0.017	0.587
Women	2049	1 to 4	9.5	5.312	5.368	6.073	6.111	0.056	0.799
Women	4059	2 to 1	16.01	5.542	5.597	5.644	5.633	0.055	0.092
Women	10821	2 to 2	42.68	5.639	5.693	5.818	5.819	0.054	0.180
Women	7330	2 to 3	28.91	5.666	5.714	5.940	5.946	0.048	0.280
Women	3144	2 to 4	12.4	5.718	5.795	6.162	6.207	0.076	0.488
Women	1712	3 to 1	8.16	5.681	5.747	5.686	5.668	0.066	-0.013
Women	5844	3 to 2	27.86	5.793	5.845	5.881	5.878	0.051	0.085
Women	7618	3 to 3	36.32	5.895	5.976	6.088	6.067	0.082	0.172
Women	5803	3 to 4	27.66	5.961	6.052	6.245	6.276	0.091	0.315
Women	827	4 to 1	4.34	5.912	5.989	5.794	5.764	0.077	-0.148
Women	1736	4 to 2	9.12	5.959	6.033	6.003	6.005	0.075	0.046
Women	4720	4 to 3	24.8	6.086	6.196	6.189	6.176	0.110	0.090
Women	11753	4 to 4	61.74	6.309	6.406	6.481	6.500	0.097	0.191

Source: Authors' calculations from Registry of Tax and Customs Board and Business Registry.

Appendix 3. The unconditional gender wage gap in original and final sample

Dependent: log real wages	Original sample	After trimming outliers	Dual-connected set	Dual-connected set with value added per employee
Men (base=women)	0.250***	0.206***	0.234***	0.243***
	(0.0007)	(0.0005)	(0.0005)	(0.0007)
No of person-years	6 189 902	5 095 244	4 550 520	2 546 593
No of firms (around)	50 000	50 000	26 000	15 000

Notes: The table reports results of the simple regression where the dependent variable is log wages and the only explanatory variable is male dummy.
Source: Authors' calculations from Registry of Tax and Customs Board and Business.

Appendix 4. The gender wage gap over the sample years

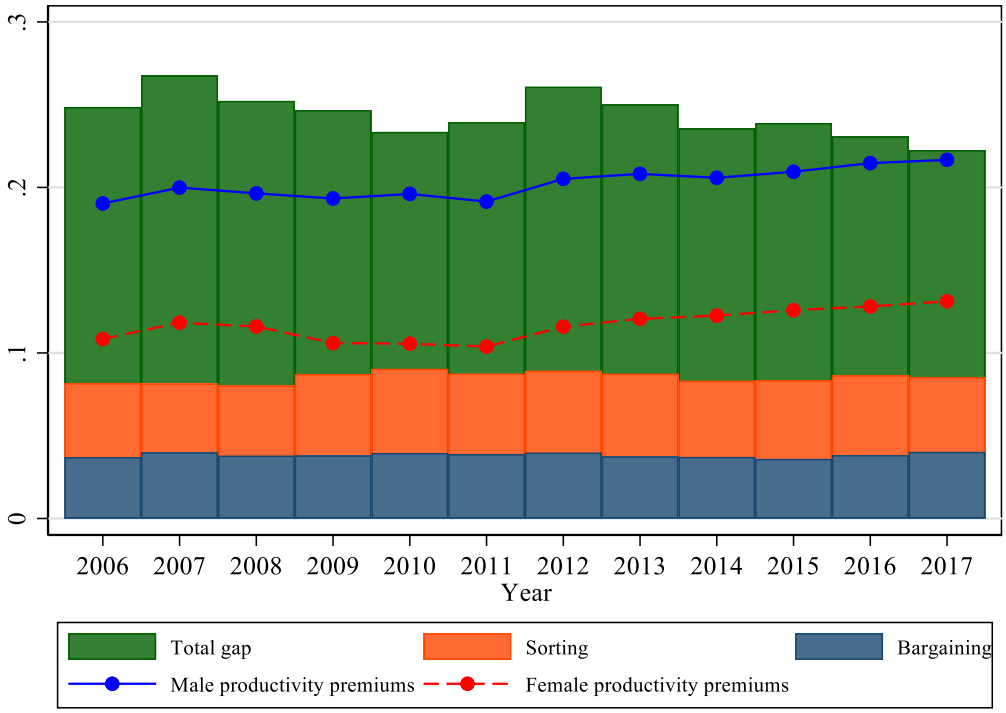

Figure 1. The unconditional gender gap (Total gap) and the role of firm productivity premiums in it (Bargaining + Sorting), 2006–2017

Source: Authors' calculations from the Registry of the Tax and Customs Board and the Business Registry.