Wage inequality: College premium, economic geography, and private-public sector*

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Abstract

College and postgraduate wage premiums to high school education are heterogeneous with respect to city size and sector of employment. We take advantage of the literature on the geographical variation in the return to higher education and introduce the role of the public sector for wage inequality. Selection is the main methodological challenge and identification is based on movers between regions and shifters between private and public sectors. We apply rich register data for Norway with information about individual education, location, and sector of employment. For private sector workers, we find that college and postgraduate premiums are higher in cities, consistent with higher return to education related to agglomeration effects. The conventional understanding is that the public sector has relative wage compression, which we confirm based on aggregate data. However, the average effect hides geographical differences. In cities, college and postgraduate wage premiums are higher in the private than the public sector, consistent with relative wage compression in the public sector. In the rest of the country, however, the wage gaps are relatively higher in the public sector. Our findings imply that the public sector reduces urban wage inequality, but contributes to higher inequality outside cities.

Keywords: Wage inequality, college wage premium, urban inequality, private-public divide

JEL codes: J31, J45, R23

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1. Introduction

The rising skill premium is shown to be an important source of growing wage inequality. The main empirical evidence is provided by a large literature estimating the college to high school wage premium (see overviews by Acemoglu and Autor, 2011, and Autor, 2014). Recent studies have moved the attention to the rising postgraduate wage premium, taking into account the rising share of students at the master and PhD levels (see overview by Lindley and Machin, 2016). Skill demand driven by technological progress is identified as an important background factor. Regional within-country variation in wage inequality is expected since industrial structure and participation in the education system differ across regions and geographical mobility is constrained. Lindey and Machin (2014) show higher increases in relative demand in more technologically advanced US states.

We concentrate on the heterogeneity of this wage inequality related to urbanization and private-public sector divide. A city-size inequality premium is shown by Baum-Snow and Pavan (2013), Glaeser et al. (2009), and Moretti (2013), and is further studied by Baum-Snow et al. (2018). We investigate the role of urbanization for the college and postgraduate wage premiums. Higher relative wages for college and postgraduate educated in cities are consistent with agglomeration economies. Carlsen et al. (2016) find a higher return to education for high educated in cities, which links agglomeration effects to the level of education.

Another aspect of the variation in wage inequality is the different wage structures in the private and public sectors. The private-public wage gap varies with both private market wage setting and government wage policies. The broad understanding summarized by Dickson et al. (2014) is that the public sector has relative wage compression. Rattsø and Stokke (2019) find that high-educated workers have significant gains from shifting from public to private employment. In the present paper, we show that the role of the public sector for wage inequality varies by geography. City labor markets are different from labor markets in the periphery. The combined geographical and private-public dimensions affect overall wage inequality.

To estimate the college and postgraduate wage premiums, we use register data for Norway during 2001–2010. To capture the geographical dimension of wage inequality we separate between the larger Oslo area, other city regions with more than 65,000 inhabitants, and the rest of the country. The main methodological challenge is selection linked to unobservable characteristics of the individuals. In our context, we are in particular concerned with geographical selection and selection into the private or the public sector. The rich register data allows us to control for selection by including worker fixed effects with identification based on movers between regions and shifters between private and public sectors. A significant number of workers move geographically and shift sectors to allow for estimates of geographical and sectoral effects.

For private sector workers, we find that college and postgraduate premiums are higher in cities, consistent with higher return to education related to agglomeration effects. In the public sector, the college and postgraduate wage premiums are higher in the periphery. The conventional understanding is that the public sector has relative wage compression, which we confirm based on aggregate data. However, the average effect hides geographical differences. In cities, college and postgraduate wage premiums are higher in the private than the public sector, consistent with relative wage compression in the public sector. In the rest of the country, however, the wage gaps are relatively higher in the public sector. The public sector reduces urban wage inequality, while it adds to wage inequality in the periphery. This brings new evidence to the debate about regional differentiation of public sector wages.

Section 2 presents the data and the econometric approach. The geographical variation in college and postgraduate premiums in the private sector is investigated in section 3. Section 4 studies the role of the public sector for wage inequality, both aggregate and across regions. Section 5 offers short concluding remarks.

2. Econometric approach and data

To estimate the college and postgraduate wage premiums, we use register data on hourly wages and worker characteristics from 2001 to 2010. The dataset is computed from three

administrative registers: employment, tax, and education. The employment register links workers and firms and gives information on work contracts for all employees. It includes the length of the contract, the type of contract[1], and the exact number of hours worked per week. We calculate the number of hours worked per year, which is combined with data on annual wage income from the tax register to give a measure of hourly wages for all employees. The education register covers the entire adult population and gives detailed information about workers' level and field of education. We also have information on the age, gender, immigrant status, industry affiliation, firm affiliation, and home region of all individuals.

We concentrate on native, male full-time workers aged 25–55, holding at least a high school degree.[2] The dataset includes 2,899,763 observations and 462,599 different workers. The workers are allocated to 56 industries, 89 labor market regions, and approximately 125,000 firms. We define three levels of education: high school degree, some college education (1–4 years of duration), and postgraduate degree. The analysis estimates college and postgraduate wage premiums relative to high school education. To capture the geographical dimension of the wage gaps, we separate between three region types: the larger Oslo area (consisting of 11 of the 89 labor market regions)[3], other cities with at least 65,000 inhabitants in 2010 (totaling 15 regions), and the rest of the country (63 regions). The public sector consists of the three industries public administration, health care, and education, while the remaining 53 industries constitute the private sector.

[1] The employment register separates between three contract types: full-time contracts with at least 30 hours of work per week, part-time contracts with 20–29 hours of work per week, and part-time contracts with fewer than 20 hours of work per week.

[2] We exclude workers in the primary industries (agriculture, fishing, and forestry), as well as workers without a high school degree. This gives a dataset of approximately 4,150,000 worker-year observations. The tax register gives information on total annual earnings, rather than separate earnings for each work contract. Workers with more than two contracts during a year, as well as workers with one full-time and one part-time contract, are excluded. For workers with two full-time contracts, we allow for a maximum of three months of overlap between the contracts. We also exclude workers whose contract length is less than three months during a year. These restrictions reduce the dataset by about 410,000 observations. Missing data on hours worked, annual earnings, level/field of education, or industry affiliation, together with exclusion of workers that change education level after entering the labor market as full-time employees, further excludes approximately 780,000 observations. To avoid extreme observations, we exclude the top and bottom 1% of the wage distribution. This leaves a dataset of about 2.9 million observations.

[3] We apply the same definition of the larger Oslo area as in Bhuller (2009).

Appendix Table 1 reports the observable characteristics of the workers, both aggregate and separately for the private and the public sector. Overall, the high school educated account for 53% of the observations, while the college educated and postgraduates represent 32% and 15%, respectively, of the dataset. These employment shares are consistent with US data applied by Lindley and Machin (2016). As seen from panels B and C of Appendix Table 1, the public sector employs a larger share of workers with college or postgraduate education compared to the private sector. The geographical allocation of workers is similar across the two sectors with about 30% in Oslo, 43% in other cities, and 27% in the rest of the country. The share of workers located in Oslo increases with the level of education, from 24% among the high school educated to 44% among postgraduates. The share of workers in other cities is similar across education groups, while the share of workers located outside Oslo and other cities decreases with the level of education. Overall, 34% of workers are employed in the industrial sector (dominated by manufacturing), 21% in the public sector, and 45% in services. Among the college and postgraduate educated, the public sector share is higher (around 1/3), while high school educated workers are overrepresented in the industrial sector.

Table 1 presents the raw college and postgraduate wage premiums for different groups of workers dependent on region type and level of education, separately for the private and the public sector. For private sector workers, the raw college and postgraduate wage premiums relative to high school education are higher in cities than in the rest of the country (25% in Oslo compared to 18% outside cities). In the public sector, there is less geographical heterogeneity in the raw wage gaps. Our understanding is that agglomeration effects are important in the private sector, consistent with Carlsen et al. (2016) and other studies. The conventional understanding of relative wage compression in the public sector is present in the raw data, both aggregate and within the three region types. The aggregate college wage premium is 23% and 9% in the private and the public sector, respectively. Similar, the raw postgraduate wage premium is 36% in the private sector compared to 29% in the public sector.

Table 1 about here

The main methodological challenge is selection linked to observable and unobservable characteristics of the individuals. In our context, we are in particular concerned with

geographic selection and differences between private and public sectors. The rich register data allows us to control for selection by including worker fixed effects with identification based on movers between regions and shifters between private and public sectors.

To compare with the existing literature, we start by estimating the aggregate college and postgraduate wage premiums for private sector workers. We run a hedonic regression of individual hourly wages for the period 2001–2010 that controls for observable worker characteristics (age, home region, industry affiliation):

$$\ln w_{it} = \sum_{j=1}^{2} \alpha_j \cdot edu_{j,i} + \gamma_t + \lambda_a + \mu_r + \eta_s + \varepsilon_{it} \quad (1)$$

where w_{it} is the hourly wage income for worker *i* in year *t*, $edu_{1,i}$ is a dummy that equals one if the worker has some college education (1–4 years of duration), and $edu_{2,i}$ is a dummy that equals one if the worker has a postgraduate degree. The reference category is workers with a high school degree as their highest level of education. Year, age group, regional, and industry fixed effects are represented by γ_t, λ_a, μ_r, and η_s, respectively. The estimated college and postgraduate wage premiums (relative to high school) are given by the coefficients α_1 and α_2, respectively. The error term is given by ε_{it}.

First, we extend the specification in (1) to allow for geographical heterogeneity in college and postgraduate wage premiums:

$$\ln w_{it} = \sum_{j=1}^{2} \alpha_j \cdot edu_{j,i} + \sum_{j=1}^{2}\sum_{k=1}^{2} \beta_{jk} \cdot edu_{j,i} \cdot city_{k,it} + \sum_{k=1}^{2} \mu_k \cdot city_{k,it} + \gamma_t + \lambda_a + \eta_s + \varepsilon_{it} \quad (2)$$

where $city_{1,it}$ and $city_{2,it}$ are dummy variables that equal one if the worker is located in the larger Oslo area and in other cities, respectively. The rest of the country act as the reference category. The college wage premium is given by $\alpha_1 + \beta_{11}$ in Oslo, $\alpha_1 + \beta_{12}$ in other cities, and α_1 in the rest of the country. If $\beta_{11} \neq 0$ and/or $\beta_{12} \neq 0$, the college wage premium has a regional dimension. Similarly, $\beta_{21} \neq 0$ and/or $\beta_{22} \neq 0$, imply that the postgraduate wage

premium differs across region types. To handle potential selection bias into cities, we extend the specification in (2) to include worker fixed effects. In our dataset, workers do not change their level of education after entering the labor market as full-time employees. This implies that the regression with worker fixed effects can only estimate the interaction terms between education group and region type, and the identification is based on workers moving between region types during the period of study. By comparing the estimated coefficients for the interaction terms with and without worker fixed effects, we can shed some light on the degree of selection bias into Oslo and other cities for different education groups.

Second, the specification in (1) is extended to capture potential differences in college and postgraduate wage premiums between the private and the public sector:

$$\ln w_{it} = \sum_{j=1}^{2}((\alpha_j + \delta_j pub_{it}) \cdot edu_{j,i}) + \delta \cdot pub_{it} + \gamma_t + \lambda_a + \mu_r + \eta_s + \varepsilon_{it} \quad (3)$$

where pub_{it} is a dummy that equals one if worker *i* is employed in the public sector in year *t*. The college and postgraduate premiums in the private sector are given by α_1 and α_2, respectively, while the coefficients on the interaction terms (δ_1 and δ_2) reflect the additional premium offered in the public sector. Given relative wage compression in the public sector, we expect public wage premiums to be lower, $\delta_1 < 0$ and $\delta_2 < 0$. Due to potential selection bias into the private sector, we also run the regression with worker fixed effects, where the interaction term effects are identified based on shifters between the private and the public sector.

Third, we combine the regional aspect of the college and postgraduate wage gaps with the private-public divide:

$$\ln w_{it} = \sum_{j=1}^{2}((\alpha_j + \delta_j pub_{it}) \cdot edu_{j,i}) + \sum_{j=1}^{2}\sum_{k=1}^{2}((\beta_{jk} + \delta_{jk} \cdot pub_{it}) \cdot edu_{j,i} \cdot city_{k,it})$$
$$+ \sum_{k=1}^{2}\mu_k \cdot city_{k,it} + \delta \cdot pub_{it} + \gamma_t + \lambda_a + \eta_s + \varepsilon_{it} \quad (4)$$

With this specification, we can estimate the college and postgraduate wage premiums across the three region types, while allowing for separate effects in the private and the public sector. Further, we can test for relative wage compression in the public sector at the regional level. We also run the specification with worker fixed effects, where interaction terms are identified based on movers between regions and shifters between sectors.

3. Geography of private sector college and postgraduate wage premiums

The canonical model to understand geographical differences in wage inequality is based on differences in relative supply and demand for different skills, here defined by different education levels. This is true in particular when we study regional differences in a country where wage institutions and technological knowledge are nation-wide. Relative supply represents design of and participation in the education system and relative demand reflects industrial structure and background resources. The geographical mobility of individuals is a serious challenge to identification of the geographical variation of wage premiums, to be discussed below.

We start by estimating the aggregate college and postgraduate wage premiums relative to high school education, given in column (1) of Table 2. The regression is based on 2.3 million observations of private sector workers, and controls for observable worker characteristics (age, home region, industry affiliation), as described by equation (1) in Section 2. The overall college and postgraduate wage premiums equals 17.3% and 27%, respectively. Compared to other industrial countries, the premiums are low and reflect the wage equalization achieved in Scandinavian type labor markets. The estimated wage gaps are consistent with previous studies of skill premiums in Norway (Eika, 2010). Further analyses of returns by field of study and over the life cycle, are offered by Kirkebøen et al. (2016) and Bhuller et al. (2017).

Our main interest is the geographical variation of wage inequality. The OLS model in column (2) follows the specification in equation (2) in section 2, and shows that the college wage premium is 6.8 percentage points higher in the larger Oslo area and 2.3 percentage points higher in other cities relative to the rest of the country. Interestingly, the geographical variation in the postgraduate to high school premium is smaller: 3 percentage points higher

than the rest of the country in the larger Oslo area and 1.5 percentage points higher in other cities. We control for selection based on unobservables by introducing worker fixed effects in column (3). Estimates with inference based on movers between the larger Oslo area, other cities, and the rest of the country reduce the importance of geography for the college educated. The additional college wage premium in Oslo now equals 3.2 percentage points (down from 6.8 percentage points). The reduction in the college premium reflects stronger positive selection into cities for college-educated workers compared to workers with a high school degree. The postgraduate estimates for Oslo and other cities are not much affected by the introduction of worker fixed effects, implying that the positive selection of workers into cities is similar for the high school educated and postgraduates. The college and postgraduate premiums in the larger Oslo area and other cities are similar when selection is accounted for. Looking at the background variation in wage levels, we conclude that college and postgraduate educated face significant differences in wages dependent on the degree of urbanization.

Table 2 about here

To further investigate the selection of workers into cities based on unobserved abilities, we compare worker fixed effects distributions across geographical locations for all education groups. The fixed effect of each worker is related to the region where the worker lived in 2010 or the last year available in the dataset. We compare distributions of unobserved abilities between workers in the larger Oslo area and workers outside cities using the methodology developed by Combes et al. (2012). The distribution of worker fixed effects in the larger Oslo area is approximated by taking the distribution of worker fixed effects for workers outside cities, shifting it by an amount *A*, and dilating it by a factor *D*. Table 3 reports estimated values of shift and dilation for the three education groups. Consistent with the findings in Table 2, the shift parameter is highest for college-educated workers, where the distribution of worker fixed effects in the larger Oslo area is 7.5% to the right of the worker fixed effects distribution for workers outside cities. For high-school educated workers and postgraduates, the shift parameter equals about 3.5%, and is not significantly different from zero at the 5% level. The stronger positive selection into cities for the college educated is confirmed.

Table 3 about here

To sum up, the private sector college and postgraduate wage premiums increase with city size, even after controlling for selection based on both observables and unobservables. The results are in accordance with studies of agglomeration effects, where high-educated workers are shown to have larger urban wage premium and higher return to experience in cities compared to the low educated (see Baum-Snow and Pavan, 2012, Wang 2016, and Carlsen et al., 2016).

4. The role of private-public sector divide for wage inequality

Private and public sectors have different wage systems and private/public wage gaps are investigated in a large literature. Both private and public wage institutions vary between countries, and the sectoral wage gaps vary across countries. The main stylized fact summarized by Dickson et al. (2014) is that the public sector has relative wage compression. Public sector wage policy is oriented towards raising the lower wages and capping the top. Lower wages for the high educated is often observed. In a model of compensating differentials, the wage differences are understood as a reflection of other aspects of the employment conditions, notably job risk and pension systems.

We start by estimating the aggregate college and postgraduate wage premiums while allowing for separate effects in the private and the public sector, as described by equation (3) in section 2. The estimation is based on about 2.9 million observations of private and public sector workers during 2001–2010, and the results are given in Table 4. As expected, the relative compression of public sector wages implies a lower college wage premium in the public sector. As seen from column (1), the public college wage premium is 10.1%, compared to 17.5% in the private sector. Interestingly, the postgraduate to high school wage premium is similar in private and public sectors, about 28%. It follows that the postgraduate to college wage premium is higher in the public than the private sector, reflecting relatively low public wages for college-educated workers. The overall wage inequality consequently depends on the composition of the labor force with respect to private versus public sectors.

In the worker fixed effect model in column (2), the inference is based on shifters between private and public sectors taking into account selection based ability. In this case, the college wage premium is the same in the two sectors. Controlling for selection, the difference in college wage premium between private and public sector disappears. The result can be understood as stronger positive selection of the college educated compared to the high school educated into the private sector. The postgraduate to high school premium is lower in the public sector. The positive selection into private sector is stronger for the high school educated than for postgraduates. It follows that we reach a ranking of the degree of selection where college educated are most affected while postgraduates least affected, with the high school educated in between. Our understanding is that many postgraduate subjects are oriented towards the public sector and with more limited labor market in the private sector. The ranking of education groups with respect to the degree of selection into the private sector is confirmed by comparing worker fixed effects distributions for private and public sector workers across education groups. The fixed effect of each worker is related to the sector where the worker were employed in 2010 or the last year available in the dataset. The distribution of worker fixed effects in the private sector is approximated by taking the distribution of worker fixed effects for public sector workers, shifting it by an amount *A*, and dilating it by a factor *D*. Table 5 reports estimated values of shift and dilation for the three education groups. The shift parameter is 14% for college-educated workers, 3.5% for high school educated and 1.2% (and insignificant) for postgraduates.

Tables 4 and 5 about here

Finally, we allow college and postgraduate wage premiums to vary across both sectors and regions, as described by equation (4) in section 2. The results are documented in Table 6, where column (1) controls for observable worker characteristics and column (2) adds worker fixed effects to control for unobservable ability. The wage gaps following from the estimated coefficients in Table 6, as well as the implied degree of selection bias, are summed up in Table 7. Based on the aggregate data in Table 4, we confirmed the conventional understanding of relative wage compression in the public sector. However, as seen from Tables 6 and 7, the average effect hides geographical differences.

As seen from column (1) of Table 6, the lower aggregate college wage premium in the public sector is a city phenomenon. In Oslo, the college premium is 21.4% in the private sector compared to 8.3% in the public sector. In the rest of the country, the college premium is the same in the two sectors, about 13-14%. In the private sector, the college wage premium is higher in cities than in the rest of the country (as shown in Table 2). Within the public sector, the college wage premium is higher in the rest of the country compared to cities. The aggregate postgraduate to high school premium is the same in the private and public sector, about 28% (column 1, Table 4). This aggregate effect also hides geographical heterogeneity. In the larger Oslo area, the postgraduate premium is higher in the private sector than in the public sector (29.7% compared to 24.2%). The opposite is the situation in the rest of the country; the postgraduate premium is 31.5% in the public sector compared to 26.1% in the private sector. The variation in the postgraduate premium is similar to the college premium: in the private sector, it is higher in cities, while in the public sector, it is higher in the rest of the country.

Table 6 about here

Including worker fixed effects, we estimate the differences in wage premiums with identification based on movers between the three geographic regions and shifters between private and public sectors (column 2, Table 6). The results indicate positive selection to the private sector stronger for college educated than for high school educated, and this is true in all three geographic regions. The negative public sector effects without worker fixed effects in column (1) are reduced in size (for Oslo, from -12.1% to -2.5%). The aggregate similarity in college premium found in column 2 in Table 4 hides geographic differences. We still get the result that the college to high school premium is higher in the private sector in Oslo, but higher in the public sector in the rest of the country. Studying postgraduate selection, we find stronger positive selection for high school educated than for postgraduates. This aggregate result is true for all geographic regions, but is stronger in the rest of the country. In the aggregate, the postgraduate premium is 3.8 percentage points lower in the public compared to the private sector. The gain in premium in the private sector is highest in Oslo, but in the rest of the country, the postgraduate premium is higher in the public sector.

We conclude that selection matters in all geographic areas, but to different degrees. An overview is given in Table 7. In the private sector, college and postgraduate premiums increase with city size. Positive selection to cities is stronger for college than high school, but similar for high school and postgraduate. The college premium is similar for private and public sectors (taking into account selection), but postgraduate premium is higher in the private sector. Positive selection to private sector is strongest for college educated and weakest for postgraduates with high school educated in between. College and postgraduate premiums increase with city size in the private sector, but in the public sector, the premiums are largest in the rest of the country. The aggregate result hides geographic differences. In Oslo, college and postgraduate premiums are higher in the private than the public sector, consistent with relative wage compression in the public sector. In the rest of the country, however, the wage gaps are relatively higher in the public sector. Our findings imply that the public sector reduces urban wage inequality, but contributes to higher inequality outside cities.

Table 7 about here

5. Concluding remarks

The analysis studies the heterogeneity of wage inequality with respect to urbanization and private/public sectors. Wage inequality is measured by college and postgraduate to high school wage premiums. We find that both the college and postgraduate premiums are higher in cities for private sector workers. In the public sector, the college and postgraduate wage premiums are higher in the periphery. The aggregate results are consistent with relative wage compression in the public sector, but the average effect hides a distinct geographical pattern. The public sector reduces urban wage inequality, but contributes to higher inequality outside cities.

The result motivates further analysis of urban wage inequality combining the influence of labor markets and agglomeration effects. The background of the variation in agglomeration effects across education groups is not well known. The other area worth further study is the wage policy of governments. Our evidence shows larger college and postgraduate wage

premiums in the periphery in the public sector compared to the private sector. It is of interest to understand more of the handling of regional wage and price variation for different education groups within the public sector.

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Table 1. Raw wage gaps (college and postgraduate relative to high school educated)

	COLLEGE WAGE PREMIUM	POSTGRADUATE WAGE PREMIUM
Panel A: Private sector workers		
Aggregate	0.23	0.36
Oslo	0.25	0.34
Other cities	0.22	0.36
Rest of country	0.18	0.31
Panel B: Public sector workers		
Aggregate	0.09	0.29
Oslo	0.10	0.27
Other cities	0.09	0.30
Rest of country	0.08	0.27

Notes: The raw wage gaps are calculated as log differences between mean hourly wages (in 2010 NOK).

Table 2. College and postgraduate wage premiums in the private sector: heterogeneity across regions

	(1)	(2)	(3)
Dependent variable	Log hourly wage	Log hourly wage	Log hourly wage
College	0.173***	0.143***	
	(0.0013)	(0.0023)	
College x Oslo		0.068***	0.032***
		(0.0031)	(0.0058)
College x Other city		0.023***	0.012**
		(0.0028)	(0.005)
Postgraduate	0.27***	0.265***	
	(0.0017)	(0.0038)	
Postgraduate x Oslo		0.03***	0.032***
		(0.0044)	(0.0069)
Postgraduate x Other city		0.015***	0.011*
		(0.0043)	(0.0062)
Oslo		0.104***	0.057***
		(0.0016)	(0.0039)
Other city		0.04***	0.018***
		(0.0012)	(0.0031)
Age controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Regional fixed effects	Yes	No	No
Industry fixed effects	Yes	Yes	Yes
Worker fixed effects	No	No	Yes
Obs.	2,286,738	2,286,738	2,286,738
R^2	0.33	0.32	0.80

Notes: The regressions are based on yearly data for male private sector workers aged 25-55 during 2001-2010. We separate between three levels of education: high school degree (the reference category), some college education (1-4 years of duration), and postgraduate degree. The age controls are given as ten-year intervals. The regional fixed effects include 89 labor market regions and industry fixed effects consist of 54 industries. In columns (2) and (3), we separate between three region types: the larger Oslo area ('Oslo'), other cities with at least 65,000 inhabitants in 2010 ('Other city'), and the rest of the country (the reference category). In this case, we drop regional fixed effects from the regression. Column (3) includes worker fixed effects, and the identification is based on workers moving between the region types during the period of study. Robust standard errors (clustered by workers) are given in parenthesis. ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. All regressions include a constant term.

Table 3. Comparison of worker fixed effects distributions: Larger Oslo area vs. outside cities

	Shift $(\hat{A})$	Dilation $(\hat{D})$	R^2	Obs.
High school educated	0.033*	1.202***	0.918	126,720
	(0.0171)	(0.0305)		
College educated	0.075***	1.157***	0.942	59,132
	(0.0229)	(0.035)		
Postgraduates	0.037	1.065	0.795	26,283
	(0.0313)	(0.0615)		

Notes: The distribution of worker fixed effects for workers in the larger Oslo area is approximated by taking the distribution of worker fixed effects for workers outside cities, shifting it by an amount *A* and dilating it by a factor *D*. We estimate $\hat{A}$ and $\hat{D}$ separately for each education group. Bootstrapped standard errors are given in parenthesis (re-estimating worker fixed effects in 100 bootstrapped iterations based on 5% random samples with replacement). The methodology is developed and explained by Combes et al. (2012a). ***, ** and * indicate significance at the 1 percent, 5 percent and 10 percent level, respectively (significantly different from 0 for $\hat{A}$ and from 1 for $\hat{D}$).

Table 4. College and postgraduate wage premiums: public vs. private sector

	(1)	(2)
Dependent variable	Log hourly wage	Log hourly wage
College	0.175***	
	(0.0013)	
College x Public	-0.074***	0.006
	(0.0023)	(0.0039)
Postgraduate	0.276***	
	(0.0017)	
Postgraduate x Public	-0.003	-0.038***
	(0.003)	(0.0044)
Public	-0.144***	-0.068***
	(0.0024)	(0.0032)
Age controls	Yes	Yes
Year fixed effects	Yes	Yes
Regional fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Worker fixed effects	No	Yes
Obs.	2,899,763	2,899,763
R^2	0.31	0.79

Notes: The regressions are based on yearly data for male private and public sector workers aged 25-55 during 2001-2010. The regressions include industry fixed effects (industries within the private sector), and the coefficient on the 'Public' dummy alone (not in interaction terms) refers to wages in the public sector relative to the reference industry in the private sector ('wholesale trade'). Robust standard errors (clustered by workers) are given in parenthesis. ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. All regressions include a constant term.

Table 5. Comparison of worker fixed effects distributions: Private vs. public sector

	Shift ($\hat{A}$)	Dilation ($\hat{D}$)	R^2	Obs.
High school educated	0.035***	1.06**	0.794	246,968
	(0.0134)	(0.0298)		
College educated	0.14***	1.496***	0.964	147,801
	(0.0128)	(0.0317)		
Postgraduates	0.012	1.057*	0.379	67,830
	(0.0182)	(0.0294)		

Notes: The distribution of worker fixed effects for private sector workers is approximated by taking the distribution of worker fixed effects for public sector workers, shifting it by an amount *A* and dilating it by a factor *D*. We estimate $\hat{A}$ and $\hat{D}$ separately for each education group. Bootstrapped standard errors are given in parenthesis (re-estimating worker fixed effects in 100 bootstrapped iterations based on 5% random samples with replacement). The methodology is developed and explained by Combes et al. (2012a). *** and ** indicate significance at the 1 percent and 5 percent level, respectively (significantly different from 0 for $\hat{A}$ and from 1 for $\hat{D}$).

Table 6. Public-private sector divide and heterogeneity across regions

	(1)	(2)
Dependent variable	Log hourly wage	Log hourly wage
College	0.14***	
	(0.0023)	
College x Public	-0.01***	0.043***
	(0.0032)	(0.0049)
College x Oslo	0.074***	0.032***
	(0.0031)	(0.0053)
College x Oslo x Public	-0.121***	-0.068***
	(0.0036)	(0.0049)
College x Other city	0.028***	0.01**
	(0.0028)	(0.0046)
College x Other city x Public	-0.064***	-0.037***
	(0.0033)	(0.0045)
Postgraduate	0.261***	
	(0.0038)	
Postgraduate x Public	0.054***	0.019***
	(0.0057)	(0.0068)
Postgraduate x Oslo	0.036***	0.033***
	(0.0044)	(0.0063)
Postgraduate x Oslo x Public	-0.109***	-0.084***
	(0.0063)	(0.0067)
Postgraduate x Other city	0.02***	0.015***
	(0.0043)	(0.0057)
Postgraduate x Other city x Public	-0.04***	-0.048***
	(0.0063)	(0.0065)
Public	-0.143***	-0.068***
	(0.0024)	(0.0032)
Oslo	0.097***	0.053***
	(0.0015)	(0.0036)
Other city	0.035***	0.016***
	(0.0012)	(0.0029)
Age controls	Yes	Yes
Year fixed effects	Yes	Yes
Regional fixed effects	No	No
Industry fixed effects	Yes	Yes
Worker fixed effects	No	Yes
Obs.	2,899,763	2,899,763
R^2	0.30	0.79

Notes: The regressions are based on yearly data for male private and public sector workers aged 25-55 during 2001-2010. Robust standard errors (clustered by workers) are given in parenthesis. ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. All regressions include a constant term.

Table 7. Calculated wage gaps and degree of selection bias

	Estimated gaps without worker FEs		Additional premium in the public sector	
	Private	Public	No worker FEs	With worker FEs
Panel A: College-high school wage gap				
Aggregate	0.175	0.101	-0.074	0.006
Larger Oslo area	0.214	0.083	-0.131	-0.025
Other cities	0.168	0.094	-0.074	0.006
Rest of country	0.14	0.13	-0.01	0.043
Panel B: Postgraduate-high school wage gap				
Aggregate	0.276	0.273	-0.003	-0.038
Larger Oslo area	0.297	0.242	-0.055	-0.065
Other cities	0.281	0.295	0.014	-0.029
Rest of country	0.261	0.315	0.054	0.019

Notes: The first two columns present college and postgraduate wage premiums (relative to high school) in the private and the public sector based on regressions that do not correct for selection bias (without worker fixed effects). The wage gaps are calculated from estimated coefficients in column (1) of Table 4 (aggregate) and column (1) of Table 6 (regional effects). The two last columns show the additional wage premium offered in the public sector compared to the private sector, both aggregate and for the three region types. A negative value implies that the wage gap is higher in the private sector. The third column refers to the case without worker fixed effects and is calculated from the wage gaps in the two first columns. The fourth column shows the difference in wage gaps between the two sectors when selection bias is accounted for, and is calculated from estimated coefficients in column (2) of Table 4 (aggregate) and column (2) of Table 6 (regional effects).

Appendix Table 1. Descriptive statistics (mean values)

	ALL	HIGH SCHOOL	COLLEGE	POSTGRADUATE
Panel A: Workers in the private or the public sector				
Log hourly wage (in 2010 NOK)	5.54	5.44	5.60	5.75
Age	38.9	38.4	39.4	39.8
Sector of employment:				
Industry	0.342	0.475	0.193	0.19
Services	0.447	0.435	0.472	0.433
Public	0.211	0.09	0.335	0.377
Location:				
Oslo	0.307	0.241	0.354	0.441
Other large city	0.433	0.444	0.425	0.412
Rest of country	0.26	0.315	0.221	0.147
No. of observations	2,899,763	1,536,650	937,033	426,080
Share of observations		0.53	0.323	0.147
Panel B: Workers in the private sector				
Log hourly wage (in 2010 NOK)	5.55	5.45	5.68	5.81
Age	38.5	38.2	39.1	39.0
Sector of employment:				
Industry	0.434	0.522	0.29	0.305
Services	0.566	0.478	0.71	0.695
Location:				
Oslo	0.311	0.24	0.4	0.47
Other large city	0.435	0.446	0.42	0.409
Rest of country	0.254	0.314	0.18	0.121
No. of observations	2,286,738	1,398,467	622,680	265,591
Share of observations		0.612	0.272	0.116
Panel C: Workers in the public sector				
Log hourly wage (in 2010 NOK)	5.47	5.35	5.44	5.64
Age	40.6	40.9	40.1	41.3
Location:				
Oslo	0.294	0.25	0.263	0.393
Other large city	0.428	0.423	0.435	0.418
Rest of country	0.278	0.327	0.302	0.189
No. of observations	613,025	138,183	314,353	160,489
Share of observations		0.225	0.513	0.262

Appendix Table 2. College and postgraduate wage premiums in the private sector: Heterogeneity across cohorts

	(1)
Dependent variable	Log hourly wage
College	0.09***
	(0.0016)
College x Age 35-44	0.116***
	(0.002)
College x Age 45-55	0.14***
	(0.0026)
Postgraduate	0.151***
	(0.002)
Postgraduate x Age 35-44	0.155***
	(0.0025)
Postgraduate x Age 45-55	0.219***
	(0.0035)
Age 35-44	0.089***
	(0.001)
Age 45-55	0.115***
	(0.0013)
Year fixed effects	Yes
Regional fixed effects	Yes
Industry fixed effects	Yes
Obs.	2,286,738
R^2	0.34

Notes: The regressions are based on yearly data for male private sector workers aged 25-55 during 2001-2010. Regional fixed effects include 89 labor market regions and industry fixed effects consist of 54 industries. For the age dummies, the reference category is workers in their early career, aged 25-34. Robust standard errors (clustered by workers) are given in parenthesis. ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. All regressions include a constant term.