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Identification of the private-public wage gap☆

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ABSTRACT

We suggest an identification strategy for the private-public sector wage gap to correct for the bias resulting from the heterogeneity of unobservable characteristics between shifters and stayers. The analysis applies a fixed effect difference-in-difference model with event study design to estimate the wage gap. As the parallel wage trend assumption between shifters from the public to the private sector and public sector stayers is rejected, late shifters still in the public sector are used as counterfactual group for early shifters. The estimates are based on rich register data for high-educated workers in Norway 1993–2010. Using this novel identification method, we show that due to positive selection, the private-public wage gap is overestimated by about 20% in the standard model comparing shifters with stayers. In an extension of the analysis, we show that the overestimation is the same for male and female workers and is robust across business cycles, although the size of the wage gap is pro-cyclical.

1. Introduction

The public sector has wage setting institutions and policies that may lead to private-public wage gap. Background factors are public sector monopolistic power in important labor markets, strong public sector unions, and government wage policies oriented towards equalization. There are large differences in raw private-public wage gaps across countries dependent on how governments and labor markets work. Estimation of the size of the gap faces serious methodological challenges related to heterogeneity and selection. The understanding here is that public employees shifting to the private sector represent a treatment group. To estimate the treatment effect, the wage achieved in the private sector must be compared with the hypothetical wage obtained in the public sector, the counterfactual. The standard approach is to estimate the counterfactual based on the non-treated, that is, those staying in the public sector. We suggest a new identification strategy where shifters early in the period studied are compared with workers still in the public sector that shift later.

The literature on public sector wage gaps is old and comprehensive, as shown in overviews by Giordano et al. (2014) and Lausev (2014). Recent contributions by Bargain et al. (2018) and Hospido and Moral-Benito (2016) offer discussion of the best studies dealing with the selection problem. The availability of register data over time allows for individual level panel analysis correcting for selection based on observables and unobservables. The identification of the gap can be based on shifters between the private and the public sector in models with worker fixed effects. Campos and Centeno (2012) provide fixed effects estimates for ten European countries. An early analysis by Bargain and Melly (2008) applies panel data in quantile regressions studying the wage distribution. Rattsø and Stokke (2018) introduce the dynamic wage gap including different returns to experience in the two sectors. Schanzenbach (2015) adds variables representing ability of individuals as an alternative to worker fixed effects, notably an IQ-score. The worker fixed effect panel analyses handle selection based on time-constant unobservables, but selection issues remain. Alternative approaches include bound analysis introduced by Depalo (2017) and the estimation of a structural model as developed by Postel-Vinay and Turon (2007) and Dickson et al. (2014).

We use administrative data for Norway to estimate the private-public wage gap. The analysis covers high-educated workers (education beyond high school) and concentrates on the core part of the public sector, public administration, with fairly high mobility towards the private sector. The data are arranged for an event study where shift from public to private sector is the event. Sector shifts are observed during 1996–2007 and we construct separate samples for each of the twelve shift-years covering three years before the shift and up to five years after the shift. The

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analysis is based on the pooled samples, giving a panel from 1993 to 2010 of approximately 1.6 million observations. The same worker can be part of several shift-year samples, and the total number of shifters and stayers in the pooled data is about 223,000 of which about 8900 are shifters from the public to the private sector. Our starting point is the individual level panel model taking into account selection on observables and unobservables. We formulate a basic difference-in-difference (DID) model where shift to the private sector is the treatment and stayers in the public sector are the control group. Given the development of public sector wages, we study how a shift to the private sector affects the wage path. The specification includes each worker's wage three years before and up to five years after the shift-year. The analysis rejects the assumption of parallel wage trends between shifters and stayers pre-treatment and shows that this comparison is invalid as a causal effect.

We suggest an identification strategy based on the assumption that shifters to the private sector are similar. The counterfactual is established comparing shifters to the private sector early in the period (early shifters) with workers who are currently in the public sector, but who shift to the private sector later (late shifters). We are able to do this because we observe sector shifts over an extended period. The suggested strategy is related to the analysis of Borjas (2003) emphasizing workers entering the private sector relative to workers leaving the private sector. However, his interest is the effect of changes over time in wage compression in the public sector for wage differentials between 'entrants' and 'quitters'. In our dataset, the late shifters as control group satisfies the requirement of parallel wage trends between treated and controls pre-treatment. An alternative semiparametric method to handle non-parallel trends is suggested by Abadie (2005), but is not pursued here.

Given identification based on comparison of early versus late shifters, the estimated average private-public wage gap is about 10% (comparing three years before and five years after the shift-year). Separating out the effect for each year after the sector shift, we find that the private wage premium is increasing over time, reflecting higher return to experience in the private sector. The basic difference-in-difference model comparing shifters with stayers overestimates the private-public wage gap by 20% (corresponding to 2 percentage points). The overestimation bias represents a positive selection of shifters to the private sector compared to stayers in the public sector.

The robustness of the results is investigated in a detailed look at the shifters and alternative analyses with different sample selections. In particular, we test the differences in the distributions of worker fixed effects and find that distributions for shifters and stayers have significantly different mean, while the hypothesis of equal mean for the distributions of early and late shifters cannot be rejected. In an extension of the analysis, we study the role of business cycles. Business cycles are shown to influence the level of the wage gap, the private wage premium is procyclical, but the overestimation comparing shifters with stayers is about the same in booms and recessions. The overestimating bias also is the same for male and female workers. Identification based on early and late shifters as treatment and control groups, respectively, reduces the selection problem compared to the standard comparison of shifters and stayers. It remains to be seen whether the strategy deals with the heterogeneity of shifters and stayers in other datasets including low-educated workers not included here. All identification challenges are not solved with this method. Endogenous mobility and reverse causality are not addressed here. More detailed information about positions and promotions in the public sector can reduce possible omitted variable bias estimating the sector shifts.

The dataset and econometric model are described in Section 2. Section 3 presents the basic DID model comparing shifters and stayers. The identification strategy based on early/late shifters is developed and applied in Section 4. Section 5 discusses the role of business cycles. The estimates separating between female and male workers are presented in Section 6. Concluding remarks are given in Section 7.

2. Data and econometric model

In most modern states, public sector labor markets are an integrated part of the overall labor market. In Norway, there are common regulations for private and public labor markets based on the 'Act of working environment, employment and protection'. The law defines rights of workers, working hours, employment protection, etc. for all workers. More broadly, all workers have right to association, collective bargaining and strike. Wages are set by collective bargaining in the whole economy and separate wage contracts are established for central government and regional/local municipal government employees. Trade unions in the public sector cover large professions (teachers, nurses etc.) with own organizations, while other public employees are part of trade unions covering both private and public sectors. The 'Act of civil servants' for all public employees gives more employment protection than in the private market.

In practice, workers seek job opportunities in a common labor market including both private and public sectors and there is significant mobility between the two sectors. This is definitely true for public administration that we concentrate on in this study.[1] When public administration recruits workers, the pay (and other aspects of the job) must match private sector alternatives and the recruitment is based on merit. There is a national pay scale determined at the central government level, but public sector institutions have flexibility within this scale and can even have elements of performance-related pay. The public sector as employer also can use positions and promotions in the recruitment policy. The overall labor market conditions are important for the recruitment of workers and skills to the public sector. In most countries, governments are equality oriented in their wage policy and this may explain the relative compression of public sector wages found in many studies. Since public sector wage setting depends on institutions and policies, we do not expect a private-public wage gap similar across countries. The general interest of this paper is methodological – how the private-public wage gap can be estimated.

The selection problem in comparing wages between private and public sector workers is the heterogeneity of workers. We concentrate on a dataset for workers with higher education to limit the heterogeneity. As shown by Rattsø and Stokke (2018), the low educated are more heterogeneous and face a more varied labor market. The dataset represents the period 1993–2010, and is computed from three administrative registers: employment, education, and tax.[2] In addition to wages and education, we have information about the age, gender, immigrant status, industry affiliation, firm affiliation, and home region of all individuals. The dataset consists of workers in public administration ('public stayers') and workers that change from public administration to the private sector during the period ('shifters').

The handling of the data follows the event study of displaced workers in Norway by Huttunen et al. (2018). The estimated wage effect is based on the event that workers shift from the public to the private sector. Sector shifts are observed during the years 1996 to 2007, and we construct separate samples for each of the twelve shift-years. We concentrate on workers with strong attachment to the labor market, and require three consecutive years as full-time public sector worker before

[1] Most public employees are registered in education and health care subsectors, but these sub-sectors are left out here – partly they are dominated by professions with particular characteristics, and partly the data do not separate private from public employees.

[2] The employment register links workers and firms and gives information on work contracts for all employees. It includes the length of the contract, and separates between full-time and part-time contracts. This is used to calculate the number of days worked per year, which is combined with data on annual wage income from the tax register to give a measure of daily wages. The education register covers the whole adult population and gives information about the highest completed education level in the beginning of October each year.

Table 1
Descriptive statistics: Public-private shifters vs. public stayers (mean values).

	Public-private shifters	Public stayers
Age	38.2	43.9
Male	0.691	0.684
Immigrant	0.09	0.074
Postgraduate degree	0.44	0.365
Field of education		
Humanities and arts	0.063	0.073
Teacher training and pedagogy	0.039	0.061
Social sciences and law	0.218	0.207
Business and administration	0.192	0.19
Natural sciences	0.298	0.18
Health, welfare and sport	0.02	0.027
Primary industries	0.021	0.024
Transport, communications, and security	0.138	0.229
Big city resident	0.552	0.468
Small city resident	0.195	0.221
No. of workers	8911	214,065

Notes: We separate between two levels of higher education: postgraduate degree (more than four years) and some college education (1–4 years of duration). Three region types: big cities (more than 150,000 inhabitants in 2010) accounting for 7 out of 89 labor market regions, small cities (population in the range 65,000–150,000 in 2010, 13 regions), and the remaining 69 regions. The mean value of age refers to the shift-year, while the resident location is based on the year before the sector shift. Other variables are constant over time.

the shift-year, for both shifters and stayers.[3] Workers are followed for up to five years after the shift-year. We have an unbalanced panel, and all workers are not observed for the full five-year period. Public-private shifters remain in the sample as long as they are full-time private sector workers. From the moment they transition to part-time work, become unemployed, or shift back to the public sector, they are dropped from the sample. Similar, public sector stayers are dropped from the moment they become part-time workers or unemployed.[4] Workers included in the sample are between 25 and 60 years of age in the shift-year (to avoid complications related to education and pensions). The wage in the shift-year represents a mix of private and public sector wages. We therefore exclude the shift-year, and compare the three years before the sector shift to the five years after the shift. The analysis is based on the pooled samples, giving a panel from 1993 to 2010 of approximately 1.6 million observations. The same worker can be part of several shift-year samples, and the total number of shifters and stayers in the pooled data is about 223,000. Robustness of the selection of the sample is investigated in Section 4.

In total, we observe 8911 shifts from the public to the private sector during 1996–2007. We have checked the number of shifts between the public and the private sector within five years of the first shift and find that 88% of shifters change sector once, 11% have two sector shifts, and 1% have three shifts. Workers with two shifts are observed as long as they are in the private sector. Workers with three shifts can be part of a later shift-year sample when they shift to the private sector the second time.

[3] Full-time contracts imply at least 30 h per week. Since the tax register gives information about 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. Workers with two full-time contracts are excluded if the number of days worked that year exceeds 455. This means that we allow for a maximum of three months of overlap between the two contracts. We also leave out workers with fewer than 89 working days during a year. Finally, to avoid extreme observations, we exclude the top and bottom 1% of the wage distribution.

[4] Two years after the shift, 86% of shifters (compared to 95% of stayers) remain in the sample. After five years, 64% of shifters and 83% of stayers are still in the working sample. Since shifters face one extra reason to be excluded (shift back to the public sector) compared to stayers, it is not surprising that they have lower probability to remain in the sample. This strengthens our argument to focus on shifters in the estimation of the private-public wage gap, since shifters are more similar than shifters and stayers.

Table 1 compares shifters and stayers with respect to observable worker characteristics. Shifters are younger than stayers (38.2 years of age compared to 43.9 years, measured in the shift-year), and are more likely to live in a big city the year before the sector shift (defined as labor market regions with more than 150,000 inhabitants in 2010). We separate between two levels of higher education: postgraduate degree (more than four years) and some college education (1–4 years of duration). The share of workers with a postgraduate degree is 44% and 37% among shifters and stayers, respectively. When it comes to field of education, shifters are much more likely to have an education in natural sciences, while stayers are overrepresented in educations related to transport, communications, and security.

As a further description of shifters versus stayers, we estimate the effect of worker characteristics on the probability of being a public-private shifter, documented in Table A1. The dependent variable is a dummy that equals one if the worker shifts from the public to the private sector during 1996–2007. Worker characteristics include age, gender, immigrant status, level and field of education, and resident location. The regression includes shift-year fixed effects. The findings supplement the descriptive statistics in Table 1. The impact of age on shifter probability is negative and convex. When a worker is one year older, the probability of being a shifter decreases by 0.6 percentage points (measured at 40 years of age). Having a postgraduate degree makes it 2.5 percentage points more likely to be a shifter, while being male or living in a big city increases the probability by one percentage point. Compared to the reference category 'Humanities and arts', higher education in the field of 'Transport, communications, and security' makes it 5.5 percentage points less likely to be a public-private shifter, while an education in natural sciences increases the probability by 2 percentage points.

In the basic model, the estimation of wage effects from shifting to the private sector applies a DID approach with shifters as the treatment group and public stayers as the control group. As explained above, we expand the model with event study design where observations are arranged before and after the shift to the private sector. The analysis applies the following regression model:

$$\ln w_{ist} = \sum_{j=-3}^{5} D_{ist-j}\delta_j + \beta X_{ist} + \gamma_{st} + \alpha_{is} + \varepsilon_{ist} \quad (1)$$

In Eq. (1), w_{ist} is the daily wage for worker i in shift-year sample s at time t. Our interest is in the dummy variables D_{ist-j} that equal one when worker i is a public-private shifter in shift-year sample s, and the shift to the private sector occurred in year $t - j$, with t being the

observation year and $j = [-3, ..., 5]$. The associated parameters δ_j measure the wage differentials between shifters and stayers in different years before and after the sector shift (three years before and five years after). X_{ist} is a vector of time-varying worker characteristics (age, age squared, resident location). Shift-year specific time dummies γ_{st} imply that we compare shifters and stayers in the same shift-year sample and at the same distance to the shift-year. Shift-year specific worker fixed effects α_{is} control for permanent differences between shifters and stayers in any shift-year. We cluster standard error by individual i to allow correlation of error terms across different time periods and shift-years. In a simplified model version separating only between pre and post shift-year periods we show the standard average DID effect. The full model in Eq. (1) estimates separate coefficients for each pre-shift and post-shift year.

The analysis is extended to investigate two issues addressed in the literature of the private-public wage gap – the role of business cycles and the heterogeneity with respect to gender.

3. A basic difference-in-difference model

The model described by Eq. (1) in Section 2 allows for a comparison of shifters to the private sector (the treatment group) and stayers in the public sector (the control group) over time. The identifying assumption of the estimated wage effect is that the average development of wages among the stayers after the shift represents the counterfactual of the shifters. The model requires that treatment and control groups follow parallel trends in daily wages during the pre-shift years. Fig. 1 shows the wage time trends of shifters versus stayers three years before and five years after the shift-year. To enable comparison across different shift-years, we focus on the development of a daily wage index set to equal 100 three years before the sector shift (denoted t–3 in the figure). In the years before the shift, the two groups of workers have roughly similar wage trends, but the wages of shifters increase somewhat in year t–1 compared to stayers. The difference in pre-trend indicates that the identifying assumption is rejected. The wage path of shifters increases rapidly after the shift and the difference in wage paths between shifters and stayers continues to increase over the time period covered.

The regression model is given two specifications: the first is the standard DID formulation studying the average post-shift wage effect of shifters, while the second takes benefit of the event study design and estimates the wage effect of pre-shift years and five years after the shift separately. The approach addresses workers with common background in the public sector, and the analysis compares public and private sector wages while controlling for unobservable worker characteristics and time-variant observable characteristics (age, age squared, resident location). The estimation results are given in Table 2.

Public sector workers have an average gain by shifting to the private sector of 11.9%, as seen from column (1). Separating out the effect for each year pre and post shift-year in column (2), we see that the wage gain is increasing from 9.3% in the first year after the shift to 15% in the fifth year after the shift. It should be noticed that as wage gains increase over time, the size of the average effect depends on the length of the period studied. The expansion of the premium over time reflects the higher return to experience in the private sector, consistent with the findings of Rattsø and Stokke (2018). The specification in column (2) tests for the different wage path of shifters before the shift-year by including interaction terms between the shifter dummy and pre-shift years. The identifying assumption is that these interaction terms are not statistically significant, confirming parallel wage trends between shifters and stayers in the years before the shift. Consistent with the pattern shown in Fig. 1, the wage effect in the year before the shift is significantly higher for shifters than for stayers. We conclude that shifters have different wage development from stayers before the shift. The assumption for the identification does not hold.

Table 2
Basic model with public stayers as control group.

Dependent variable	(1) Log daily wage	(2) Log daily wage
Shifter × post shift-year	0.119***	
	(0.0025)	
Shifter × shift-year$_{t-2}$		0.001
		(0.0016)
Shifter × shift-year$_{t-1}$		0.012***
		(0.0021)
Shifter × shift-year$_{t+1}$		0.093***
		(0.0027)
Shifter × shift-year$_{t+2}$		0.125***
		(0.003)
Shifter × shift-year$_{t+3}$		0.136***
		(0.0033)
Shifter × shift-year$_{t+4}$		0.145***
		(0.0036)
Shifter × shift-year$_{t+5}$		0.15***
		(0.0039)
Observations	1,634,402	1,634,402
Number of groups	222,976	222,976
Number of shifters	8911	8911
Number of stayers	214,065	214,065
R^2 (within)	0.40	0.40

Notes: The regressions are based on a panel from 1993 to 2010, consisting of pooled samples for twelve different shift-years (1996–2007). The treatment group is public-private shifters and the control group is public stayers. The number of groups refers to the total number of shifters and stayers in the pooled data (the same worker can be part of several shift-year samples). All regressions include time-variant worker characteristics (age, age squared), regional dummies (89 labor market regions), shift-year specific time dummies, shift-year specific worker fixed effects, and a constant term. Since the regression includes fixed effects for each worker in a given shift-year sample, we cannot estimate the effect for the first time period (three years before the shift), which is used as reference in column (2). Robust standard errors (clustered by workers) are given in parenthesis. *** indicates significance at the 1 percent level.

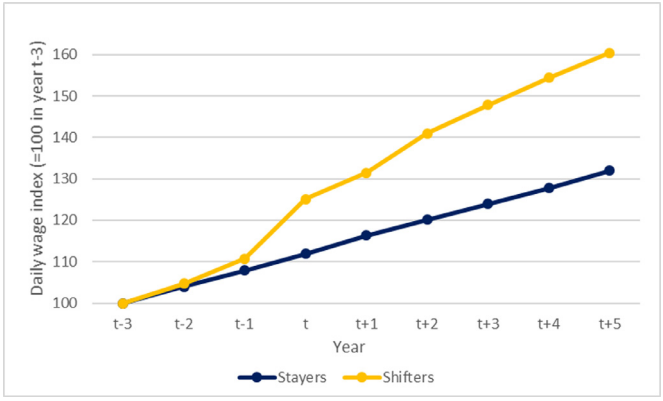


Fig. 1. Wage trends: Shifters vs. stayers (shift-year = t).

The size of the wage gap between private and public sectors vary with the wage institutions of the country. Interestingly, Schanzenbach (2015) estimate a 'public sector pay penalty' of similar size, about 9%, for workers with college degree (excluding teachers) in the US. Controlling for college major categories and occupation, the static wage gap is reduced to 5–6% in his study.

To investigate the role of unobservables, we estimate the model without worker fixed effects in Table A2. Compared with the average post-shift effect of 11.9% in Table 2, we now get 13.4%. Excluding worker fixed effects leads to an overestimation of the average return to shifting to the private sector of 1.5 percentage points or about 13%. It follows that the shifters to the private sector are positively selected among high-educated workers – their unobservable characteristics help explain the higher private wages. Estimates of the average wage effect for ten Euro-

Table 3
Identification based on early vs. late shifters.

	Early stayers as control		Late shifters as control	
Dependent variable	(1) Log daily wage	(2) Log daily wage	(3) Log daily wage	(4) Log daily wage
Shifter × post shift-year	0.125***		0.106***	
	(0.0033)		(0.0042)	
Shifter × shift-year$_{t-2}$		0.001		−0.002
		(0.002)		(0.0023)
Shifter × shift-year$_{t-1}$		0.007***		−0.002
		(0.0026)		(0.0032)
Shifter × shift-year$_{t+1}$		0.098***		0.08***
		(0.0036)		(0.0043)
Shifter × shift-year$_{t+2}$		0.129***		0.108***
		(0.004)		(0.0049)
Shifter × shift-year$_{t+3}$		0.14***		0.117***
		(0.0043)		(0.0055)
Shifter × shift-year$_{t+4}$		0.147***		0.123***
		(0.0045)		(0.0061)
Shifter × shift-year$_{t+5}$		0.148***		0.126***
		(0.0047)		(0.0069)
Observations	811,130	811,130	110,089	110,089
Number of groups	108,368	108,368	17,560	17,560
Number of early shifters	5014	5014	5014	5014
Number of early stayers	103,354	103,354		
Number of late shifters			12,546	12,546
R^2 (within)	0.40	0.40	0.46	0.46

Notes: All regressions include time-variant worker characteristics (age, age squared), regional dummies (89 labor market regions), shift-year specific time dummies, shift-year specific worker fixed effects, and a constant term. Robust standard errors (clustered by workers) are given in parenthesis. *** indicates significance at the 1 percent level.

pean countries by Campos and Centeno (2012) are generally lower with worker fixed effects than without, thus confirming positive selection.

4. Identification based on early vs. late shifters

Since the basic model reported in Table 2 rejects the identifying assumption of parallel wage trends between treatment and control groups, public stayers are not a valid control group for shifters from the public to the private sector. Most of the recent literature estimate the wage gap with worker fixed effect panel analysis including a private sector dummy variable. This approach may give biased estimates of the wage gap when there is heterogeneity of unobservable characteristics between sector shifters and stayers. We suggest an identification strategy concentrating on the shifters. The argument is that shifters are different from stayers and have some common unobserved characteristics relevant for the wage formation.

Our treatment group consists of workers that shift from the public to the private sector during 1996–2001, referred to as early shifters. The dataset is constructed in the same manner as in Section 2, with separate samples for each of the six shift-years. The control group consists of workers in the public sector that shift to the private sector at least two years later than the treatment group in the respective shift-year sample, referred to as late shifters. We only include observations of late shifters as control group in the years before they shift sector (while still working in the public sector). Both early and late shifters are observed three years before and up to five years after the shift of early shifters. The analysis is based on the pooled samples, giving a panel from 1993 to 2006 of approximately 110,000 observations. The same worker can be part of several shift-year samples, and the total number of workers in the pooled data is 17,560, of which 5014 are part of the treatment group and the remaining 12,546 constitute the control group.

The underlying assumption of identification is that early and late shifters are similar with respect to unobserved characteristics important for the wage effect of shifting to the private sector. To get a measure of the possible bias related to selection, we compare the private sector wage premium estimated from an analysis of early versus late shifters to the basic model with public sector stayers as the control group. The findings are given in Table 3. In columns (1) – (2), the control group consists of public sector stayers during the same period. Columns (3) – (4) represent our suggested identification, where the control group consists of workers who are currently in the public sector, but who shift to the private sector later. The main result is that the parallel paths assumption holds for the model when late shifters serve as counterfactual. The pre-shift difference in wage paths from Table 2 is reproduced when stayers are the control group (column 2), but disappears when they are replaced by late shifters (column 4). There are parallel trends in wages before the shift for early and late shifters. This is confirmed in Fig. 2, which illustrates the development of the daily wage index for early and late shifters three years before and five years after the sector shift for early shifters. The wage trend in the years before the sector shift is similar for the two groups of workers.

The estimated average wage gain is reduced from 12.5% to 10.6% when late shifters (rather than early stayers) are used as control group, as shown in columns (1) and (3) of Table 3. The reduction of the estimated wage effect from the basic model to the shifter model is a measure of the bias when not taking into account unobservable characteristics affecting the selection of stayers into shifters. The selection problem

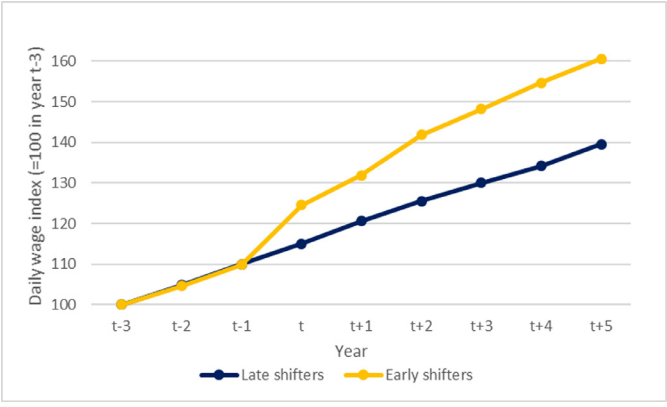


Fig. 2. Wage trends: Early shifters vs. late shifters (shift-year of early shifters = *t*).

Table 4
Descriptive statistics: early shifters, early stayers, and late shifters (mean values).

	Early shifters	Early stayers	Late shifters
Age	37.5	43.0	37.9
Male	0.728	0.701	0.698
Immigrant	0.086	0.068	0.077
Postgraduate degree	0.406	0.379	0.416
Field of education			
Humanities and arts	0.062	0.076	0.065
Teacher training and pedagogy	0.045	0.066	0.054
Social sciences and law	0.186	0.206	0.185
Business and administration	0.194	0.183	0.166
Natural sciences	0.307	0.188	0.255
Health, welfare and sport	0.018	0.029	0.035
Primary industries	0.018	0.023	0.026
Transport, communications, and security	0.162	0.22	0.205
Big city resident	0.531	0.468	0.517
Small city resident	0.202	0.217	0.196
No. of workers	5014	103,354	12,546

Notes: The mean value of age refers to the shift-year of early shifters, while the resident location is based on the year before the sector shift. Other variables are constant over time. Variables are described in the notes to Table 1.

implies overestimation of the wage gain from shifting to the private sector. The bias is about 2 percentage points or about 20%. The overestimation of the private-public wage premium represents a positive selection of shifters to the private sector compared to stayers in the public sector. When we concentrate on shifters only, we correct for this source of bias. Columns (2) versus (4) in Table 3 investigate the dynamics of adjustment in the basic model versus the shifter model. The private wage premium is increasing over time in both models. Our understanding is that there is higher return to experience accumulated in the private sector. Comparing the wage effect year by year, we observe that the difference between stayers and shifters as controls in all years $t+1$ to $t+5$ is about 2 percentage points.

Early and late shifters may be different and shift to the private sector for different reasons. To follow up on this, Table 4 compares observable characteristics of early shifters, early stayers, and late shifters before shifting. The mean values of age refer to the shift-year of early shifters and resident location is based on the year before the shift for early shifters. Other variables are constant over time. While early shifters are younger than early stayers (38 compared to 43 years of age), both early and late shifters are on average about 38 years of age at the time when early shifters change sector. More importantly, the age distributions of early and late shifters (measured in the shift-year of early shifters) have the same shape and differ significantly from the age distribution of early stayers, as documented in Fig. 3. In addition, early and late shifters are more comparable in terms of level of education (share with postgraduate degree), field of education and likelihood of living in a big city. These descriptive statistics give support to our argument that late shifters serve as a better counterfactual than stayers.

The main contribution of this analysis is to take into account differences in unobserved characteristics between shifters and stayers. We compare distributions of worker fixed effects using the methodology developed by Combes et al. (2012) and applied by Carlsen et al. (2016). The distribution of worker fixed effects for early shifters is approximated by taking the distribution of worker fixed effects of early stayers, shifting it by an amount A, and dilating it by a factor D. Table 5 reports estimated values for shift and dilation for this comparison and the alternative where the distribution for early shifters is approximated by the distribution of worker fixed effect of late shifters allowing for shift and dilation. In the shifter-stayer comparison, the shift factor is statistically significant at the 1% level. The value of the shift parameter indicates that the mean value of worker fixed effects is 13% higher for shifters than for stayers. The distribution for early shifters is placed distinctly to the right of the distribution for early stayers – early shifters have better unobservable characteristics. The distributions for early shifters and stayers are shown in the upper panel of Fig. 4. Comparing the distributions between early and late shifters, we find that the shift factor is much smaller, 2.9%, and not statistically significant. The lower panel in Fig. 4 shows two distributions much more similar than in the upper

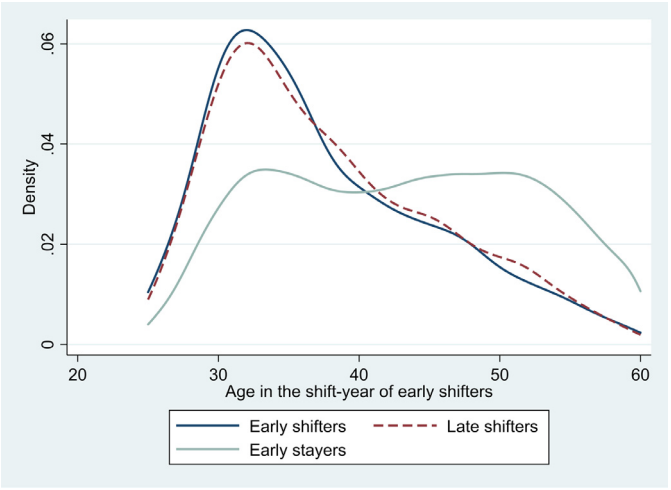


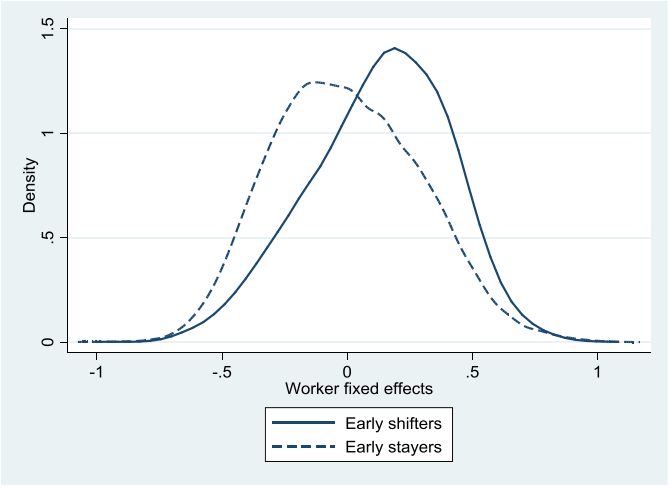
Fig. 3. Age distribution of early shifters, late shifters, and early stayers (measured in the shift-year of early shifters).

Table 5
Comparison of worker fixed effects distributions.

	Shift ($\hat{A}$)	Dilation ($\hat{D}$)	R^2	Obs.
Early shifters vs. early stayers	0.13***	0.946	0.91	108,368
	(0.0156)	(0.0384)		
Early shifters vs. late shifters	0.029	1.027	0.59	17,560
	(0.0247)	(0.0547)		

Notes: In the first row, the distribution of worker fixed effects for early shifters is approximated by taking the distribution of worker fixed effects for early stayers, shifting it by an amount A and dilating it by a factor D. In the second row, the same approximation is done for early shifters vs. late shifters. Bootstrapped standard errors are given in parenthesis (re-estimating worker fixed effects in 100 bootstrapped iterations based on 5% random samples with replacement). *** indicates significance at the 1 percent level (significantly different from 0 for $\hat{A}$ and from 1 for $\hat{D}$).

Panel a: Distribution of worker fixed effects, early shifters vs. early stayers



Panel b: Distribution of worker fixed effects, early shifters vs. late shifters

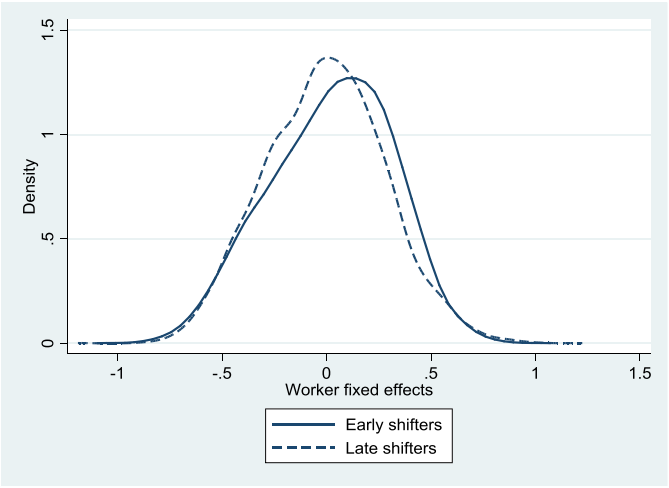


Fig. 4. *Panel a*: distribution of worker fixed effects, early shifters vs. early stayers. *Panel b*: distribution of worker fixed effects, early shifters vs. late shifters.

panel. The dilation parameters are not significantly different from 1 in any of the comparisons, implying that the distributions have the same dispersion.

We investigate the robustness of the analysis with respect to sample selection and design of the model. Results are reported in an external online appendix available from the authors.[5]

We define early shifters as workers shifting during 1996–2001. Two alternative cutoffs are investigated, one assuming early shifts during 1996–2000 (fewer early shifters) and one studying 1996–2002 (more early shifters). The overestimation bias is the same, about 2 percentage points. The analysis is documented in Tables A.1 and A.2 in the external online appendix. In the main analysis, we define late shifters as workers that shift to the private sector at least two years later than the treatment group of early shifters. Early shifters shift during 1996–2001, while late shifters shift during 1998–2007 and only observations in the years before they shift sector are included. As a check of robustness, we fully separate shift-years of early and late shifters, assuming that early shifters shift during 1996–2001 and late shifters shift during 2002–2007. The sample of late shifters is reduced, but the estimated wage effect is the same. Results are documented in Table A.3 in the external online appendix.

As explained in Section 2, we focus on workers with strong labor market attachment and require observations in three consecutive years as full-time public sector worker before the shift-year, for both shifters and stayers. The requirement reduces the dataset to 8911 shifters and 214,065 stayers in the working sample. The total number of observations (without this requirement) is 14,327 shifters and 248,087 public stayers. We compare the descriptive statistics of included and excluded shifters and stayers (documented in Table A.4 in the external online appendix). Compared to workers included in the sample, excluded workers are on average younger, more likely to be immigrant, and more likely to be female. To check for potential sample selection bias, we run the regressions in Table 3 (with identification based on early vs. late shifters) using the full sample of shifters and stayers, as suggested by Nijman and Verbeek (1992). The estimations are documented in Table A.5 in the external online appendix. The overestimation of the basic model is still 1.9 percentage points. The exclusion of workers with weaker labor market attachment prior to the sector shift does not affect the estimated bias.

5. Role of business cycles

Public sector employment and wages vary with business cycles and the private-public wage gap may depend on cycles. The broad understanding is that private sector wages are pro-cyclical, while public sector wages are less responsive to cycles. During the period studied, government wage and recruitment policy has been stable and is operated at the administrative level. Boeing-Reicher and Caponi (2016) investigate the public sector adjustment in a cross section of US metro areas. They confirm the stylized fact that public sector wages correlate weakly and positively with business cycle volatility. Maczulskij (2013) tests the relationship between wage gap and unemployment variation using Finnish micro data and concludes that the private sector wage premium is strongly pro-cyclical. The importance for the size of the gap and our suggested identification strategy is studied here.

Table 6
Shifters vs. stayers: Separate regression for each shift-year.

	Average post-shift effect	No. of shifters	No. of stayers
Shift-year = 1996	0.169***	622	16,123
	(0.0092)		
Shift-year = 1997	0.102***	1254	16,754
	(0.006)		
Shift-year = 1998	0.144***	1015	17,146
	(0.0068)		
Shift-year = 1999	0.13***	615	17,298
	(0.0092)		
Shift-year = 2000	0.116***	689	17,786
	(0.0088)		
Shift-year = 2001	0.11***	819	18,247
	(0.008)		
Shift-year = 2002	0.077***	510	18,023
	(0.0103)		
Shift-year = 2003	0.065***	444	18,149
	(0.0112)		
Shift-year = 2004	0.095***	452	18,433
	(0.011)		
Shift-year = 2005	0.145***	559	18,432
	(0.0106)		
Shift-year = 2006	0.131***	931	18,508
	(0.008)		
Shift-year = 2007	0.115***	1001	19,166
	(0.0073)		
Total		8911	214,065

Notes: Each row represents a separate shift-year sample. All regressions include time-variant worker characteristics (age, age squared), regional dummies (89 labor market regions), time dummies, worker fixed effects, and a constant term. Robust standard errors (clustered by workers) are given in parenthesis. *** indicates significance at the 1 percent level.

[5] A set of tables describing alternative model specifications is available as an external online appendix: https://sites.google.com/site/hildegunnestokke/.

Table 7
Business cycle effects (shifters vs. stayers).

Dependent variable	Log daily wage
Shifter × post shift-year	0.116***
	(0.0055)
Shifter × post shift-year x boom years	0.016***
	(0.0063)
Shifter × post shift-year x recession years	−0.03***
	(0.0078)
Observations	1,634,402
Number of groups	222,976
Number of shifters	8911
Number of stayers	214,065
R^2 (within)	0.40

Notes: The regression includes time-variant worker characteristics (age, age squared), regional dummies (89 labor market regions), shift-year specific time dummies, shift-year specific worker fixed effects, and a constant term. We allow the private-public wage gap to vary with the business cycle. Boom years are defined as years where the output gap is positive and increasing over time (1996–1998 and 2005–2007 in our dataset). Recession years are defined as years where the output gap is negative and the absolute value of the output gap is increasing over time (2001–2003 in our dataset). The remaining shift-years constitute the reference category. Robust standard errors (clustered by workers) are given in parenthesis. *** indicates significance at the 1 percent level.

We start out studying the wage gap year by year and relating this to business cycles as identified in official documents (Statistics Norway, 2012). The year-by-year estimates are at the same time a robustness check of the results above. Statistics Norway classify four phases of the business cycle, recovery and boom from bottom to peak and slump and recession from peak to bottom. During the period studied, 1998 and 2007 are considered as peak years, while the bottom of the cycle was experienced in 1992, 2003 and 2011. Bjørnland et al. (2005) document various methods of estimating the output gap up to 2004 and confirm the peak in 1998 and the troughs in 1992 and 2003. Liu et al. (2016) analyze cyclical skill match and long-term effects of graduating in recession using similar data for Norway.

Separate regressions for each shift-year are provided in Table 6. The table reports the average post-shift wage effect, the number of shifters observed each year and numbers of stayers in the comparison group. The average wage effect varies from low 6–7% to high 14–17%. The highest wage effect appears in the boom years 1996, 1998, 1999, 2005 and 2006. The lowest wage effect is estimated for recession years 2002 and 2003. The business cycle also affects number of shifters from the public to the private sector. More than 1000 workers shift to the private sector in boom years 1997, 1998 and 2007. On the other hand, less than 500 workers shift in recession years 2003 and 2004.

The difference between boom and recession years are tested in Table 7 where the average wage effect is separated between boom years and recession years by interaction terms. In the analysis, we concentrate on the 1996–98 and 2005–07 boom years when the output gap is positive and increasing over time versus the recession years 2001–03 when the output gap is negative and increasing in absolute value. The remaining shift-years represent the reference category. The estimated private-public wage gap is 1.6 percentage points higher in booms and 3 percentage points lower in recessions compared to other years. We conclude that the private-public wage gap is pro-cyclical. The results are consistent with the year-by-year regressions and with the results of Maczulskij (2013). Bargain et al. (2018) relate their trends in the estimated wage gaps for France to business cycles and find indications of pro-cyclical private wage premium. Interestingly, they also indicate effects of policy shifts towards the public sector resulting from changing party of the president in power. We assume that such policy cycles are less relevant in the public sector wage setting system in Norway where politicians are held at a distance.

The important question in our setting is whether business cycles affect the overestimation of the wage effect in standard comparison of shifters and stayers. The comparison of early versus late shifters implies that we can only investigate this for a part of the observation period – the years when we have early shifters shifting sector. The year-by-year regressions comparing early stayers and late shifters as controls are shown in Table 8. The overestimation of the wage effect using early stayers as control is about the same in all years. This is true in particular for boom years 1996 and 1998 and the recession years 2001 and 2002. While the size of the wage effect varies across booms and recessions, our measure of overestimation of the wage effect using stayers as control group is quite stable across cycles.

6. Heterogeneity: gender

A large literature has shown gender differences in the labor market. It is of interest to study how the private-public wage gap relates to the gender gap. Public sector wage policy in Norway is generally oriented towards equalization of wages and certainly to avoid discrimi-

Table 8
Early vs. late shifters: Separate regression for each shift-year.

	(1) Early stayers as control	(2) Late shifters as control	No. of early shifters	No. of early stayers	No. of late shifters
Shift-year = 1996	0.169***	0.149***	622	16,123	2723
	(0.0092)	(0.0094)			
Shift-year = 1997	0.102***	0.092***	1254	16,754	2288
	(0.006)	(0.0066)			
Shift-year = 1998	0.144***	0.12***	1015	17,146	2198
	(0.0068)	(0.0076)			
Shift-year = 1999	0.13***	0.103***	615	17,298	2030
	(0.0092)	(0.0097)			
Shift-year = 2000	0.116***	0.095***	689	17,786	1714
	(0.0088)	(0.0096)			
Shift-year = 2001	0.11***	0.093***	819	18,247	1593
	(0.008)	(0.009)			
Shift-year = 2002	0.068***	0.054***	510	18,023	1451
	(0.0101)	(0.0111)			
Total			5524	121,377	13,997

Notes: Each row represents a separate shift-year and the first two columns show the estimated average post-shift effect with early stayers and late shifters, respectively, as the control group. For the shift-year 2002, the late shifters are not observed in the public sector in time period $t+5$ (year 2007) since they have already shifted to the private sector by then. We therefore drop all observations of early shifters and early stayers in period $t+5$ for this shift-year sample, so that the average post-shift effect refers to the first four years after the sector shift. This explains why the estimated coefficient in column (1) differs from the coefficient for shift-year 2002 in Table 6. All regressions include time-variant worker characteristics (age, age squared), regional dummies (89 labor market regions), time dummies, worker fixed effects, and a constant term. Robust standard errors (clustered by workers) are given in parenthesis. *** indicates significance at the 1 percent level.

Table 9
Identification based on early vs. late shifters: female workers.

	Early stayers as control		Late shifters as control	
Dependent variable	(1) Log daily wage	(2) Log daily wage	(3) Log daily wage	(4) Log daily wage
Shifter × post shift-year	0.118***		0.097***	
	(0.0065)		(0.0079)	
Shifter × shift-year$_{t-2}$		−0.001		−0.003
		(0.0046)		(0.0053)
Shifter × shift-year$_{t-1}$		0.009		0.001
		(0.0061)		(0.0071)
Shifter × shift-year$_{t+1}$		0.091***		0.075***
		(0.0073)		(0.0085)
Shifter × shift-year$_{t+2}$		0.122***		0.102***
		(0.0082)		(0.0098)
Shifter × shift-year$_{t+3}$		0.129***		0.108***
		(0.0088)		(0.0108)
Shifter × shift-year$_{t+4}$		0.14***		0.113***
		(0.0093)		(0.0117)
Shifter × shift-year$_{t+5}$		0.149***		0.112***
		(0.0101)		(0.0135)
Observations	241,265	241,265	31,826	31,826
Number of groups	32,300	32,300	5151	5151
Number of early shifters	1362	1362	1362	1362
Number of early stayers	30,938	30,938		
Number of late shifters			3789	3789
R^2 (within)	0.32	0.32	0.36	0.36

Notes: All regressions include time-variant worker characteristics (age, age squared), regional dummies (89 labor market regions), shift-year specific time dummies, shift-year specific worker fixed effects, and a constant term. Robust standard errors (clustered by workers) are given in parenthesis. *** indicates significance at the 1 percent level.

nation based on gender. If public sector wages are female friendly, the private-public wage gap will be smaller for women compared to men. Hospido and Moral-Benito (2016) estimate differences by gender in a dataset for Spain. They find that high-educated women always gain from staying in the public sector, while high-educated male workers lose.

All workers are high educated in our sample, and separate regressions for female workers are reported in Table 9. Male workers represent about 70% of observations, and the results for men are quite similar to the overall results. Their estimates are shown in Table A3. The average wage effect for female workers is 11.8% with early stayers as control and this is reduced to 9.7% with late shifters as control. The overestimation when using stayers as control is the same as overall, 2.1 percentage points or about 20%.

Female workers represent about 27% of the early shifters and consequently the propensity to shift from public to private is about the same as for men. The estimates show that the private-public wage gap is 1 percentage point lower for female workers compared to men. The economic importance is limited, but works in the expected direction. The result is consistent with little difference between genders in the analysis of France by Bargain et al. (2018).

7. Concluding remarks

The wage gap between the private and public sectors is analyzed in comparison of shifters from the public to the private sector with stayers in the public sector. We have shown that heterogeneity of unobservable characteristics disturbs the identification of the wage effect in this standard approach. In an extension of the basic model, we suggest an identification strategy comparing early shifters with workers still in the public sector, but shifting later. The extended model satisfies the identifying assumption of the difference-in-difference model with parallel wage paths in the years before the sector shift. The analysis implies an overestimation of the wage gap by about 20% in the model comparing shifters with stayers. The overestimation bias represents a positive selection of shifters to the private sector compared to stayers in the public sector.

The analysis has concentrated on workers with higher education and future work can expand the analysis to include all workers. If all workers in the private and the public sector are part of the analysis, the return to shifts from public to private can be compared with shifts from private to public. In addition, this will allow for an application of the identification strategy for the private-public wage gap along the wage distribution. The main lack of data in this study is on positions in the public sector, both to capture the role of promotions and to study assortative matching.

Appendix

Tables A1–A3.

Table A1
Probability of being a public-private shifter (vs. public stayer).

Dependent variable	Shifter
Age	−0.014***
	(0.0005)
Age^2	0.0001***
	(0.0000)
Male	0.01***
	(0.0009)
Immigrant	0.002
	(0.0016)
Big city resident	0.01***
	(0.001)
Small city resident	0.004***
	(0.0011)
Postgraduate degree	0.025***
	(0.001)
Field of education	
Teacher training and pedagogy	0.008***
	(0.0022)
Social sciences and law	−0.012***
	(0.0019)

(*continued on next page*)

Table A1 (*continued*)

Dependent variable	Shifter
Business and administration	0.001
	(0.0018)
Natural sciences	0.02***
	(0.0018)
Health, welfare and sport	0.006**
	(0.0029)
Primary industries	−0.019***
	(0.0031)
Transport, communications, and security	−0.055***
	(0.0019)
Observations	222,976
Number of shifters	8911
Number of stayers	214,065
R^2	0.04

Notes: The dependent variable is a dummy that equals one if the worker shifts from the public to the private sector during 1996–2007. Resident location is measured the year before the sector shift, while other variables are measured in the shift-year. The reference category for field of education is 'Humanities and arts'. The regression includes shift-year fixed effects and a constant term. ***, ** and * indicate significance at the 1 percent, 5 percent and 10 percent level, respectively.

Table A2
Basic model (public stayers as control group) without worker fixed effects.

Dependent variable	(1) Log daily wage	(2) Log daily wage
Shifter	−0.027***	−0.034***
	(0.0025)	(0.0027)
Shifter × post shift-year	0.134***	
	(0.0027)	
Shifter × shift-year$_{t-2}$		0.003*
		(0.0016)
Shifter × shift-year$_{t-1}$		0.017***
		(0.0021)
Shifter × shift-year$_{t+1}$		0.103***
		(0.0028)
Shifter × shift-year$_{t+2}$		0.137***
		(0.0032)
Shifter × shift-year$_{t+3}$		0.152***
		(0.0035)
Shifter × shift-year$_{t+4}$		0.166***
		(0.004)
Shifter × shift-year$_{t+5}$		0.176***
		(0.0045)
Observations	1,634,402	1,634,402
Number of groups	222,976	222,976
Number of shifters	8911	8911
Number of stayers	214,065	214,065
R^2	0.36	0.36

Notes: All regressions include time-variant and constant worker characteristics (age, age squared, gender, immigrant status and level of education within the broader group of higher education), regional dummies (89 labor market regions), shift-year specific time dummies, and a constant term. Robust standard errors (clustered by workers) are given in parenthesis. *** indicates significance at the 1 percent level.

Table A3
Identification based on early vs. late shifters: male workers.

	Early stayers as control		Late shifters as control	
Dependent variable	(1) Log daily wage	(2) Log daily wage	(3) Log daily wage	(4) Log daily wage
Shifter × post shift-year	0.128***		0.109***	
	(0.0038)		(0.0049)	
Shifter × shift-year$_{t-2}$		0.002		−0.002
		(0.0022)		(0.0025)
Shifter × shift-year$_{t-1}$		0.007**		−0.003
		(0.0028)		(0.0034)
Shifter × shift-year$_{t+1}$		0.101***		0.082***
		(0.0041)		(0.0049)
Shifter × shift-year$_{t+2}$		0.132***		0.11***
		(0.0045)		(0.0056)
Shifter × shift-year$_{t+3}$		0.143***		0.119***
		(0.0049)		(0.0063)
Shifter × shift-year$_{t+4}$		0.148***		0.126***
		(0.0051)		(0.0071)
Shifter × shift-year$_{t+5}$		0.147***		0.129***
		(0.0053)		(0.0081)
Observations	569,865	569,865	78,253	78,253
Number of groups	76,068	76,068	12,409	12,409
Number of early shifters	3652	3652	3652	3652
Number of early stayers	72,416	72,416		
Number of late shifters			8757	8757
R^2 (within)	0.44	0.44	0.51	0.51

Notes: All regressions include time-variant worker characteristics (age, age squared), regional dummies (89 labor market regions), shift-year specific time dummies, shift-year specific worker fixed effects, and a constant term. Robust standard errors (clustered by workers) are given in parenthesis. *** indicates significance at the 1 percent level.

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