The Impact of Payroll Tax Subsidies: Theory and Evidence*

Anikó Bíró
CERS

Réka Branyiczki
CEU and Tárki

Attila Lindner
UCL

Lili Márk
CEU and CERS

Dániel Prinz
IFS

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Abstract

We study the employment and wage effects of age-dependent payroll tax subsidies for both younger (under 25) and older (over 55) workers using a policy change in Hungary. Using rich administrative data and a difference-in-differences strategy, we find that employment increases in both age groups as a result of the payroll tax cut, but the effects differ by job and firm characteristics. Employment of older workers mostly increases blue collar jobs and at less productive and lower-quality firms. On the other hand, employment of older workers at more productive and higher-quality firms is unaffected, but their wages increase in response to the tax cut. We explain these findings using an equilibrium job search model with heterogeneous firms and workers. In the model, more productive firms hire skilled workers by poaching them from other firms. Tax reduction for these firms mainly increase worker's wages, while employment is not affected. On the other hand, low-productivity firms, which tend to hire from unemployment, mainly react to the tax subsidy by increasing employment and the effect on wages is limited. These results point to important heterogeneity in the incidence of payroll tax subsides by firm and worker types: the incidence mainly falls on low-productivity firms, and higher-skilled workers.

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1 Introduction

Improving the employment prospects of vulnerable groups is a major policy priority for many governments. A number of countries have implemented targeted employment subsidies, such as payroll tax cuts, to support employment for specific groups with low employment rates. However, to date there is no conclusive evidence on whether such policies are successful at boosting the employment of the targeted groups. Some studies find non-negligible positive effects on employment (Kramarz and Philippon, 2001; Egebark and Kaunitz, 2018; Saez, Schoefer and Seim, 2019*b*), while others find little evidence for employment effects (Boockmann, Zwick, Ammermüller and Maier, 2012; Huttunen, Pirttilä and Uusitalo, 2013).

In this paper, we study the impact of payroll tax subsidies through the lens of an equilibrium job search model. We introduce a payroll tax subsidy into a search model with heterogeneous workers and firms and show a number of novel and intuitive results. First, firms' hiring intensity is increasing in the tax subsidy. Second, the subsidy matters less for the hiring decisions of more productive firms, who instead increases workers' wages. This is because more productive firms poach larger fraction of their workforce in the model and because the (potentially) poached workers are able to extract more of the surplus from the subsidy. Third, since higher-skilled workers sort to more productive firms, the tax subsidy mainly affects lower-skilled workers, who are employed by low-productivity firms, and higher-skilled workers, who are employed by high-productivity firms.

The model also predicts differential impacts on younger and older workers. For younger workers who are just entering the labor market and tend to move in and out of the labor force, the model predicts that the positive effect of the subsidy on hiring intensity is larger—firms are able to claim the surplus when they are hiring new workers from unemployment. At the same time, for older workers, who are already higher up the job ladder, the subsidy will affect both hiring intensity and wages.

After establishing these results, we test the model's predictions by studying the impact of an age-specific payroll tax cut among younger (below 25) and older (above 55) workers

in Hungary. We focus on a 2013 tax reform which decreased the social security contribution rate from 27% to 14.5% for workers below 25 and above 55. This policy allows us to compare the impact of payroll tax cuts on the two age groups and also to study heterogeneity across different firms, jobs, and workers with different skill levels.

We estimate the impact of the policy in a difference-in-differences framework, comparing younger workers below the 25-year cutoff to workers just above and comparing older workers above the 55-year cutoff to workers just below. The overall employment impact is about two times larger for younger workers than for older workers: we find that the policy increased the private sector employment of younger workers by 2.0 percentage points and of older workers by 0.8 percentage points. Among previously employed workers, the wage impacts were statistically and economically insignificant for younger workers. For older workers, wages increased by 0.51% in the short-run.

These average results mask substantial heterogeneity across job types and firms: the types of jobs and firms impacted also differ across the two age groups. For a variety of measures of firm quality—including the poaching index (Bagger and Lentz, 2019), total factor productivity, and firm fixed effects measured in the AKM framework (Abowd, Kramarz and Margolis, 1999)—we find little evidence of heterogeneity among younger workers. Among older workers, the employment-increasing effect of the policy is larger for lower-quality jobs and lower-quality firms. We find that lower-quality firms drive our results, while the employment of older workers in higher-quality firms is unchanged. Similar results emerge when instead of measures of firm quality, we focus on worker skill. Among older workers, there is only small employment boost for higher-earning and white-collar workers. At the same time, the wage effect is stronger at higher-quality firms for older workers.

These empirical findings together with our theoretical framework point to interesting (and so far undocumented) heterogeneity in the incidence of tax subsidies. Older, higher-skilled workers employed by productive firms are able to extract more of the surplus from the subsidy and so the incidence of the subsidy (partly) falls on them. At the same time,

younger, lower-skilled workers, and workers who are employed by less productive firms are benefiting from the tax subsidy through increased hiring, while firms capture a larger share of the surplus for these workers.

Related Literature. This paper is most closely related to studies of age-based employment subsidies (Kramarz and Philippon, 2001; Boockmann, Zwick, Ammermüller and Maier, 2012; Huttunen, Pirttilä and Uusitalo, 2013; Egebark and Kaunitz, 2018; Saez, Schoefer and Seim, 2019*b*). This literature is overall inconclusive on the impacts and effectiveness of these subsidies. We contribute to this literature in several ways: we analyze the differential impact of payroll tax cuts on workers in different age groups and focus on heterogeneity across firm and worker types. Our heterogeneity results are not without antecedents in the literature, although our data and institutional setting make it possible to provide a more comprehensive overview on the differing impacts of payroll tax cuts by age groups, as well as job and firm types. In line with our results, Albanese and Cockx (2019) find that a wage cost subsidy in Belgium targeting employees above age 58 increased employment of workers at high risk of early retirement, workers employed by firms with high shares of low-wage workers, and workers in small firms. Similarly, Laun (2017) report that an earned income tax credit and a payroll tax credit in Sweden for workers above age 65 increased participation mostly among low- and middle-income earners. The effect of the policy change was insignificant for workers in the top income quintile. Breda, Haywood and Wang (2019) study the impact of payroll tax subsidies on low-wage work in a search-and-matching framework using French administrative data and point to increased employment among low-skill workers but negative spillovers for high-skill workers.

More broadly, our study also relates to the literature on payroll tax incidence. Studies using payroll tax reforms to analyze incidence provide mixed evidence. Some studies find that the burden of the payroll tax is shifted on the workers (Gruber, 1997; Anderson and Meyer, 2000). However, some later studies find that the burden of the payroll tax is mostly borne

by the employer (Kugler and Kugler, 2009; Saez, Matsaganis and Tsakloglou, 2012; Saez, Schoefer and Seim, 2019*b*). Evaluating the incidence of business tax credits, Carbonnier, Malgouyres, Py and Urvoy (2021) find that the incidence of wage gains is on high-skill workers. Our study contributes to this literature by providing evidence that the incidence of an age-dependent payroll tax cut varies with firm quality.

The remainder of this paper proceeds as follows. Section 2 introduces our model. In Section 3, we provide background on the payroll tax reform we study. We describe our data in Section 4 and present our results in Section 5. Section 6 concludes.

2 Model

2.1 Set-up

Firms are heterogeneous characterized by productivity $y \in [0, 1]$, with cumulative distribution function $\Gamma()$. The production function is $f()$, increasing in y.

Workers are homogeneous. Workers are either unemployed or employed. If unemployed, they receive b value of leisure and search for jobs with probability one. If employed, they receive wage w, search for a new job with probability $s \in [0, 1]$ and can separate from their job exogeneously with probability $\delta \in [0, 1]$.

Firms can advertise vacancies at the unit cost κ. Job market tightness is the ratio between vacancies (v) and total search effort by the unemployed (u) and employed ($(1-\delta)(1-u)$):

$$\theta = \frac{v}{u + s(1-\delta)(1-u)}. \tag{1}$$

The probability for a searching worker of locating an open vacancy is $\phi(\theta)$, increasing in θ. The probability for an open vacancy of meeting a worker who is searching for jobs is $\phi(\theta)/\theta$, decreasing in θ.

Wage setting is as in the sequential auction model of Postel-Vinay and Robin (2002).

When an employed worker contacts an open vacancy, the prospective poacher and the incumbent employer observe each other's match qualities with the worker, and engage in Bertrand competition over contracts. The worker chooses the contract that delivers the larger value.

2.2 Bellman equations

The value of unemployment, using that firms extract all the rents from unemployed workers, making them indifferent between working and remaining unemployed:

$$V_u = b + \beta V_u, \tag{2}$$

where β is the discount factor. Thus,

$$V_u = \frac{b}{1-\beta}. \tag{3}$$

The maximum value the firm is willing to promise to deliver to the worker is:

$$V(y,\tau) = f(y) + \tau + \delta\beta V_u + (1-\delta)\beta V(y,\tau), \tag{4}$$

where τ is the employment subsidy. After rearrangement:

$$(1-\beta+\delta\beta)V(y,\tau) = f(y) + \tau + \frac{\delta\beta b}{1-\beta}. \tag{5}$$

The value of a vacancy is:

$$\begin{aligned}(1-\beta)V_v(y,\tau) = -\kappa + \beta\frac{\phi(\theta)}{\theta}P(u)\left[\frac{f(y)+\tau+\frac{\delta\beta b}{1-\beta}}{1-\beta+\delta\beta} - V_u - V_v(y,\tau)\right] + \\ + \beta\frac{\phi(\theta)}{\theta}(1-P(u))\int_0^y \left[\frac{f(y)-f(y')}{1-\beta+\delta\beta} - V_v(y,\tau)\right]d\Gamma(y'),\end{aligned} \tag{6}$$

where the probability that a randomly drawn job applicant is unemployed is:

$$P(u) = \frac{u}{u + (1-\delta)s(1-u)}. \tag{7}$$

2.3 Employment, free entry and equilibrium

The cumulative distribution of employment is $L()$, with:

$$L(y) = (1-\delta)\Big[1 - s\phi(\theta)(1-\Gamma(y))\Big]L(y) + \phi(\theta)\Gamma(y)u. \tag{8}$$

Employment at firms with productivity y is:

$$l(y) = (1-\delta)\left[\Big[1 - s\phi(\theta)(1-\Gamma(y))\Big]l(y) + s\phi(\theta)\gamma(y)\int_0^y l(y')dy'\right] + \phi(\theta)\gamma(y)u. \tag{9}$$

The steady state rate of unemployment is:

$$u = (1-\phi(\theta))u + \delta(1-u). \tag{10}$$

Thus,

$$u = \frac{\delta}{\delta + \phi(\theta)}. \tag{11}$$

There is free entry of firms on the search market. Firms will therefore post vacancies up to the point where the expected value of a vacancy is zero. The free entry condition determines the equilibrium value of θ:

$$\kappa\frac{\theta}{\phi(\theta)} = \beta P(u)\left[\frac{\int_0^1 f(y)dL(y) + \tau + \dfrac{\delta\beta b}{1-\beta}}{1-\beta+\delta\beta} - V_u\right] + \beta(1-P(u))\int_0^1\int_0^y (f(y)-f(y'))dL(y)d\Gamma(y'). \tag{12}$$

If we normalize the steady state average productivity to one, the free entry condition sim-

plifies to:

$$\kappa\frac{\theta}{\phi(\theta)} = \beta P(u)\frac{1-b+\tau}{1-\beta+\delta\beta} + \beta(1-P(u))\int_0^1\int_0^y (f(y)-f(y'))dL(y)d\Gamma(y'). \tag{13}$$

The equilibrium is a solution for θ in equation (12), given $P(u)$ in equation (7), unemployment in equation (11) and the distribution of employment $L()$ in equation (8).

2.4 Effects of the employment subsidy

Lemma 1 *The direct effect of the employment subsidy on vacancy posting is positive.*

Proof. The value of vacancy (equation (6)) increases with y. Neglecting the equilibrium effects, the employment subsidy (τ) increases the value of a vacancy. ■

Lemma 1 implies that due to its effect on vacancy posting, the employment subsidy has a positive effect on job market tightness (θ), which in turn, decreases the equilibrium unemployment rate u.

Lemma 2 *The equilibrium value of unemployment and $P(u)$ decrease in τ.*

Proof. It follows directly from equation (11) that the impact of the tax subsidy on the rate of unemployment is negative, using that θ increases in τ and $\phi(\theta)$ increases in θ. Equation (7) can be rewritten as:

$$P(u) = \frac{\delta}{\delta+(1-\delta)\phi(\theta)}. \tag{14}$$

Using that $\phi(\theta)$ increases in θ, which in turn increases in τ, the proof immediately follows. ■

Proposition 1 *The direct effect of employment subsidy on the value of vacancy decreases with firm productivity.*

Proof. Equation (6) can be rewritten as:

$$\left[1-\beta+\beta\frac{\phi(\theta)}{\theta}[P(u)+(1-P(u))\Gamma(y)]\right]V_v(y,\tau)=$$
$$=-\kappa+\beta\frac{\phi(\theta)}{\theta}P(u)\left[\frac{f(y)+\tau+\dfrac{\delta\beta b}{1-\beta}}{1-\beta+\delta\beta}-V_u\right]+\beta\frac{\phi(\theta)}{\theta}(1-P(u))\int_0^y\left[\frac{f(y)-f(y')}{1-\beta+\delta\beta}\right]d\Gamma(y'). \tag{15}$$

Thus,

$$V_v(y,\tau)=$$
$$=\frac{-\kappa+\beta\dfrac{\phi(\theta)}{\theta}P(u)\left[\dfrac{f(y)+\tau+\dfrac{\delta\beta b}{1-\beta}}{1-\beta+\delta\beta}-V_u\right]+\beta\dfrac{\phi(\theta)}{\theta}(1-P(u))\int_0^y\left[\dfrac{f(y)-f(y')}{1-\beta+\delta\beta}\right]d\Gamma(y')}{1-\beta+\beta\dfrac{\phi(\theta)}{\theta}[P(u)+(1-P(u))\Gamma(y)]}. \tag{16}$$

The direct impact of the employment subsidy on $V_v(y,\tau)$ is

$$\frac{\beta\dfrac{\phi(\theta)}{\theta}P(u)\dfrac{1}{1-\beta+\delta\beta}}{1-\beta+\beta\dfrac{\phi(\theta)}{\theta}[P(u)+(1-P(u))\Gamma(y)]}, \tag{17}$$

which decreases in y, using that $\Gamma(y)$ increases in y. ■

Proposition 2 *The effect of the employment subsidy on wages increases with firm productivity.*

Proof. Contracts can be renegotiated by mutual consent. Assume that employment subsidy $\tau>0$ is introduced. If a worker of a firm with productivity y receives an outside offer from a firm with productivity y' then three events can occur:

1. *Worker is poached:* The poaching firm wins the competition over the incumbent firm if $V(y',\tau)>V(y,\tau)$ and the wage increases.

2. *Wage renegotiation:* If the worker meets an outside firm that would be willing to offer greater value than the worker's current contract but cannot offer more than the worker's current firm, the contract is renegotiated and the worker stays. After the introduction of the employment subsidy, wage renegotiation happens if $V_e(y, w, 0) < V(y', \tau) < V(y, \tau)$. Since $V(y, \tau)$ is increasing in τ, the introduction of the employment subsidy increases the probability of wage renegotiation at the incumbent firm.

3. *No change:* If neither of the above two conditions is met, the worker stays at the current firm and the wage remains unchanged.

Competition between firms implies that workers are moving in the direction of extracting the full value of the employment subsidy, using the full surplus extraction at the less productive firm as the outside option. The probability of poaching a worker (case 1) increases in firm productivity (and is zero at the firm with the lowest productivity), thus this channel of the wage-increasing effect of τ is more likely to be realized at higher-productivity firms. The probability of wage renegotiation (case 2) also increases in τ. However, the positive effect of τ on wages due to wage renegotiation is zero at the firm with the lowest productivity. Thus, overall, the employment subsidy is more likely to have a positive wage effect at more productive firms both due to the higher probability of poaching and to the higher probability of wage renegotiation. ■

Proposition 3 *The employment subsidy does not have wage effects on new entrants.*

Proof. Young workers enter the labor market as non-employed, thus, essentially, poaching and wage renegotiation (cases 1 and 2 under the proof of Proposition 2) are not relevant for them. This means that new entrants cannot use current wages as outside option to achieve full surplus extraction – instead, they accept any offer (as the reservation threshold of firm productivity is zero), and can start bargaining over wages once employed. ■

3 Background

Labor income is taxed heavily in Hungary. In 2013, the average tax wedge was 49%, much higher than the OECD average of 36.5% (OECD, 2019). Labor income taxes include a personal income tax, which was a flat-rate tax of 16% in 2013, social security contributions paid by the employee (18.5% in 2013), and social security contributions paid by the employer (28.5% in 2013).

The overall employment rate in Hungary was 64%, slightly below the OECD average (66%). The employment rate of older people was only 46%, substantially below the OECD average (58%), which suggests that the labor market functioned particularly poorly for older workers. In contrast, the NEET (neither in education nor employment or training) rate of youth was virtually identical with the OECD average of 16.5% (OECD, 2016).

In 2013, the government implemented a policy called the Job Protection Act (JPA) which incentivized the employment of disadvantaged groups in the labor market. Groups eligible for an age-specific permanent payroll tax cut included employees under 25 years of age and employees over 55 years of age. Under the policy, employer social security contributions were decreased from 28.5% to 14%.[1] The cut applied to both new and ongoing jobs and it was available for private sector employers and for employees in standard employment contracts (atypical forms of employment such as temporary work, public works, and self- employment were excluded).[2]

[1]The amount of the allowance was 14.5% of the gross wage but the base was capped at HUF 100,000 (453 USD on January 1, 2013), so the allowance was capped at 14,500 HUF (63 USD) per month. The cap of HUF 100,000 corresponded to the minimum wage at the time (though the level of the allowance did not follow the slight increases in the minimum wage in later years). For context, the average monthly gross wage was HUF 230,000 ($1042) and the average net monthly wage was HUF 151,000 ($684) in 2013.

[2]Permanent reductions also applied to employees working in elementary occupations. Temporary reductions (a decrease of 28.5% for the first two years and 14.5% for the third) were introduced for the long-term unemployed re-entering the labor market; people returning to work after child-care leave; and career starters, in case they started a job after the introduction of the JPA. We focus on the impact of the permanent cut targeting employees under age 25 and over age 55. The other beneficiary categories do not have discontinuities at ages 25 and 55. Specification checks indicate that our results are robust to the exclusion of the non-age-specific subsidized groups from the sample.

In 2015, the so-called Youth Guarantee Programme was introduced, with the aim of enhancing the employment of people aged up to 25 who were not employed and not working. The programme was implemented via the employment centers and supported the non-working youth via education programmes, wage subsidies,

The reform proposal was first publicly discussed in Parliament on July 2, 2012 and the corresponding accepted law was officially announced on October 15, 2012. The JPA was effective from January 1, 2013. Due to the relatively short period of time between the discussion and enactment of the reform, anticipatory effects appearing before the implementation of the tax cut are likely to be negligible and we find no evidence of such effects in our empirical analysis. As the social contribution tax was cut in 2017 to 23.5%, the maximum allowance also decreased to 11% (capped at 11,000 HUF per month, given that the cap of 100,000 HUF remained in place).

While the JPA was enacted as a permanent tax cut, it was repealed at the end of 2018 by the same government introducing the allowance. Motivations behind the repeal were rather unclear. The government argued that employment of the elderly would still be incentivized as from the following year social security contributions would be eliminated for workers above the retirement age who also receive their pension. However, workers above age 55 but before retirement lost the benefits of the eliminated tax cut without any compensating interventions. Our data set does not cover years after 2017, so we are not able to assess the impact of the elimination of the policy.[3]

4 Data and Sample

We use linked employer-employee administrative data from Hungary, covering years 2003–2017 on a random 50% sample of the 2003 population.[4] We exclude years 2003-2010 from the analysis because before 2011, the employment rate increased at ages just above 55 due to changes in the pension system, interfering with the later impact of the payroll tax subsidy.

subsidies for entrepreneurship and subsidies for travel. According to the administrative data we use in the current analysis, in May 2017, the programme had 9,120 participants. The exclusion of the participants in the Youth Guarantee Programme does not affect our results.

[3]Saez, Schoefer and Seim (2019*a*) find that in Sweden a payroll tax cut for younger workers had an employment impact even after it was repealed.

[4]The monthly labor force status and wage indicators originate from the Central Administration of National Pension Insurance. The demographic indicators originate from the National Health Insurance Fund Administration. The firm-specific indicators originate from the National Tax and Customs Administration of Hungary.

In our main analysis, we use monthly data for years 2012-2017. In the analysis of wages, we use data from a representative month (May) of each year.[5] We restrict the sample to males because the average retirement rate is lower for females than for males and changes to the pension system affected the employment rate of women even at ages 56-57 over the analyzed time period (see Appendix Figure F1 for old-age pension rates). We show in Appendix F that the main results also hold for females.

An individual is defined to be a private sector employee if the pension authority records employment on the 15th of a month at a private sector firm. We exclude those employees who work fewer than 20 hours per week. We also exclude the few giant firms from the analysis (with firm size above 5,000). We observe gross wage, which includes all income that enter the pension benefit calculations. We do not observe taxes paid by firms or workers.

We generate a set of individual-, job- and firm-specific indicators that we use in the heterogeneity analyses. We group occupations into blue collar and white collar occupations based on International Standard Classification of Occupations (ISCO) codes, with ISCO codes 1-5 categorized as white collar and ISCO codes 6-9 as blue collar occupations. We categorize wages as above- or below-median based on median wages at age 27 (for younger workers) and 52 (for older workers). From occupation histories, we impute education levels. First, we impute the median education level of employees of the same 4-digit ISCO code as observed in the year 2013 edition of the Labor Force Survey of the Central Statistical Office of Hungary. Second, for each individual, using their occupation histories, we identify the highest level of the so imputed education levels. Due to the limited history of occupation, this imputation is not feasible for younger individuals.

We follow Bagger and Lentz (2019) to calculate a poaching index. Using data from a representative month (May) of 2011-2012, for each firm we calculate the fraction of hires that are poached from other firms (i.e., where the newly hired worker was employed at another firm the year before). We impute missing values of the poaching index using other

[5]Reported wages in the data are smoothed within employment spells and years.

firm-specific indicators (average wage, logarithm of firm size, foreign ownership) and then extrapolate the poaching index to years 2013-2017. As further indicators of firm quality, we calculate firm-level average wage and also classify firms as foreign-owned if foreign ownership is above 50%. We estimate revenue-based total factor productivity (TFP) by regressing the log of net turnover on log wage bill and log material cost; the estimated TFP is the sum of the firm fixed effects and residuals. We also perform an Abowd, Kramarz, Margolis (AKM) style decomposition of wages (Abowd, Kramarz and Margolis, 1999) and calculate firm and individual fixed effects (the correlation coefficient between the two fixed effects is 0.21).

In our main empirical analysis, we restrict the sample to males, use workers aged between 22-27 (with workers aged 22-24 comprising the treatment group and workers aged 25-27 serving as the control group) and workers between 52-57 (with workers aged 52-54 serving as the control group and workers aged 55-57 comprising the treatment group). Table 1 provides summary statistics on our data.

5 Results

5.1 Average payroll tax rate by age

Figure 1 depicts the average effective payroll tax rate by age before and after the payroll tax subsidy was implemented. It shows the discontinuities at ages 25 and 55 after the policy (in blue) compared to the constant rate of 28.5% before (in black). After the policy the average tax rate is lower than 28.5% (rate without subsidy) at all ages due to the not age-dependent beneficiary groups of the subsidy: employees working in elementary occupations, the long-term unemployed, people returning from child-care leave and career starters (the last three groups enjoyed a cut of 27% for the first two years, capped at 27,000 HUF per month). As a result some of the workers are also treated in the control age groups, nevertheless there is a jump from 17% to 23% from age 24 to 25 and a drop from 26% to 20% from age 54 to 55. (There are no discontinuities in the fraction of the other beneficiary groups at age 25 and

55, see Figure A1.) The higher than 14% tax rates among the treated are due to the cap at 14,500 HUF per month. The lower than 14% tax rates among the treated young below age 25 are the result of the larger tax cut of 27% for career starters in 2013 and 2014. The strong increase in average payroll tax rates by age among workers under age 25 is driven by the steady decline of career starters as worker age increases. Overall, this figure indicates that young and old workers are subsidized according to the aims of the age-dependent tax policy with a larger average effective tax cut for workers below age 25 than for workers above 55 between 2013-2016.

5.2 Effect on Employment

5.2.1 Descriptive Evidence

Figure 2 shows private plus public employment rates by age before and after the payroll tax subsidy was introduced in 2013. Panel (a) shows raw employment rates by age before (in black) and after (years 2013-2017, in gray) the policy. It shows that employment rates increase rapidly with age between ages 20 and 26, are roughly constant between ages 26 and 35 and then start slowly declining. Pre-reform, they dropped quite quickly starting at age 53. (The low employment of older workers was one of the rationales for the policy.) Comparing the period before and after the policy, this figure suggests that employment rates were similar in 2012 and 2013-2017 for most age groups, but show some divergence below 26 and above 50 with a growing gap above age 55.

Panel (b) shows estimates of the age-specific differences in employment before vs after the payroll tax subsidy was introduced. It suggests that for ages between 25 and 55 changes in employment rates were between -1 and +2 percentage points. The differences compared to 2012 are stronger in years 2016-2017 than in years 2013-2015. These differences do not appear to be systematic and are consistent with the presence of secular trends in employment with somewhat differing impacts across the age distribution. This panel also suggests that below the age 25 and above the age 55 cutoffs, age-specific employment levels strongly diverge

between the pre-reform and the post-reform periods. Among younger workers, a 24-year-old worker was close to 4 percentage points more likely to be employed shortly after the policy was introduced (years 2013-2017). The gap widens with age. Similarly, among older workers, a 55-year-old worker was 2 percentage points more likely to be employed shortly after the policy was introduced. The difference widens with age. Overall, this figure suggests that the payroll tax cut had a positive employment effect among both younger and older workers, concentrated in the specific age ranges targeted by the reform, with little evidence of either negative or positive spillovers across age groups.[6]

5.2.2 Baseline Results

To study the impact of the payroll tax subsidy in a difference-in-differences framework, we focus on two groups of treated workers. The first is younger workers under 25. We use workers aged 22-24 as our treated group and workers aged 25-27 as our control group. The second is older workers above 55. We use workers aged 55-57 as our treated group and workers aged 52-54 as our control group. Table 1 shows summary statistics on the two treatment and control groups. It suggests that they are relatively comparable, with the only major differences arising between treated and control individuals for private sector employment and wages among younger workers. Our empirical strategy controls for level differences in outcomes between the treatment and control groups. Relative to the before-after comparison above, this strategy has the advantage of allowing us to assess trends over time. The downside is that it focuses on narrower age groups around the cutoff. We estimate the equation

$$y_{it} = \alpha_a + \beta_q + \sum_q \delta_q Treated_{it} + \varepsilon_{it} \tag{18}$$

[6]Appendix Figure B1 shows employment rates by year and age. The figure shows that at ages 21-24, compared to 2012, the employment gap increased over years 2013-2016 and widened with age. Similarly, at ages 55-57, compared to 2012, the employment difference increased over years 2013-2016 and widened with age.

where y_{it} is the indicator of private sector employment of individual i in month t. The a age index runs from 22 to 27 for the younger workers and from 52 to 57 for the older workers. The quarterly date q index runs between $2010 - 2017$. The binary indicator $Treated$ is one for ages under 25 (young treated) or for ages at and above 55 (old treated). The δ_q terms are quarter-specific dummies. In all regression models, we cluster the standard errors at the individual level.

We also estimate a pooled version of equation (18) where we replace the quarter-specific δ_t terms with a binary indicator $After$ which equals zero for year 2012 and one for years $2013 - 2017$, i.e. after the introduction of the JPA in 2013:

$$y_{it} = \alpha_a + \beta_q + \delta After_t Treated_{it} + \varepsilon_{it}. \tag{19}$$

Our coefficients of interest are the δ terms in both equations. The identifying assumption is that besides age and quarterly date fixed effects, the remaining differences between treated and control workers in employment are only due to the policy.

Figure 3 shows the quarter-specific effect of the tax cut on employment in private sector companies. This figure suggests that prior to the introduction of the policy, the employment rates of treated and control workers evolved similarly, suggesting that the control workers are likely good counterfactuals for the treatment workers. The impact on employment increased gradually over 2013-2017 from 1 percentage point to 3 percentage points among younger workers and from 0.5 percentage point to 1 percentage point among older workers. This could be because employer-employee matches may take time to form even if firms are incentivized to hire more workers from the subsidized age group. Since the outcome is private-sector employment in a given month, it also reflects the cumulative effect of increased hiring on the rate of employment. Appendix C shows that the impact of the subsidy both on the entry into and exit from private sector employment is roughly constant between 2014-2017 in both subsidized age groups.[7]

[7]Saez, Schoefer and Seim (2019*b*) also find that employment effects increase over time after the introduc-

The first part of Table 2 shows the baseline difference-in-differences results, corresponding to equation (19). The tax cut of an average 8.3 percentage points (young) or 6.2 percentage points (old) is estimated to increase the private sector employment of people aged 22-24 by 1.98 percentage points (6.1%) and of people aged 55-57 by 0.84 percentage points (2.5%) over the years 2013-2017. The implied labor demand elasticity is 0.903 (SE 0.096) for the young (young employment increases by 6.1%, labor cost decreases by 6.7%) and 0.504 (SE 0.126) for the old (old employment increases by 2.5%, labor cost decreases by 4.9%). Based on the results reported in Appendix Table G1, the short-run demand elasticity is 0.310 (SE 0.087) for the young and 0.252 (SE 0.108) for the old. The short-run elasticity estimates are about 1-1.5 times higher than the demand elasticities estimated by Saez, Schoefer and Seim (2019*b*) (0.23), Laun (2017) (0.22) and Egebark and Kaunitz (2018) (0.3). Huttunen, Pirttilä and Uusitalo (2013) estimate even lower elasticities (0.07-0.13).

Placebo Analyses. We conduct a sequence of placebo analyses, where we assume that the treatment ages were 25-27, 26-29, ..., 30-32 among younger workers (using ages 28-30, 39-31, ..., 33-35 as control) and 47-49, 48-50, ..., 52-54 among older workers (using ages 44-46, 45-47, ..., 49-51 as control). This is similar in spirit to the estimates of age-specific changes in Section 5.2.1. The results are reported in panels (b) and (d) of Figure 4. Under the placebo treatments, the treatment effects are close to zero and mostly statistically insignificant.

5.2.3 Heterogeneity

We conduct three sets of heterogeneity analyses. In the first two sets of heterogeneity analyses, we investigate if the treatment effect differs by firm and job characteristics. Here, we again use equation (19) but replace the outcome variable with binary indicator of employment in a given type of job or firm. Then, we look at heterogeneities in the treatment effect by individual characteristics.

tion of a payroll tax subsidy.

In Table 2, we also show how the impact of the payroll tax cut varies by firm characteristics. Overall, we see positive employment effects for all firm types and for both affected age groups, although some of the estimated effects are statistically and economically insignificant. However, we see major differences in the results between the two age groups. As a consequence of the tax cut, the private sector employment of older workers increases mostly at worse quality firms —firms with below median poaching index, domestic firms, firms with below-median TFP, and worse paying firms (measured as the average of wage). Among younger workers, the treatment effects are more balanced across firm types.

In the top part of Table 3, we present heterogeneity results by individual characteristics. Among younger workers, the employment effect is stronger in districts with higher year-specific employment rates. Appendix Table F1 indicates that the effect of the policy does not appear to be heterogeneous by gender.

Next, we investigate whether the impact of the payroll tax cut on employment in private sector companies differs by job characteristics. The average effects of the tax cut are reported in the lower part of Table 3. As a results of the payroll tax cut, among younger workers, the employment probability increases more in blue collar and white collar jobs but among older workers, the increasing impact is much smaller in white collar jobs. Among younger workers, the treatment effect is realized only in occupations characterized by higher separation rates, whereas among the old, the treatment effect is stronger in occupations with lower separation rates.

5.3 Effect on Wages

In this part, we focus on years 2012-2013 (2012 is the last year before the implementation of the policy). We restrict the sample to ages 22-27 for younger workers (22-24 are the treatment ages, 25-27 are the control ages) and 52-57 for older workers (52-54 are the control ages, 55-57 are the treatment ages). Due to data limitations (some wages are smoothed within a job spell), we cannot use monthly wage data. Instead, we calculate the mean annual wage and

then restrict the sample to May of each year.

To analyze the impact of the tax subsidy on wages, we estimate the following regression:

$$ln(w_{it}) = \xi_a + \eta_t + (\phi_a + \zeta_t)ln(w_{it-1}) + \psi X_{it} + \theta_t Treated_{it} + \nu_{it}, \tag{20}$$

where w_{it} is the monthly wage adjusted for working hours of individual i at time t (May of years 2012-2013). We include age effects (ξ_a) and calendar year effects (η_t) in the model. We also include the age-specific and year-specific effects of the one-year lag of wage ($ln(w_{it-1})$). The X_{it} vector of control variables includes occupation dummies, log firm size, the binary indicator of the poaching index of the firm being above the median, and the binary indicator of foreign ownership. The rationale for this specification is that lagged wage, occupation and firm characteristics can capture unobserved individual characteristics that affect current wages and are related to treatment status (age $\times$ calendar year). The coefficient of interest is θ_t, which is the year-specific coefficient of treatment age ($Treated_{it}$). In addition to estimating the average treatment effect on wages, we also allow the treatment effect to vary with indicators of firm quality.

By definition, equation (20) is estimated on the sample of private sector workers who also worked in the private sector during the previous year (i.e., for whom the lagged wage indicator is not missing), thus, new entrants are excluded from the regression. Among younger private sector workers (age 22-27), 31% are new entrants. Among older private sector workers (age 52-57), 12% are new entrants.

The results of the wage regressions are reported in Table 4. On average, the payroll tax subsidy decreases wages at younger ages by a statistically insignificant -0.60%, while at older ages the effect on wage is 0.51% (significant at the 10% level). Heterogeneity results by the poaching index, TFP, firm fixed effects, and firm-level average wage show that among older workers, the positive wage effect is stronger at higher-quality firms. Among younger workers, the heterogeneity patterns are mixed. [8]

[8] Appendix Table G1 indicates that while the estimated employment effects are smaller on the restricted

5.4 Employment versus wages

Figure 6 relates the wage effects to the employment effects and shows heterogeneity in the incidence of the payroll tax subsidy by the poaching index and worker age. Overall, we see a negative relationship between the impact on employment and wages—the wage effect of the payroll tax subsidy is stronger if the employment effect is weaker. As a result of the payroll tax cut, the employment of older workers increase at lower-quality firms where wages are less affected. At the same time, the employment of older workers does not increase significantly at higher-quality firms but we observe positive wage effects there. These findings are in line with our conceptual framework in Section 2. Among younger workers, the employment increases more at higher-quality firms, where the wage effect is smaller (even negative).

Figure **??** presents the relationship between employment and wage effects at the level of industries. We find that there is a negative relationship between industry-level wage and employment effects: industries that experienced a higher wage effect had lower industry effects and vice versa. This relationship is noisy, but exists for both younger and older workers. These results are similar in flavor to those reported by Nekoei and Weber (2017) who find that the effect of unemployment insurance on wages is negatively related to the effect of unemployment insurance on non-employment duration across samples.

6 Conclusion

This paper provides theoretical and empirical evidence for heterogeneities in the impact of payroll tax subsidies on employment and wage by firm and worker types. Based on an equilibrium search model we show that the effect of a fixed amount of payroll tax subsidy is positive on employment but this effect decreases with firm productivity. On the other hand, the positive effect on wages increases with firm productivity. The model also implies that the subsidy does not affect the wages of new entrants.

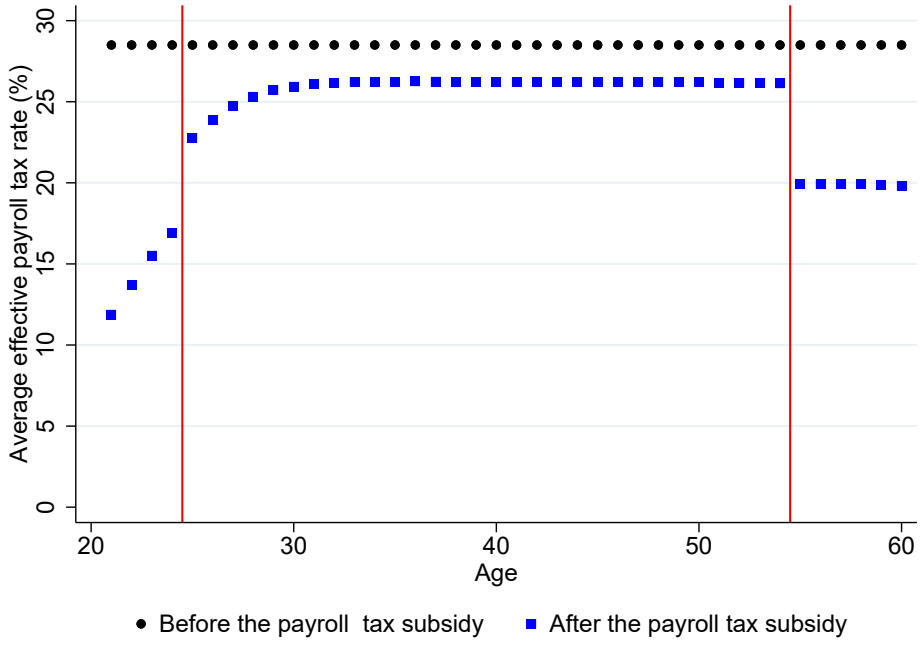
sample (years 2012-2013) than on the longer horizon, the heterogeneity patterns by firm characteristics are similar.

Based on the introduction of age-dependent payroll tax reductions in Hungary and using rich administrative data, we provide empirical evidence that supports the predictions of our model. We estimate positive employment effects among both younger and older workers and small positive wage effects among older workers. However, there are substantial heterogeneities across job and firm types among older workers, but less so among younger workers. Among older workers, the positive effect of the payroll tax cut on employment is much higher for lower-quality jobs and lower-quality firms, while the wage effect is stronger at higher-quality firms.

Overall, our results suggest that—at least among the experienced (older) workers—for lower-quality firms and lower-skilled workers, the incidence of payroll tax cuts mainly falls on firms, while for higher-quality firms and higher-skilled workers, the incidence mainly falls on workers.

Figures and Tables

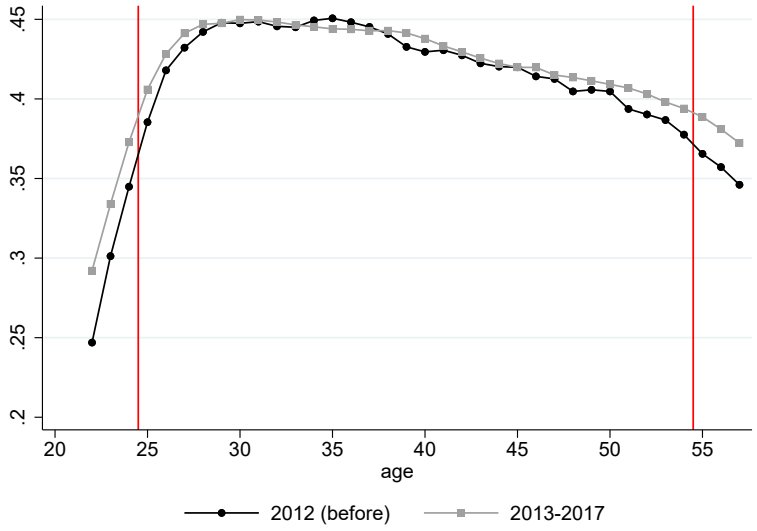
Figure 1: Average payroll tax rate (males)



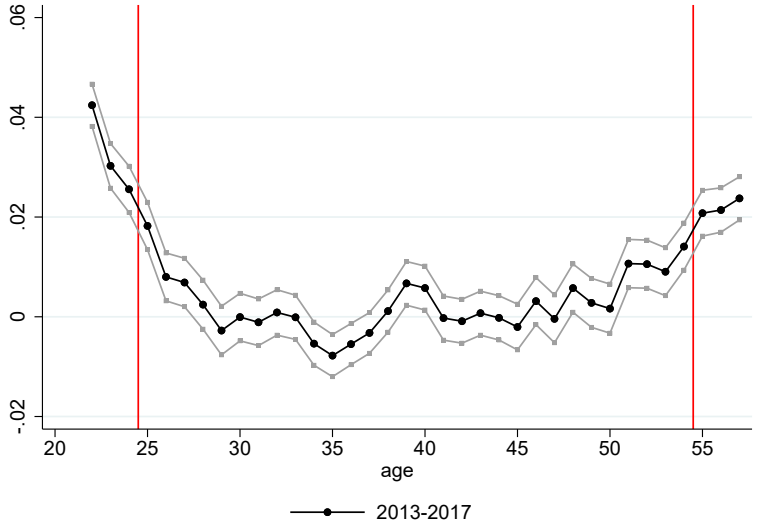
Notes: This figure shows the average payroll tax rate by worker age. Before the implementation of the payroll tax subsidy, the payroll tax rate was a flat 28.5%. Between 2013-2017 (after the implementation of the subsidy), the payroll tax rate was 28.5% minus the subsidy. Using the observed gross wages in years 2013-2017 and the prevalence of beneficiaries, we calculate the effective payroll tax rate. We consider the following beneficiary groups: ages below 25 and at or above 55; career starters (who had a work experience of less than 180 days); long-term unemployed (who were registered unemployed for at least 6 months the previous 9 months); people returning to work after a child-care leave and people working in elementary occupations. Figure A1 shows the prevalence of the beneficiary groups by age. The age-specific subsidy and the subsidy of elementary occupations was 14.5% but capped at 14,500 HUF per month. The subsidy of career starters, long-term unemployed and people returning to work after a child-care leave was 27% but capped at 27,000 HUF per month. The capped 27% subsidy could be claimed only for two years.

Figure 2: Employment in private sector companies by age (males)

(a) Employment Rate



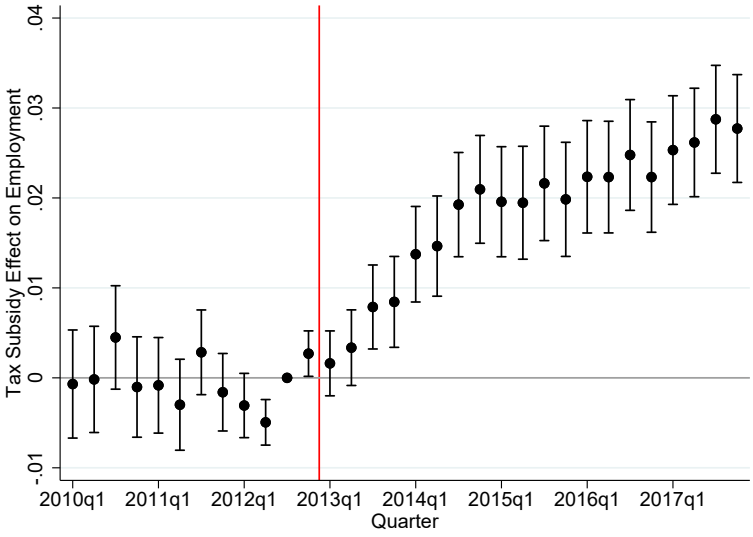
(b) Change in Employment Rate



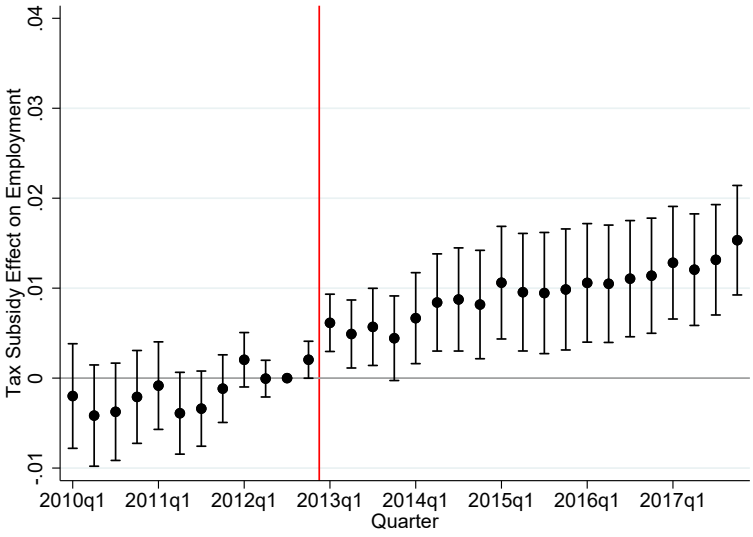
Note: Panel (a) shows the employment rate in private sector companies by age separately for year 2012 (before the implementation of the payroll tax subsidy) and for years 2013-2017 (after the implementation of the payroll tax subsidy). Panel (b) shows the differences between years 2013-2017 and 2012, net of age and quarterly date effects, with the 95% confidence interval. The vertical red lines shows the age thresholds where the tax subsidy became effective from 2013. The subsidy affected workers younger than 25 and older than 55.

Figure 3: Effect of the Payroll Tax Subsidy on Employment in Private Sector Companies

(a) Young

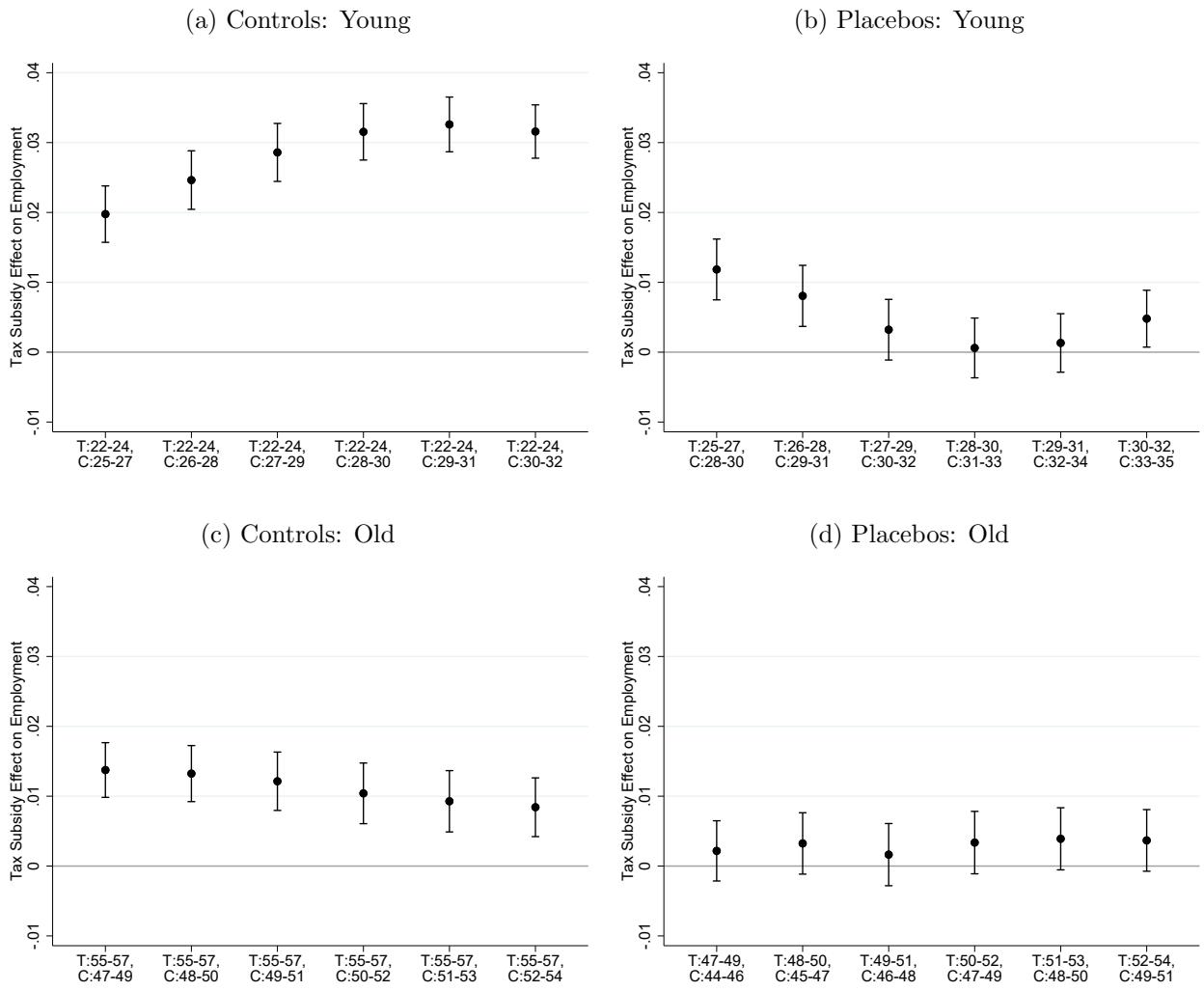


(b) Old



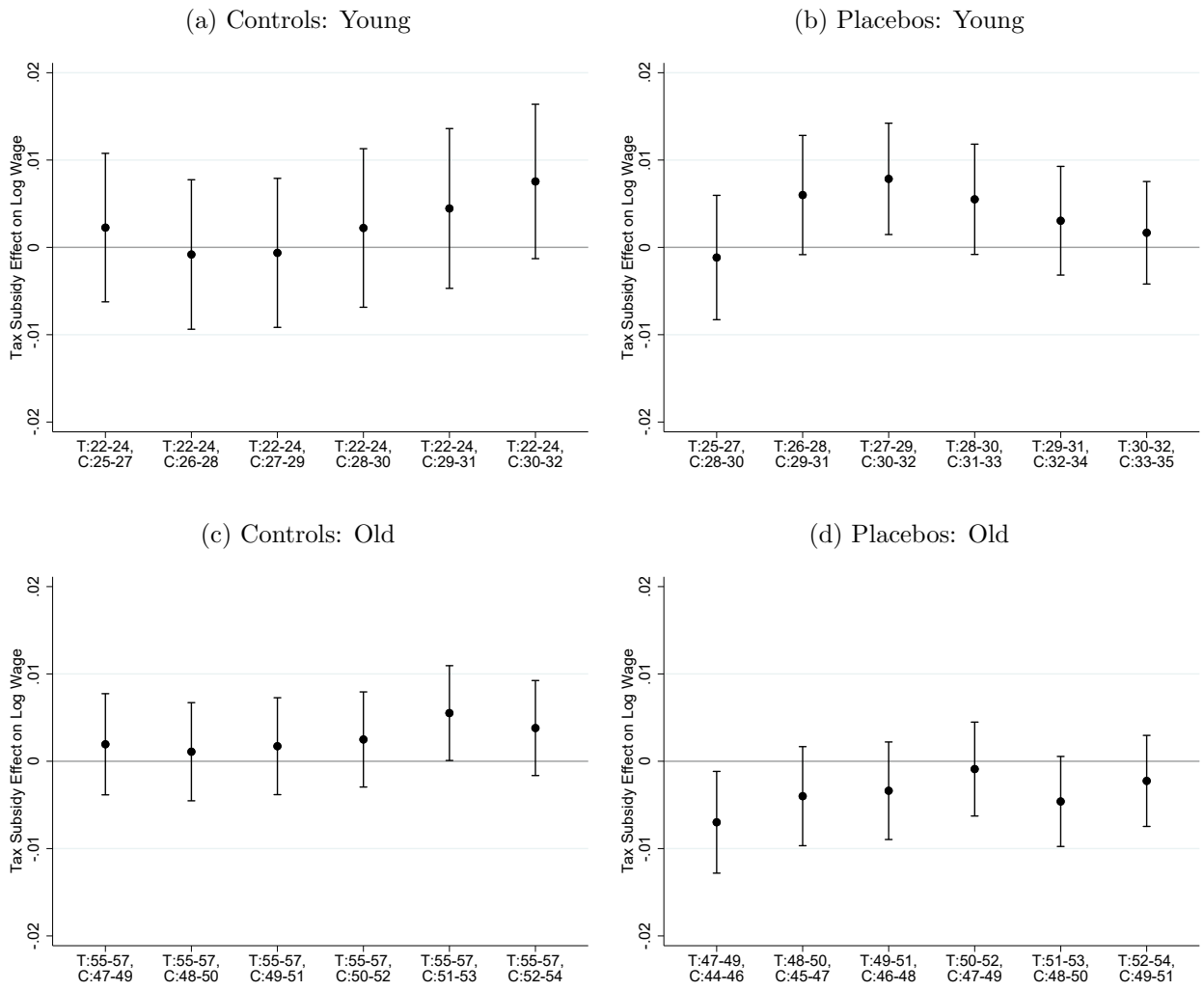
Notes: The figures show the change in employment for treated age groups (affected by the payroll tax subsidy) relative to the control age groups (similar age group, but unaffected by the tax subsidy) before and after the reform. In particular, we plot the δ_q from equation (18). Panel (a) shows the estimates for the young where the treated individuals are aged between 22 and 24, while the control individuals are aged 25 to 27. Panel (b) shows the estimates for the old, where the treated individuals are aged 55 to 57, while the control individuals are aged 52 to 54. The 95% confidence intervals are reported, where the standard errors are clustered at the worker-level.

Figure 4: Private sector employment: alternative control ages and placebo analyses



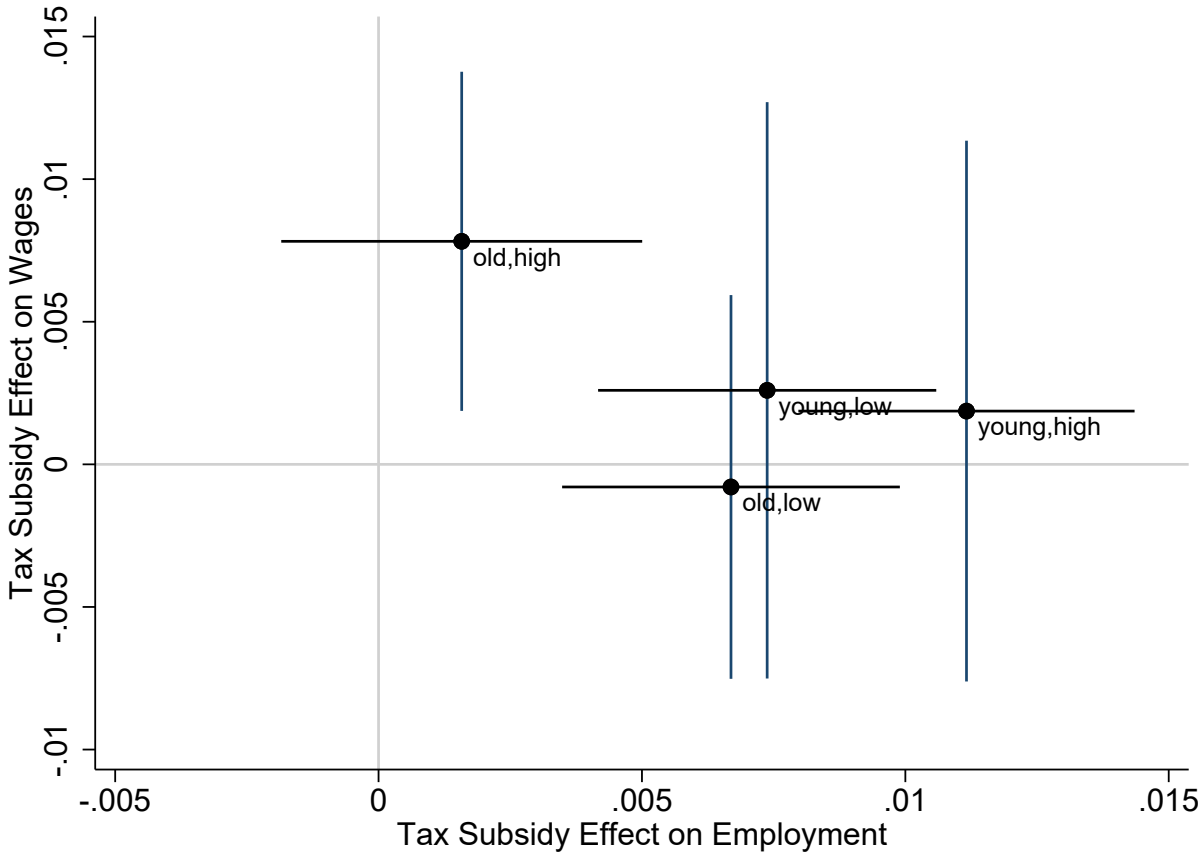
Notes: The figures show estimated employment effects with the corresponding 95% confidence intervals, based on equation (19). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2017 period (after the introduction of the payroll tax subsidy in 2013). "T" denotes treatment group ages, "C" denotes control group ages. In panels (a) and (c), we keep the treatment group the same and vary the control group. In panels (b) and (d), we vary both the control and the treatment groups.

Figure 5: Wages: alternative control ages and placebo analyses



Notes: The figures show estimated log wage effects with the corresponding 95% confidence intervals, based on equation (20). The sample is restricted to years 2012 (before the introduction of the payroll tax subsidy) and 2013 (after the introduction of the payroll tax subsidy). "T" denotes treatment group ages, "C" denotes control group ages. In panels (a) and (c), we keep the treatment group the same and vary the control group. In panels (b) and (d), we vary both the control and the treatment groups.

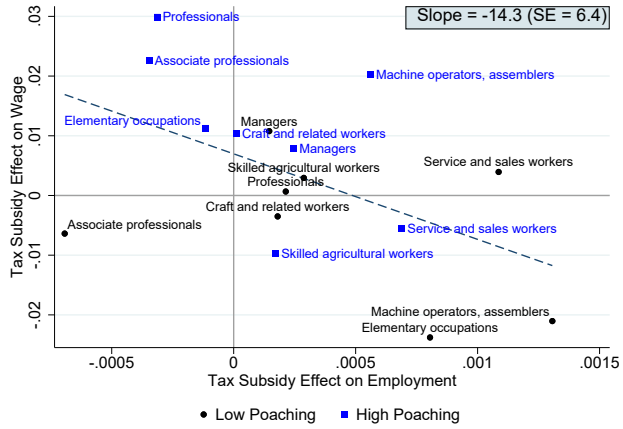
Figure 6: Heterogeneity of Treatment Effects By Subgroups



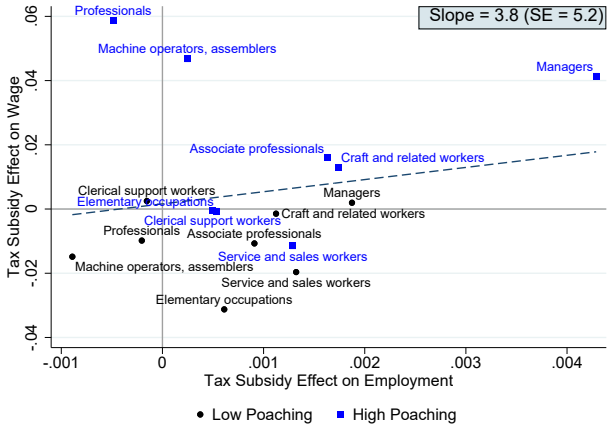
Notes: The figure shows the estimated employment effects (x-axis) and wage effects (y-axis) with the corresponding 95% confidence intervals for four sub-groups: old workers at high-poaching firms, old workers at low-poaching firms, young workers at high-poaching firms, and young workers at low poaching firms. "High" refers to above median poaching index, "low" refers to below median poaching index. The estimated effects are from equation (19) for employment and (20) for wage. The employment effects are estimated on years 2012-2017, the wage effects are estimated on years 2012-2013. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54.

Figure 7: Heterogeneity of Treatment Effects by Occupation

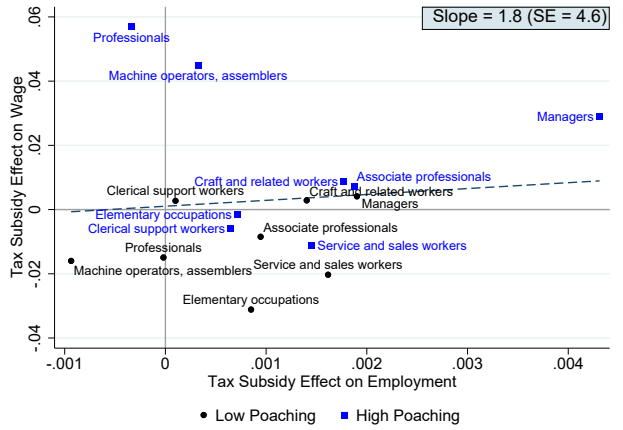
(a) Old



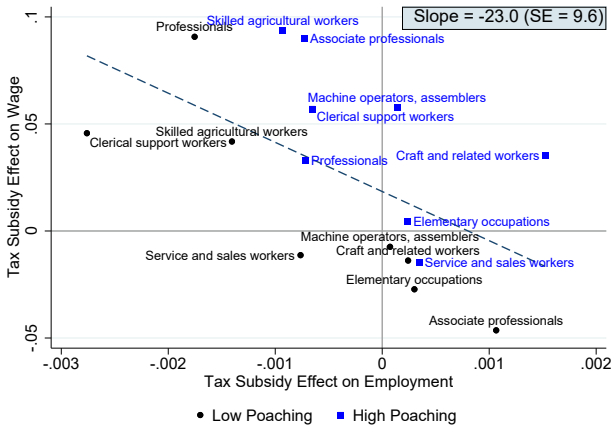
(b) Young (no restriction)



(c) Young, less than 6 months work at age 18-19



(d) Young, at least 6 months work at age 18-19



Notes: The figure shows the estimated employment effects (x-axis) and wage effects (y-axis) for one-digit ISCO occupation categories and workers at high-poaching and low-poaching firms. "High" refers to above median poaching index, "low" refers to below median poaching index, where the median is occupation specific. The estimated effects are from equation (19) for employment and (20) for wage. The employment effects are estimated on years 2012-2017, the wage effects are estimated on years 2013-2015. To make the employment effects comparable across different sized occupation categories, we divide the employment effects with the share of the occupation in the age group and multiply with the average share. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. In each figure, we exclude the occupation with the fewest number of workers in the analyzed age group in year 2012.

Table 1: Summary statistics (males)

	young		old	
	age 22-24 (treated)	age 25-27 (control)	age 52-54 (control)	age 55-57 age (treated)
Private sector employment	0.303	0.394	0.360	0.342
Monthly private sector wage (HUF)	178,823	215,055	248,774	242,050
Education level (1-primary to 3-tertiary)			1.826	1.786
Firm quality (private sector workers)				
Above median poaching index	0.476	0.523	0.548	0.545
Above median TFP	0.556	0.596	0.520	0.508
Above median firm FE	0.503	0.543	0.499	0.502
Above median firm level average wage	0.484	0.546	0.518	0.520
Foreign ownership	0.318	0.348	0.208	0.195
Industry (private sector workers)				
Agriculture	0.039	0.034	0.076	0.083
Manufacturing	0.380	0.361	0.329	0.329
Construction	0.081	0.076	0.106	0.106
Wholesale and retail trade	0.145	0.147	0.119	0.111
Accommodation and food service	0.056	0.042	0.017	0.016
Transportation and storage	0.054	0.063	0.113	0.109
Information and communication	0.011	0.017	0.012	0.010
Financial and insurance activities	0.186	0.208	0.121	0.125
Other	0.048	0.052	0.107	0.111
Total number of observations	6,458,610	6,578,087	6,665,956	7,146,295

Note: The table shows summary statistics for treated and and control group workers over years 2012-2017. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. The poaching index is calculated following Bagger and Lentz (2019). Using data from a representative month (May) of 2011-2012, for each firm we calculate the fraction of hires that are poached from other firms (i.e., where the newly hired worker was employed at another firm the year before). We impute missing values of the poaching index using other firm-specific indicators (average wage, logarithm of firm size, foreign ownership) and then extrapolate the poaching index to years 2013-2015. We calculate revenue-based total factor productivity (TFP) by regressing the log of net turnover on log wage bill and log material cost; the estimated TFP is the sum of the firm fixed effects and residuals. We calculate firm fixed effects from the Abowd-Kramarz-Margolis (AKM) model described in Abowd, Kramarz and Margolis (1999). We regress wages on individual and firm fixed effects, controlling for year fixed effects, using individuals who move between firms to identify the fixed effects. Foreign ownership refers to companies that are more than 50% owned by a foreign entity.

Table 2: Heterogeneity by firm characteristics: Impact on employment in private sector companies

	Employment of Young Age 22-27	Employment of Old Age 52-57
Average treatment effect	0.0198***	0.0084***
	[0.0021]	[0.0021]
Poaching index (PI)		
Below median PI, treatment effect	0.0074***	0.0067***
	[0.0016]	[0.0016]
Above median PI, treatment effect	0.0112***	0.0016
	[0.0016]	[0.0017]
p-value of equality test	0.133	0.050
TFP		
Below median TFP, treatment effect	0.0083***	0.0068***
	[0.0013]	[0.0015]
Above median TFP, treatment effect	0.0048***	0.0017
	[0.0016]	[0.0016]
p-value of equality test	0.108	0.026
Firm FE (based on AKM decomposition)		
Below median FE, treatment effect	0.0138***	0.0061***
	[0.0016]	[0.0016]
Above median FE, treatment effect	0.0053***	0.0027
	[0.0017]	[0.0017]
p-value of equality test	0.000	0.195
Firm level average wage		
Below median, treatment effect	0.0128***	0.0067***
	[0.0016]	[0.0016]
Above median, treatment effect	0.0068***	0.0020
	[0.0017]	[0.0018]
p-value of equality test	0.019	0.077
Foreign ownership		
Domestic firm, treatment effect	0.0184***	0.0094***
	[0.0018]	[0.0020]
Foreign firm, treatment effect	0.0016	-0.0007
	[0.0014]	[0.0012]
p-value of equality test	0.000	0.000

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates from the model in equation (19). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2017 period after the 2013 introduction of the payroll tax subsidy. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets. In each regression, the outcome is the binary indicator of private sector employment at a firm with the given characteristic. In each regression, we control for age and quarterly date effects. The equality of the coefficients is tested with a Wald-test (using Stata's *suest* command).

Table 3: Heterogeneity by individual and job characteristics: Impact on employment in private sector companies

	Employment of Young Age 22-27	Employment of Old Age 52-57
Heterogeneity by individual characteristics		
Imputed education level		
Primary education, treatment effect		0.0024**
		[0.0010]
Secondary education, treatment effect		0.0013
		[0.0012]
Tertiary education, treatment effect		-0.0011
		[0.0015]
p-value of equality test		0.008
Heterogeneity by job characteristics		
Skill		
Blue collar job, treatment effect	0.0134***	0.0094***
	[0.0019]	[0.0020]
White collar job, treatment effect	0.0063***	-0.0010
	[0.0013]	[0.0013]
p-value of equality test	0.005	0.000

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates from the model in equation (19). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2017 period after the 2013 introduction of the payroll tax subsidy. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets. In each regression, we control for age and quarterly date effects. The control variables are interacted with the heterogeneity indicator in the analysis of heterogeneity by individual characteristics. In the regressions of heterogeneity by job characteristics, the outcome is the binary indicator of private sector employment at a job with the given characteristic. When checking the heterogeneity by education level, we also control for the 12-month lag of private sector employment to capture the huge heterogeneities in labor force attachment by education level. The equality of the coefficients is tested with an F-test in the case of the eduction level and with a Wald-test (using Stata's *suest* command) in the case of skill level.

Table 4: Average treatment effect on log wage by firm quality indicators

	Log Wage of Young Age 22-27	Log Wage of Old Age 52-57
Average treatment effect	0.0023	0.0038
	[0.0043]	[0.0028]
Poaching index (PI)		
Below median PI, treatment effect	0.0026	-0.0008
	[0.0052]	[0.0034]
Above median PI, treatment effect	0.0019	0.0078**
	[0.0048]	[0.0030]
p-value of equality test	0.885	0.009
TFP		
Below median TFP, treatment effect	-0.0079	-0.0021
	[0.0055]	[0.0035]
Above median TFP, treatment effect	0.0038	0.0080**
	[0.0059]	[0.0041]
p-value of equality test	0.053	0.014
Firm FE (based on AKM decomposition)		
Below median FE, treatment effect	-0.0091*	0.0013
	[0.0047]	[0.0032]
Above median FE, treatment effect	0.0156***	0.0063
	[0.0057]	[0.0041]
p-value of equality test	0.000	0.274
Firm level average wage		
Below median, treatment effect	-0.0035	-0.0034
	[0.0045]	[0.0031]
Above median, treatment effect	0.0119**	0.0108***
	[0.0057]	[0.0041]
p-value of equality test	0.011	0.003
Foreign ownership		
Domestic firm, treatment effect	-0.0045	0.0028
	[0.0045]	[0.0028]
Foreign firm, treatment effect	0.0156**	0.0093*
	[0.0063]	[0.0054]
p-value of equality test	0.001	0.200

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates of the model in equation equation (20). We report difference-in-differences estimates of wages allowed to vary with firm quality indicators. The sample is restricted to years 2012 (before the introduction of the payroll tax subsidy) and 2013 (after the introduction of the payroll tax subsidy). Firm quality indicators are measured in 2013. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets. The equality of the coefficients is tested with a t-test.

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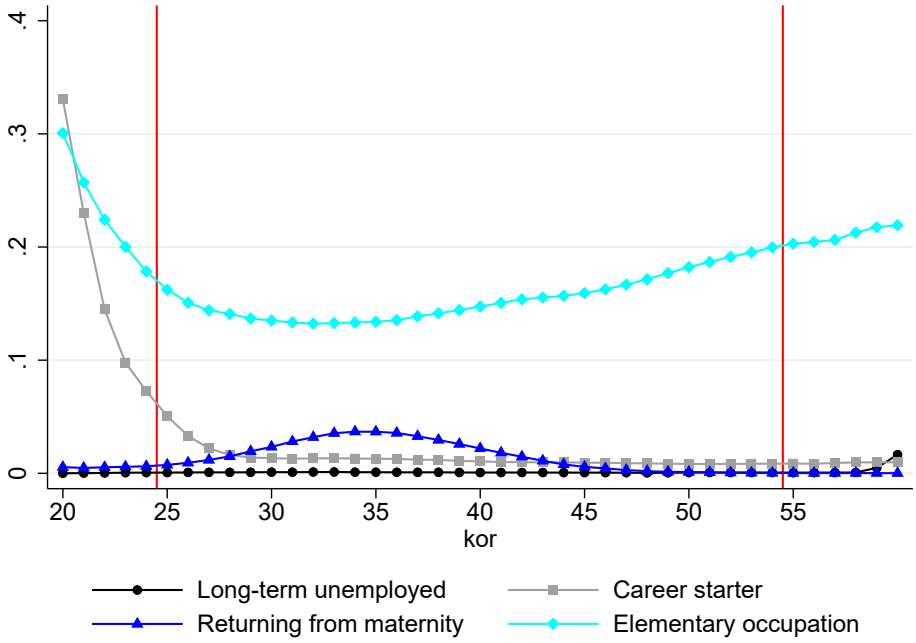
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Appendix

A Not age-dependent beneficiary groups

Appendix Figure A1: Fraction of not age-dependent beneficiary groups among private sector workers

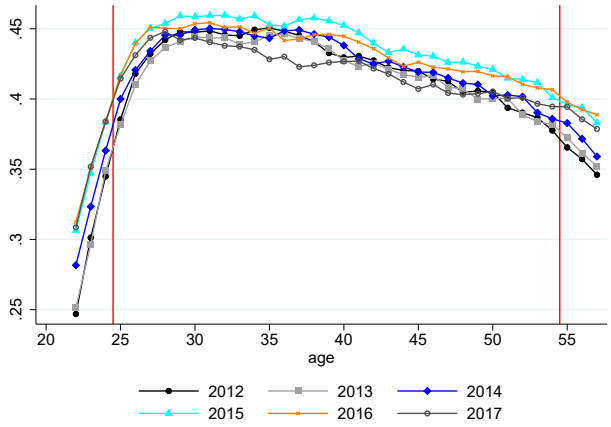


Note: The table shows the fraction of not age-dependent beneficiary groups among private sector workers over years 2013-2017 both for males and females. The long-term unemployed were registered unemployed for at least 6 months during the previous 9 months. Career starters had at most 180 days of prior employment. People returning from maternity are those who start an employment after receiving maternity payments. Elementary occupations correspond to ISCO code 9.

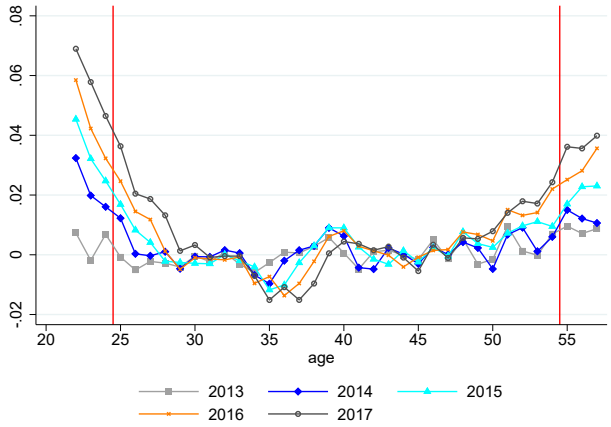
B Employment over years by age and placebos

Appendix Figure B1: Employment in private sector companies by age (males)

(a) Employment Rate



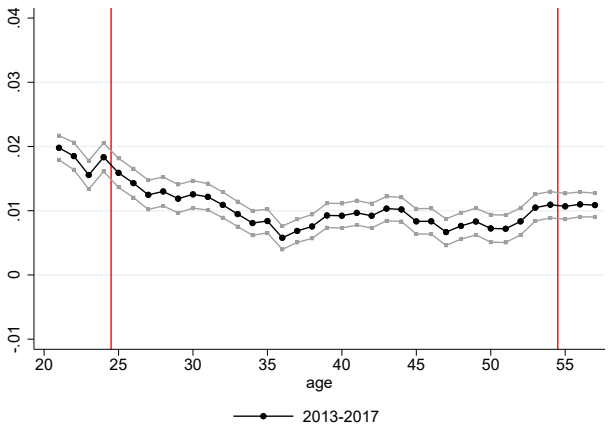
(b) Change in Employment Rate



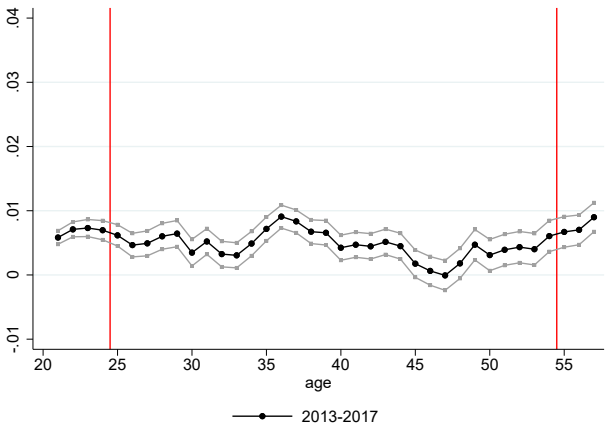
Note: Panel (a) shows the employment rate in private sector companies by age for years 2012-2017. Panel (b) shows the difference between years 2013-2017 and 2012, adjusted to mean zero at ages 28-51 (i.e., at ages that are neither in the treatment nor in the control groups in the difference-in-differences estimations). The vertical red lines shows the age thresholds where the tax subsidy became effective from 2013. The subsidy affected workers younger than 25 and older than 55.

Appendix Figure B2: Change in employment rate in placebo groups

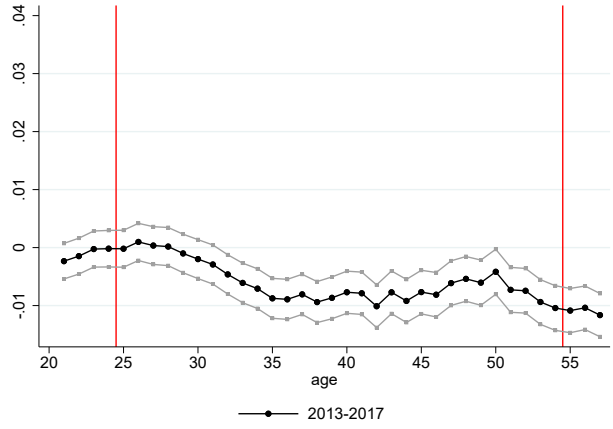
(a) Elementary Occupation Employment Rate



(b) Public Sector Employment Rate



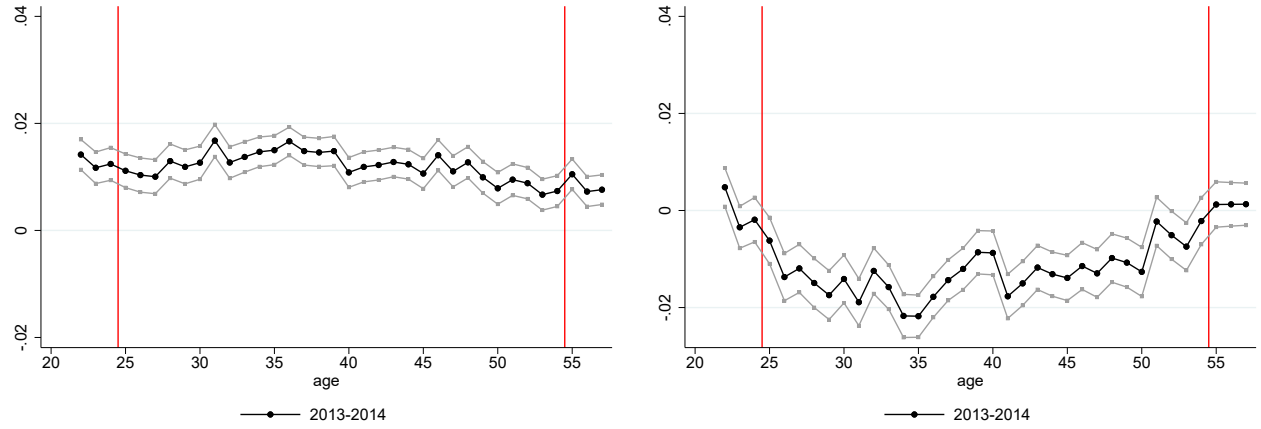
(c) Self-Employment Rate



Note: Panel (a) refers to employment in elementary occupations (ISCO-08 code 9), which occupation category was eligible for payroll tax subsidy without age restrictions. Panel (b) refers to employment in the public sector where the payroll tax subsidy did not apply. Panel (c) refers to the self-employed who were not eligible for paroll tax subsidy. All panels show the difference between years 2013-2017 and 2012, net of age and quarterly date effects, with the 95% confidence interval. The vertical red lines shows the age thresholds where the tax subsidy became effective from 2013. The subsidy affected workers younger than 25 and older than 55.

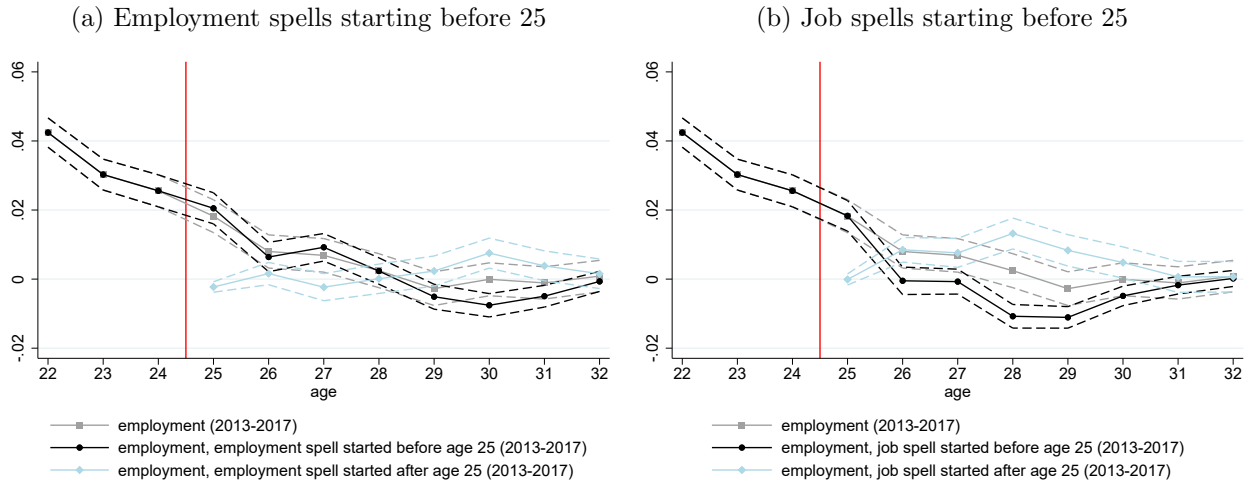
Appendix Figure B3: Change in employment rate in private sector companies by job duration

(a) Employment in jobs lasting less than 3 more years (b) Employment in jobs lasting at least 3 more years



Note: Panel (a) refers to employment where the worker is employed at another firm or is non-employed 36 months later. Panel (b) refers to employment where the worker is employed at the same firm 36 months later. Both panels show the difference between years 2013-2014 and 2012, net of age and quarterly date effects, with the 95% confidence interval. The vertical red lines shows the age thresholds where the tax subsidy became effective from 2013. The subsidy affected workers younger than 25 and older than 55.

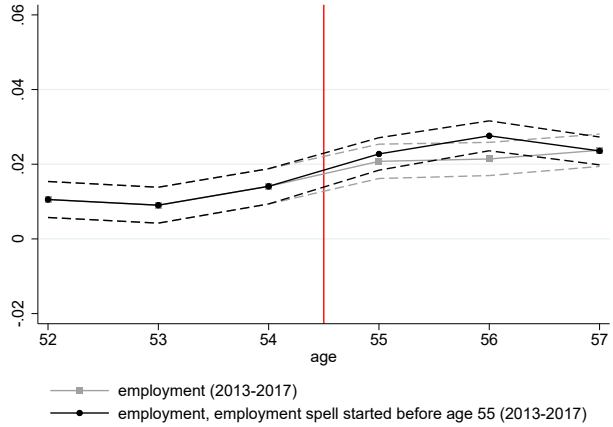
Appendix Figure B4: Employment in private sector companies by age (males), employment or job spells starting before age 25



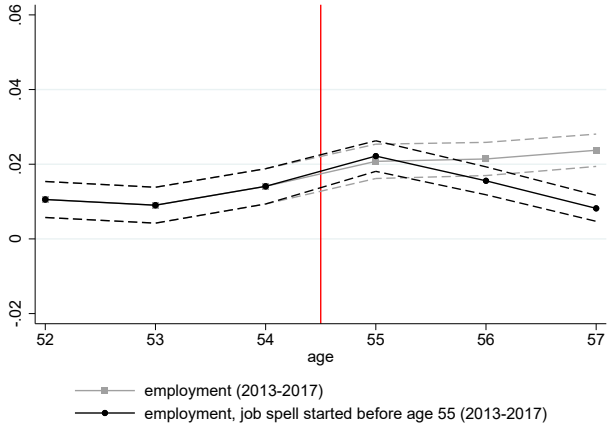
Notes: The figure shows the differences between years 2013-2017 and 2012, net of age and quarterly date effects, with the 95% confidence interval. The gray line refers to any employment in private sector companies, the black line refers to employment (panel a) or job (panel b) in private sector companies that started before age 25. The vertical red line shows the age threshold (age 25) where the tax subsidy became effective from 2013.

Appendix Figure B5: Employment in private sector companies by age (males), employment or job spells starting before age 55

(a) Employment spells starting before 55



(b) Job spells starting before 55



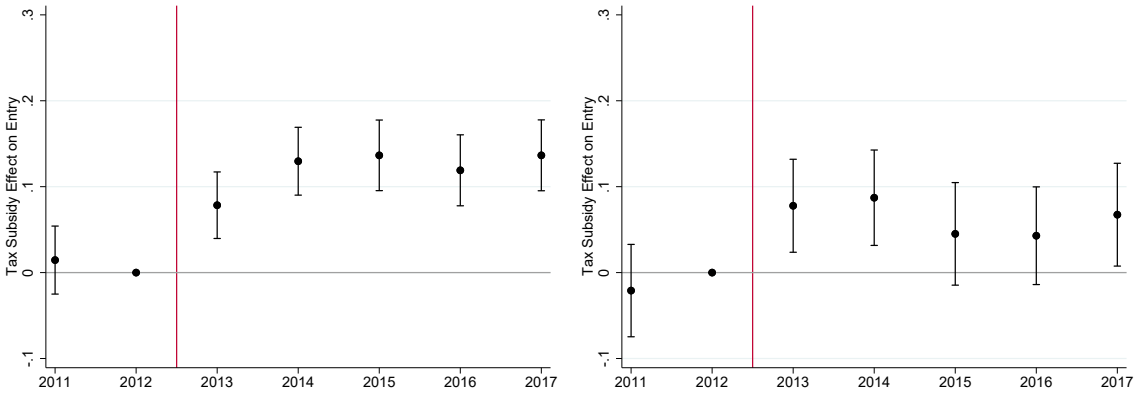
Notes: The figure shows the differences between years 2013-2017 and 2012, net of age and quarterly date effects, with the 95% confidence interval. The gray line refers to any employment in private sector companies, the black line refers to employment (panel a) or job (panel b) in private sector companies that started before age 55. The vertical red line shows the age threshold (age 55) where the tax subsidy became effective from 2013.

C Effect on employment transitions

Appendix Figure C1: Effect of the payroll tax cuts on entry and exit, relative to the transition rates in year 2012 at ages 22-24 (young) or 55-57 (old)

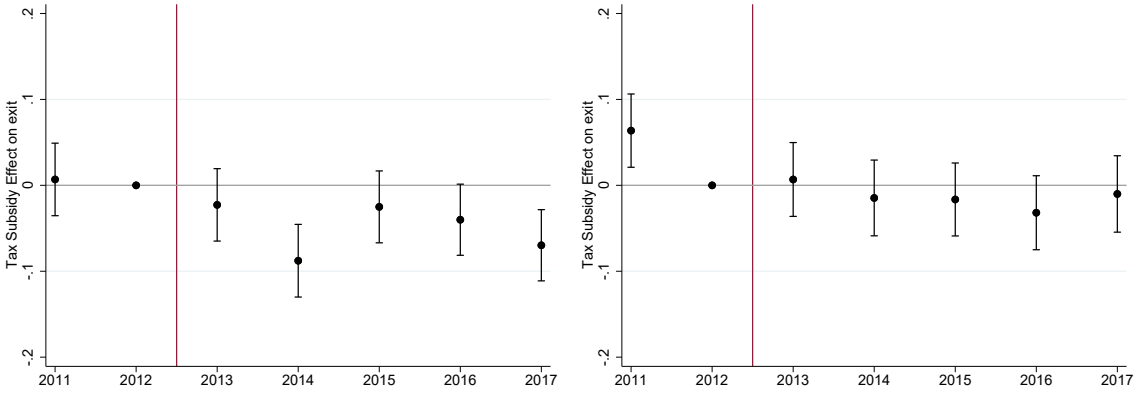
(a) Young, age 22-27, entry

(b) Old, age 52-57, entry



(c) Young, age 22-27, exit

(d) Old, age 52-57, exit



Notes: Entry is defined as working in the private sector, conditional on not working in the private sector 12 months before. Exit is defined as not working in the private sector, conditional on working in the private sector 12 months before. The data is restricted to May of each year, the reference year is 2012. Coefficients of interaction term between quarterly date (reference: 2012) and treatment age are displayed with 95% CI. Annual date and age dummies are included as controls (as in equation (18)). Panels (a) and (c) show the estimates for the young where the treated individuals are aged between 22 and 24, while the control individuals are aged 25 to 27. Panels (b) and (d) show the estimates for the old, where the treated individuals are aged 55 to 57, while the control individuals are aged 52 to 54. All numbers are relative to the transition rates in year 2012 at ages 22-24 (young) or 55-57 (old). The young exit rate is 0.25, the young entry rate is 0.14. The old exit rate is 0.15, the old entry rate is 0.07.

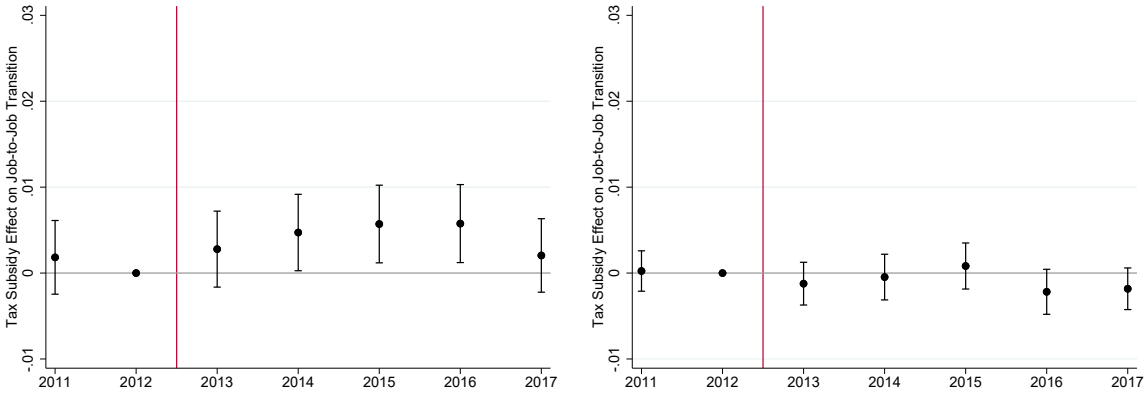
Appendix Table C1: Effect of the payroll tax cuts on entry by original labor force status

	Young (age 22-27)			Old (age 52-57)		
	coefficient (SE)	baseline entry rate	% of entrants	coefficient (SE)	baseline entry rate	% of entrants
other sector	0.0039	0.156	17.43	0.0003	0.092	29.66
	(0.0047)			(0.0021)		
student	0.0505***	0.111	18.11	-0.0014	0.040	0.10
	(0.0027)			(0.0190)		
childcare	0.0239	0.077	0.28	0.0581**	0.058	0.19
	(0.0164)			(0.0248)		
unemployed	0.0281*	0.328	8.13	0.0016	0.279	15.02
	(0.0139)			(0.0108)		
disability	0.0566	0.046	0.04	0.0191***	0.019	3.97
	(0.0490)			(0.0019)		
other	0.0101***	0.145	56.01	0.0068***	0.067	51.05
	(0.0027)			(0.0018)		

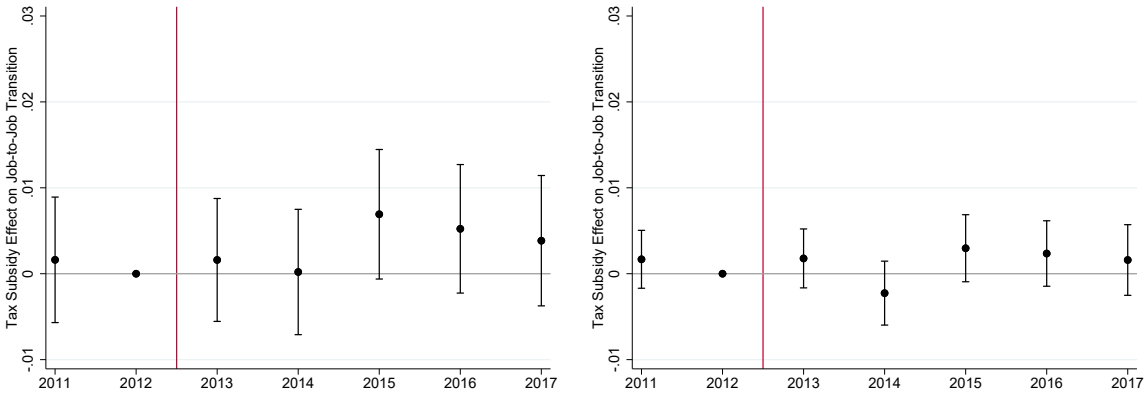
Note: Cluster robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (19), with the sample restriction of not working in the private sector 12 months before and restricting the data to May of each year. These are difference-in-differences estimates that compare the change in entry rate between year 2012 and the 2013-2017 period after the 2013 introduction of the payroll tax subsidy. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. The treatment effect is interacted with labor force status 12 months before – the coefficients of the interacted treatment effects are reported. The baseline entry rate and the % of entrants are measured in year 2012.

Appendix Figure C2: Job-to-Job Transitions by Wage Differences

(a) Young, age 22-27, transition to lower wage job (b) Old, age 52-57, transition to lower wage job



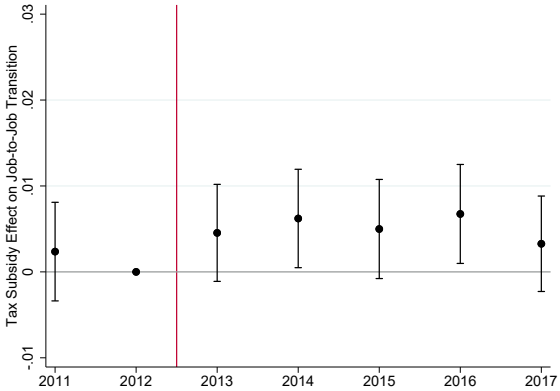
(c) Young, age 22-27, transition to higher wage job (d) Old, age 52-57, transition to higher wage job



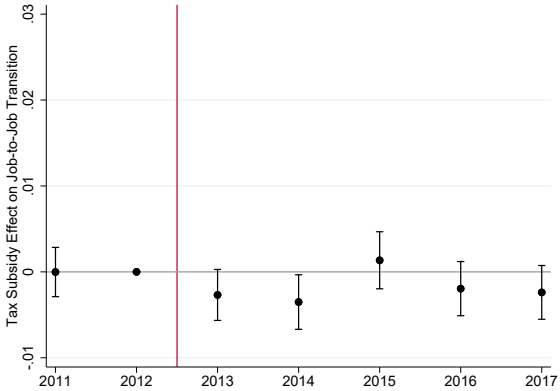
Note: The data is restricted to May of each year and to workers who worked in the private sector both the current year and a year before. Job-to-job transition is defined as working at a different firm this year than a year before. We also require no gaps in employment for job-to-job transition (based on monthly data). Coefficients of interaction term between annual date (reference: 2012) and treatment age are displayed with 95% CI.

Appendix Figure C3: Job-to-Job Transitions by Poaching Index (PI) Differences

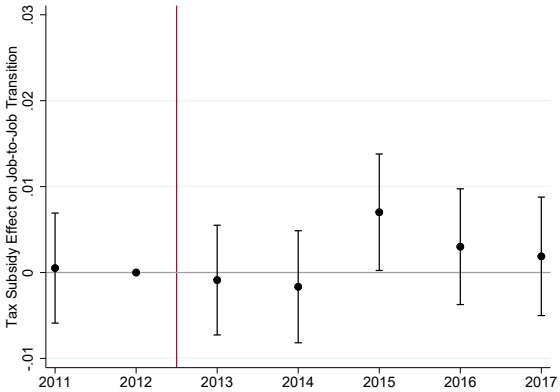
(a) Young, age 22-27, transition to lower PI firm



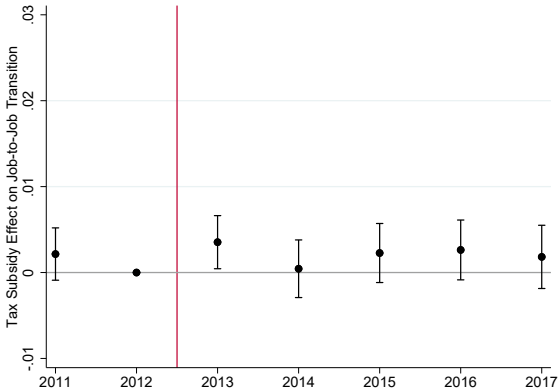
(b) Old, age 52-57, transition to lower PI firm



(c) Young, age 22-27, transition to higher PI firm



(d) Old, age 52-57, transition to higher PI firm



Note: The data is restricted to May of each year and to workers who worked in the private sector both the current year and a year before. Job-to-job transition is defined as working at a different firm this year than a year before. We also require no gaps in employment for job-to-job transition (based on monthly data). Coefficients of interaction term between annual date (reference: 2012) and treatment age are displayed with 95% CI.

D Role of the minimum wage

In this section, we provide indicative evidence that the estimated employment effects of the payroll tax subsidy is not a consequence of the presence of a minimum wage in Hungary.

Harasztosi and Lindner (2019) show that the disemployment effects of the minimum wage in Hungary are considerably larger in the tradable and in the exporting sectors than in the non-tradable or service sectors. To check if the impact of the tax subsidy is larger in sectors more affected by the minimum wage, we estimate the treatment effects by NACE industry categories. We report the estimated effects only for those industries where the effect is at least 0.1 percentage point in either of the analyzed age groups. The results reported in Table D1 indicate that the relative impact of the subsidy is smaller in manufacturing (a mainly tradable sector) than in the non-tradable sectors such as wholesale and retail trade, accommodation and food service. Thus, these results do not support that the role of the minimum wage drives the estimated effects.

Similarly, the estimated effect of the subsidy is smaller at exporting firms (Table D2, top panel), that are more affected by the minimum wage (Harasztosi and Lindner, 2019). Also, at least among the young, the impact of the subsidy is smaller at firms that employ a higher fraction of workers at the minimum wage (Table D2, bottom panel).

Appendix Table D1: Effect of the payroll tax cuts on employment in private sector companies by industry

	Young (age 22-27)			Old (age 52-57)		
	Employment effect	% of population	% change in employment	Employment effect	% of population	% change in employment
Agriculture	-0.0001 [0.0005]	1.311	-0.763	0.0015* [0.0008]	2.950	5.085
Manufacturing	0.0039*** [0.0015]	11.517	3.386	-0.0016 [0.0015]	10.992	-1.546
Construction	0.0020*** [0.0007]	2.695	7.421	0.0014* [0.0008]	3.540	3.955
Wholesale and retail trade	0.0073*** [0.0010]	4.962	14.712	0.0013 [0.0009]	3.782	3.437
Accommodation and food service	0.0023*** [0.0005]	1.512	15.212	0.0003 [0.0003]	0.533	5.629
Transportation and storage	0.0012** [0.0006]	1.994	6.018	0.0052*** [0.0009]	3.765	13.811
Information and communication	0.0023*** [0.0003]	0.599	38.397	-0.0004 [0.0003]	0.367	-10.899

Note: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (19). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2017 period after the 2013 introduction of the payroll tax subsidy. We estimate a separate linear probability model for the employment in each industry category. In each model, we control for age and quarterly date effects. The % of population indicator is measured in 2012. The % change in employment shows the increase in employment relative to the population employed in the given industry.

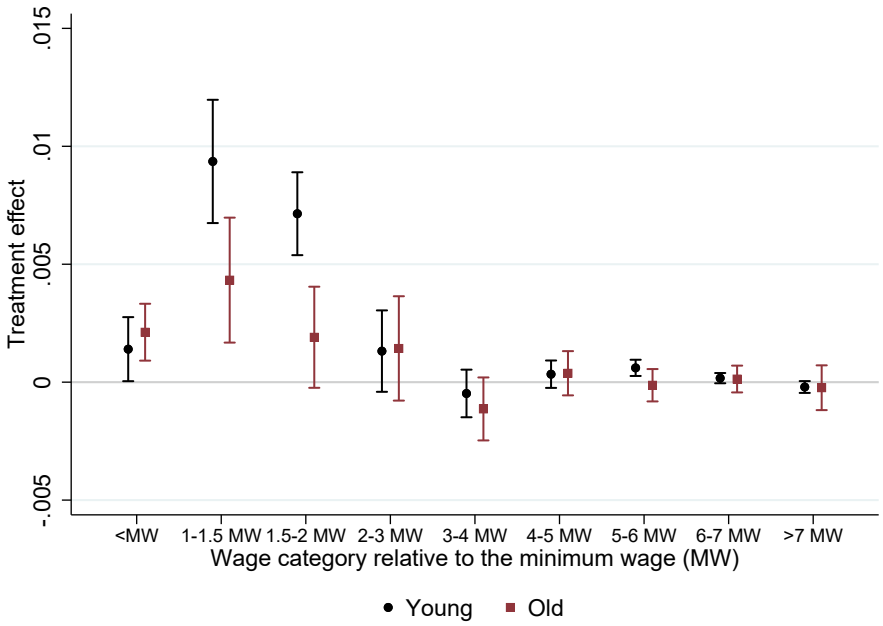
Appendix Table D2: Treatment effect on employment in private sector companies by some firm level indicators

	Employment of young Age 22-27	Employment of old Age 52-57
Treatment effect, not exporting firm	0.0144***	0.0066***
	[0.0015]	[0.0017]
Treatment effect, exporting firm	0.0054***	0.0019
	[0.0017]	[0.0017]
p-value of equality test	0.000	0.075
Treatment effect, ratio MW earners below median	0.0152***	0.0037**
	[0.0016]	[0.0017]
Treatment effect, ratio MW earners above median	0.0093***	0.0067***
	[0.0016]	[0.0017]
p-value of equality test	0.018	0.259

Note: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (19). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2017 period after the 2013 introduction of the payroll tax subsidy. In each regression, the outcome is the binary indicator of private sector employment at a firm with the given characteristic. In each regression, we control for age and quarterly date effects. The equality of the coefficients is tested with a Wald-test (using Stata's *suest* command). When calculating the ration of minimum wage (MW) earners on the firm level, we consider a window of plus/minus 5,000 HUF around the year specific minimum wage level.

Figure D1 shows the employment effect of the payroll tax cut by wage categories. It can be seen that there are non-negligible employment effects even at jobs paying above 150% of the minimum wage.

Appendix Figure D1: Effect of the payroll tax cuts on employment in private sector companies by wage categories

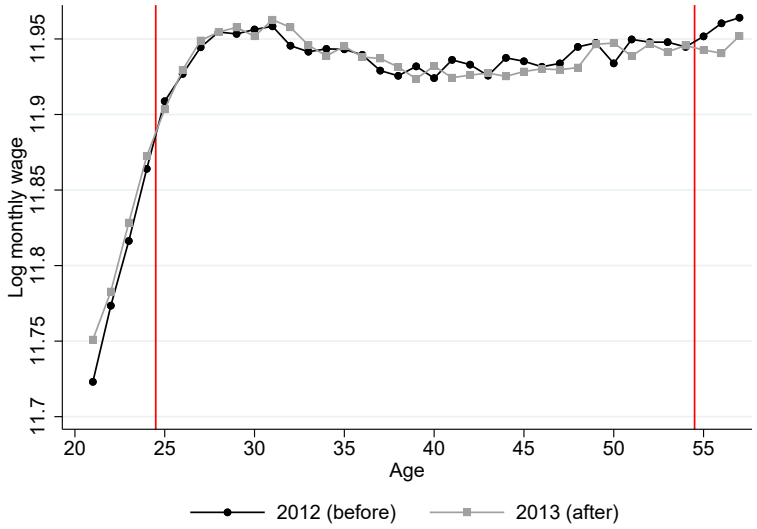


Note: The figure shows the estimated employment effects with the corresponding 95% confidence intervals, based on Equation (19). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2017 period (after the introduction of the payroll tax subsidy in 2013).

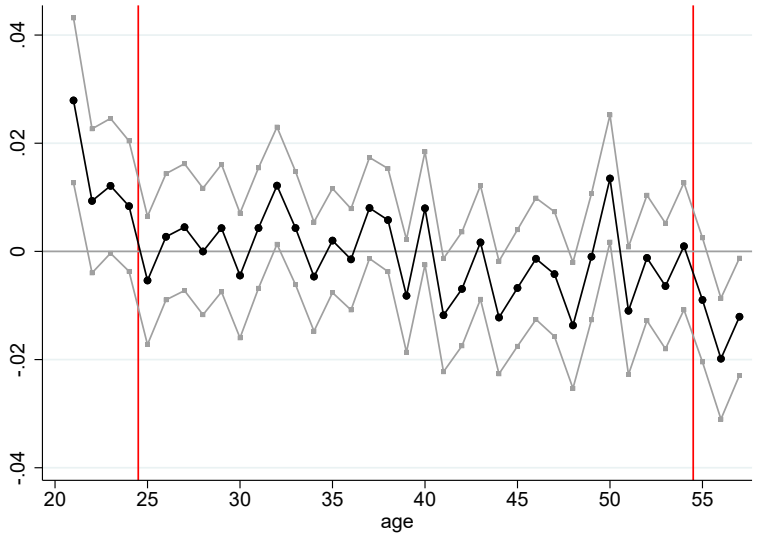
E Further wage regression results

Appendix Figure E1: Wage by age (males)

(a) Logarithm of monthly wage



(b) Change in the logarithm of monthly wage



Note: Panel (a) shows the private log wage by age separately for year 2012 (before the implementation of the payroll tax subsidy) and for year 2013 (after the implementation of the payroll tax subsidy). The 2013 wages are deflated to year 2012 values using the aggregate gross wage index. Panel (b) shows the differences between years 2013 and 2012, net of age effects, with the 95% confidence interval. The vertical red lines shows the age thresholds where the tax subsidy became effective from 2013. The subsidy affected workers younger than 25 and older than 55.

Appendix Table E1: Impact on log wage of new entrants

	Log Wage of Young Age 22-27		Log Wage of Old Age 52-57	
Treatment effect	0.0001	0.0018	-0.0316*	-0.0149
	[0.0115]	[0.0092]	[0.0167]	[0.0148]
Controls:				
Age and year dummies	yes	yes	yes	yes
Occupation dummies and firm indicators	no	yes	no	yes

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows difference-in-differences estimates of log wages of new entrants to the private sector. The sample is restricted to years 2012 (before the introduction of the payroll tax subsidy) and 2013 (after the introduction of the payroll tax subsidy). Job indicators are measured in 2012. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets.

Appendix Table E2: Heterogeneity by individual and job characteristics: Impact on log wage

	Log Wage of Young Age 22-27	Log Wage of Old Age 52-57
Education proxy		
Treatment effect		0.0031
		[0.0062]
Treatment effect × secondary		-0.0000
		[0.0062]
Treatment effect × tertiary		0.0058
		[0.0077]
Skill		
Treatment effect	0.0012	0.0030
	[0.0045]	[0.0029]
Treatment effect × white collar	0.0065	0.0043
	[0.0067]	[0.0041]

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates of the model in equation equation (20). We report difference-in-differences estimates of wages allowed to vary with individual and job characteristics. The sample is restricted to years 2012 (before the introduction of the payroll tax subsidy) and 2013 (after the introduction of the payroll tax subsidy). Job indicators are measured in 2012. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets.

Appendix Table E3: Average treatment effect on log wage by transition between firms

	Log Wage of Young Age 22-27	Log Wage of Old Age 52-57
Average treatment effect	0.0023	0.0038
	[0.0043]	[0.0028]
Heterogeneity by new hire		
Treatment effect	0.0009	0.0028
	[0.0043]	[0.0027]
Treatment effect × new hire	0.0075	0.0136
	[0.0133]	[0.0169]

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates of the model in equation equation (20). We report difference-in-differences estimates of wages allowed to vary with being a new hire at the firm. The sample is restricted to years 2012 (before the introduction of the payroll tax subsidy) and 2013 (after the introduction of the payroll tax subsidy). A new hire is a worker who worked at different firms in May 2012 and May 2013. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets.

Appendix Table E4: Average treatment effect on log wage: three-year results

	Log Wage of Young Age 22-27	Log Wage of Old Age 52-57
Average treatment effect, year 2013	0.0044	0.0035
	[0.0042]	[0.0027]
Average treatment effect, year 2014	-0.0004	0.0029
	[0.0044]	[0.0027]
Average treatment effect, year 2015	0.0071*	0.0052*
	[0.0043]	[0.0027]

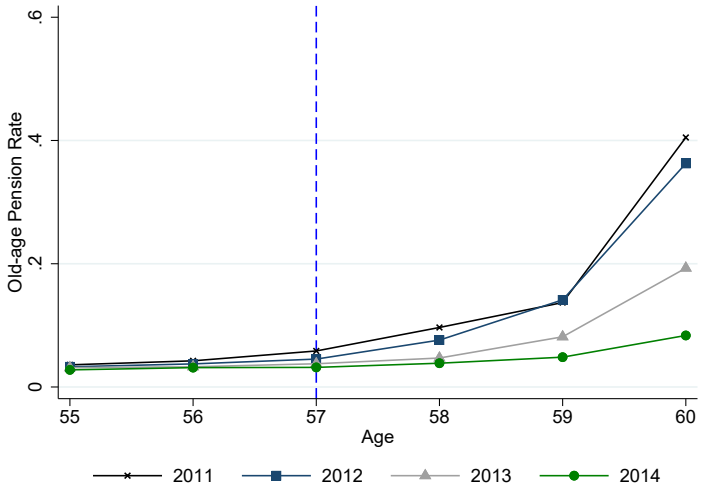
*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates of the model in equation equation (20) over years 2012-2015, with year 2012 treatment effects used as baseline. The payroll tax susbidy was introduced in 2013. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets.

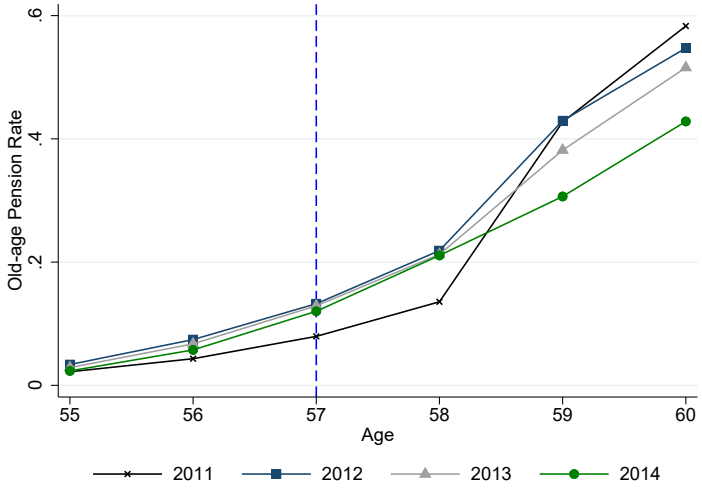
F Gender specific results

Appendix Figure F1: Old-age Pension Rate by Gender

(a) Males



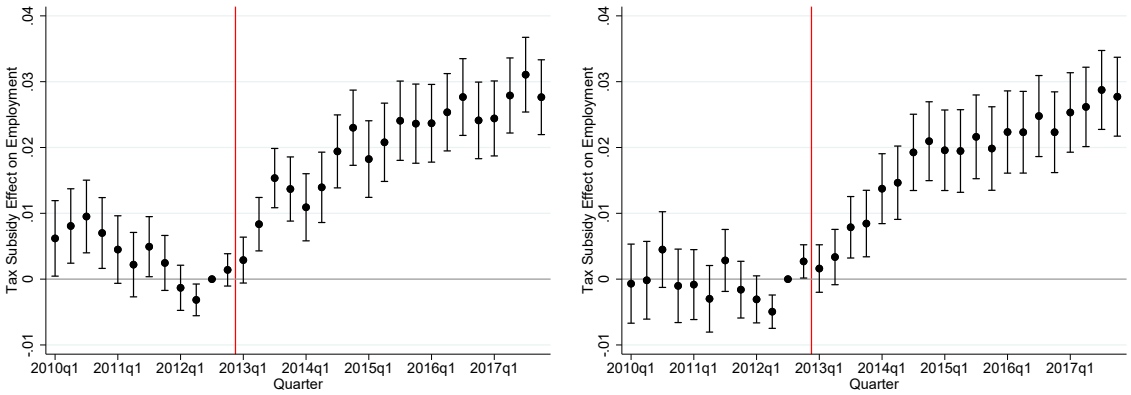
(b) Females



Appendix Figure F2: Effect of the Payroll Tax Subsidy on employment in private sector companies by Gender

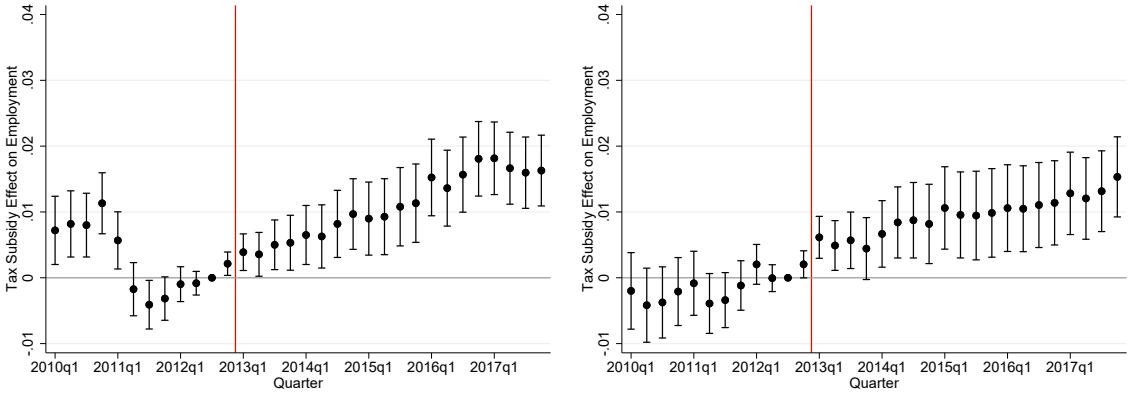
(a) Young, females

(b) Young, males



(c) Old, females

(d) Old, males



Notes: The figures show the change in employment for treated age groups (affected by the payroll tax subsidy) relative to the control age groups (similar age group, but unaffected by the tax subsidy) before and after the reform. In particular, we plot the δ_q from equation (18). Panel (a) shows the estimates for the young where the treated individuals are aged between 22 and 24, while the control individuals are aged 25 to 27. Panel (b) shows the estimates for the old, where the treated individuals are aged 55 to 57, while the control individuals are aged 52 to 54. The 95% confidence intervals are reported, where the standard errors are clustered at the worker-level.

Appendix Table F1: Impact on employment in private sector companies: Gender specific results

	Employment of Young Age 22-27		Employment of Old Age 52-57	
	Females	Males	Females	Males
Average treatment effect	0.0210***	0.0198***	0.0106***	0.0084***
	[0.0020]	[0.0021]	[0.0019]	[0.0021]
Poaching index (PI)				
Below median PI, treatment effect	0.0105***	0.0074***	0.0102***	0.0067***
	[0.0015]	[0.0016]	[0.0015]	[0.0016]
Above median PI, treatment effect	0.0087***	0.0112***	-0.0001	0.0016
	[0.0015]	[0.0016]	[0.0014]	[0.0017]
p-value of equality test	0.406	0.133	0.000	0.050
Skill				
Blue collar job, treatment effect	0.0051***	0.0134***	0.0071***	0.0094***
	[0.0015]	[0.0019]	[0.0015]	[0.0020]
White collar job, treatment effect	0.0159***	0.0063***	0.0035**	-0.0010
	[0.0015]	[0.0013]	[0.0014]	[0.0013]
p-value of equality test	0.000	0.005	0.108	0.000

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates from the model in equation (19). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2015 period after the 2013 introduction of the payroll tax subsidy. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets. In each regression, the outcome is the binary indicator of private sector employment at a firm with the given characteristic. In each regression, we control for age and quarterly date effects. The equality of the coefficients is tested with a Wald-test (using Stata's *suest* command).

Appendix Table F2: Average treatment effect on log wage by firm quality indicators: Gender specific results

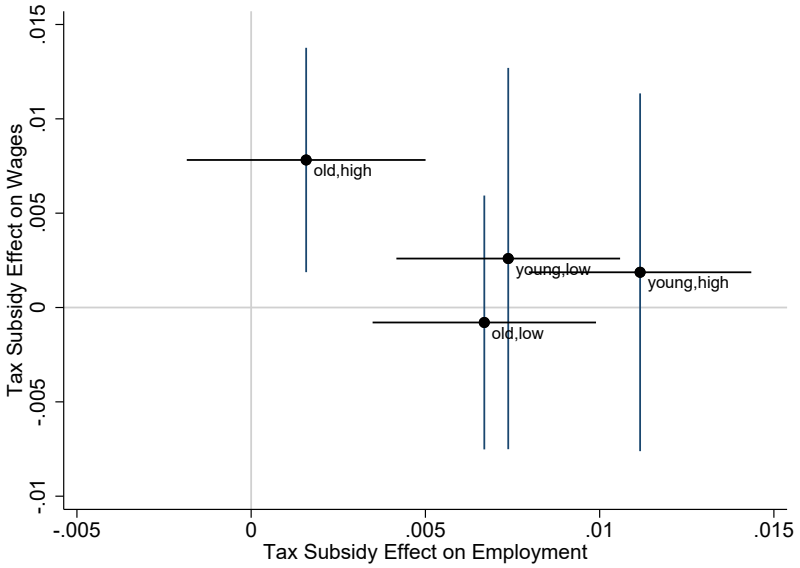
	Log Wage of Young Age 22-27		Log Wage of Old Age 52-57	
	Males	Females	Males	Females
Average treatment effect	0.0023	0.0041	0.0038	0.0022
	[0.0043]	[0.0057]	[0.0028]	[0.0029]
Poaching index (PI)				
Below median PI, treatment effect	0.0026	0.0195***	-0.0008	-0.0026
	[0.0052]	[0.0065]	[0.0034]	[0.0033]
Above median PI, treatment effect	0.0019	-0.0149**	0.0078**	0.0076**
	[0.0034]	[0.0065]	[0.0030]	[0.0033]

*** p<0.01, ** p<0.05, * p<0.1

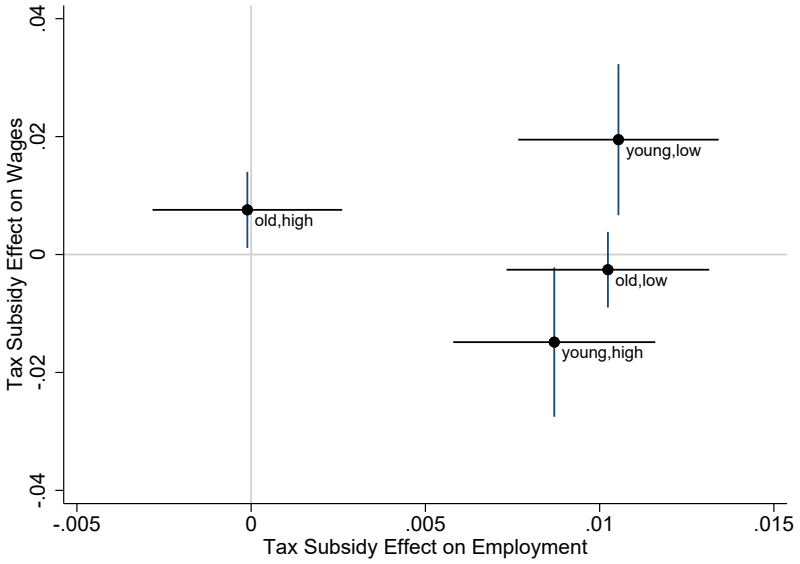
Note: The table shows estimates of the model in equation equation (20). We report difference-in-differences estimates of wages allowed to vary with firm quality. The sample is restricted to years 2012 (before the introduction of the payroll tax subsidy) and 2013 (after the introduction of the payroll tax subsidy). Firm quality indicators are measured in 2013. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets.

Appendix Figure F3: Heterogeneity of Treatment Effects By Subgroups by Gender

(a) Males



(b) Females



Note: The figure shows the estimated employment effects (x-axis) and wage effects (y-axis) with the corresponding 95% confidence intervals for four sub-groups: old workers at high-poaching firms, old workers at low-poaching firms, young workers at high-poaching firms, and young workers at low poaching firms. "High" refers to above median poaching index, "low" refers to below median poaching index. The estimated effects are from equation (19) for employment and (20) for wage. The employment effects are estimated for years 2012-2017, the wage effects are estimated for years 2012-2013. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54.

G Employment effect on the short run

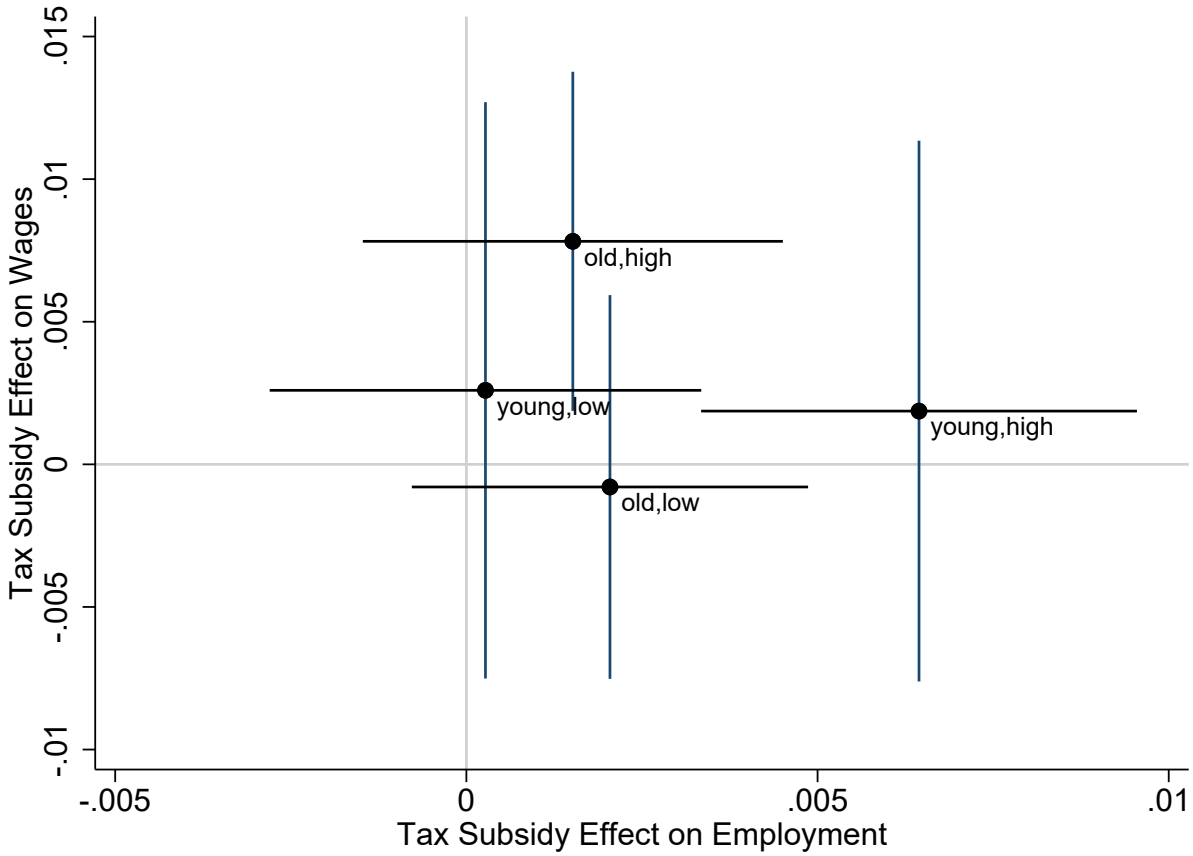
We estimate equation (19) using data from years 2012 and 2013, only.

Appendix Table G1: Average treatment effect on employment in private sector companies by firm quality indicators

	Employment of Young Age 22-27	Employment of Old Age 52-57
Average treatment effect	0.0068***	0.0042**
	[0.0019]	[0.0018]
Poaching index (PI)		
Below median PI, treatment effect	0.0003	0.0020
	[0.0016]	[0.0014]
Above median PI, treatment effect	0.0064***	0.0015
	[0.0016]	[0.0015]
p-value of equality test	0.012	0.821
TFP		
Below median TFP, treatment effect	0.0026**	0.0062***
	[0.0013]	[0.0013]
Above median TFP, treatment effect	0.0001	-0.0007
	[0.0014]	[0.0013]
p-value of equality test	0.237	0.001
Firm FE (based on AKM decomposition)		
Below median FE, treatment effect	0.0044***	0.0035***
	[0.0014]	[0.0014]
Above median FE, treatment effect	0.0015	0.0004
	[0.0015]	[0.0014]
p-value of equality test	0.195	0.135
Firm level average wage		
Below median, treatment effect	0.0039**	0.0038***
	[0.0015]	[0.0014]
Above median, treatment effect	0.0028*	0.0006
	[0.0015]	[0.0015]
p-value of equality test	0.645	0.154
Foreign ownership		
Domestic firm, treatment effect	0.0084***	0.0047***
	[0.0017]	[0.0017]
Foreign firm, treatment effect	-0.0016	-0.0004
	[0.0013]	[0.0009]
p-value of equality test	0.000	0.015

Note: δ parameter from equation (19), allowed to vary with firm category. Years 2012-2013. Cluster robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. In each regression, the outcome is the binary indicator of private sector employment at a firm with the given characteristics. In each regression, we control for age and quarterly date effects. The equality of the coefficients is tested with a Wald-test (using Stata's *suest* command).

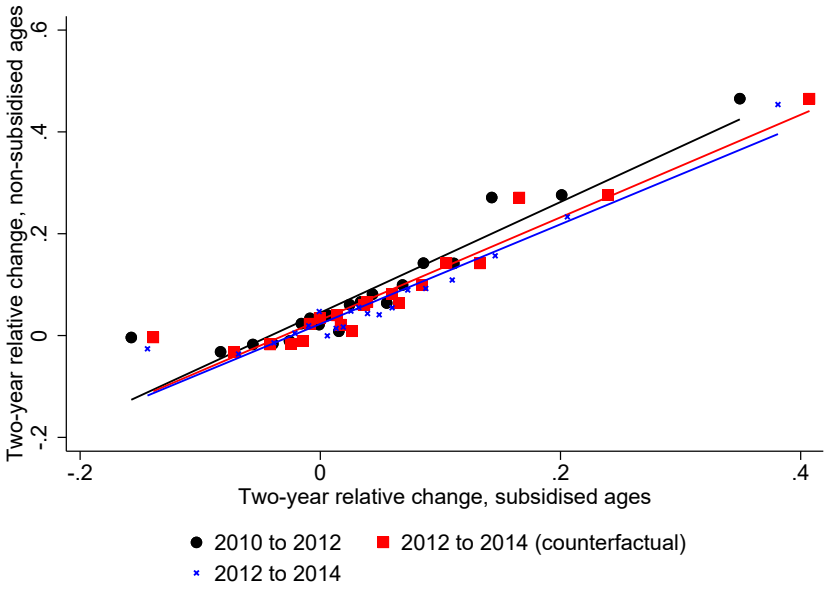
Appendix Figure G1: Heterogeneity of Treatment Effects By Subgroups



Note: The figure shows the estimated employment effects (x-axis) and wage effects (y-axis) with the corresponding 95% confidence intervals for four sub-groups: old workers at high-poaching firms, old workers at low-poaching firms, young workers at high-poaching firms, and young workers at low poaching firms. "High" refers to above median poaching index, "low" refers to below median poaching index. The estimated effects are from equation (19) for employment and (20) for wage. The sample is restricted to years 2012 (before the introduction of the payroll tax subsidy) and 2013 (after the introduction of the payroll tax subsidy). Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54.

H Firm level evidence for substitution and windfall effects

Appendix Figure H1: Firm level relative growth in employment by age groups



Note: On the x-axis, we indicate the two-year change from year t to year $t+2$ in the number of workers aged up to 24 or at least 55 (subsidized ages) relative to the observed firm size in year t. On the y-axis, we indicate the same two-year relative change in the number of workers aged 25-54 (non-subsidized ages). We exclude firms with less than 10 registered workers (5 workers in our sample, on average). After this restriction, we also exclude those firms that are not in the sample throughout years 2010-2014. We report binscatter plot of the observations with a linear fitted regression line. The black dots and line refer to relative change from 2010 to 2012 (i.e., before the introduction of the tax subsidy). The blue dots and line refer to relative change from 2012 to 2014 (with the tax subsidy being introduced in 2013). The red dots and line correspond to a counterfactual scenario under which the 2010-2012 relative change in employment rate in the subsidised age groups is increased by 4.3%, which is the estimated average rate of increase, while the 2010-2012 change in employment rate in the non-subsidised ages is left at its observed value.

The direct replication of the basic results of Saez, Schoefer and Seim (2019*b*) is not straightforward for multiple reasons. First, firms that employ many subsidized young or old workers have different characteristics and have different growth patterns than firms with fewer workers at the subsidized ages. Second, if we compare, for example, firms that employ many young workers to firms that employ fewer young workers (as control group), it might still be the case that there is a high fraction of other subsidized individuals in the control group. Third, due to the cap on the subsidy, the number of subsidized individuals (e.g., workers aged under 25) does not capture how the amount of subsidy relates to the total payroll.

Due to these limitations, we apply the following firm-level approach.

1. Sample: We drop those firm-year observations where the size of the firm is less than 10 or more than 5,000 (based on the size recorded by the tax authority, not the firm size generated from the sample.) After this restriction, we keep firms that existed throughout 2010-2014.

2. We calculate the effective payroll tax subsidy rate in 2013, considering the age and occupation based subsidies only. We neglect the subsidies payable to long-term unemployed, career starters and people returning from maternity leave as the fraction of such workers is less persistent over years and the majority of career starters are likely captured by the age based subsidy.

3. Based on the effective subsidy rate in 2013, we group firms into two categories according to whether the subsidy rate was below or above its median in 2013. We extrapolate these groups to the other sample years. The treatment (control) group is the group with the above (below) median subsidy rate.

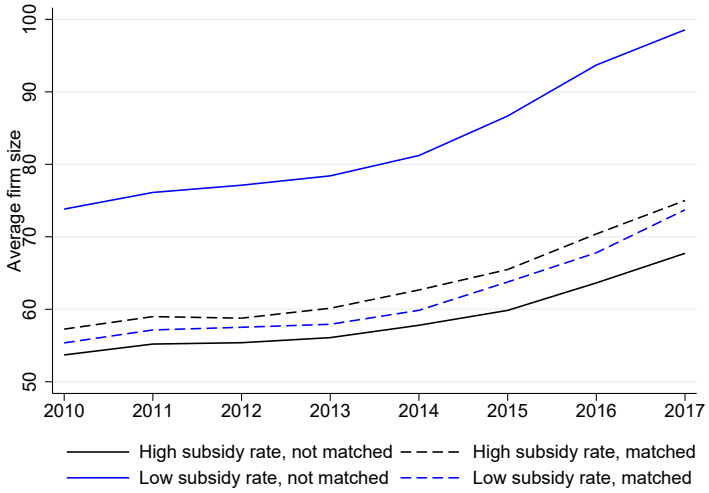
4. We perform propensity score matching in year 2012. The variables used in the logit model are firm size, firm level average wage and two-digit industry code dummies. We

do 1:1 nearest neighbor matching with no replacement and with caliper 0.01 (which is lower than usual).

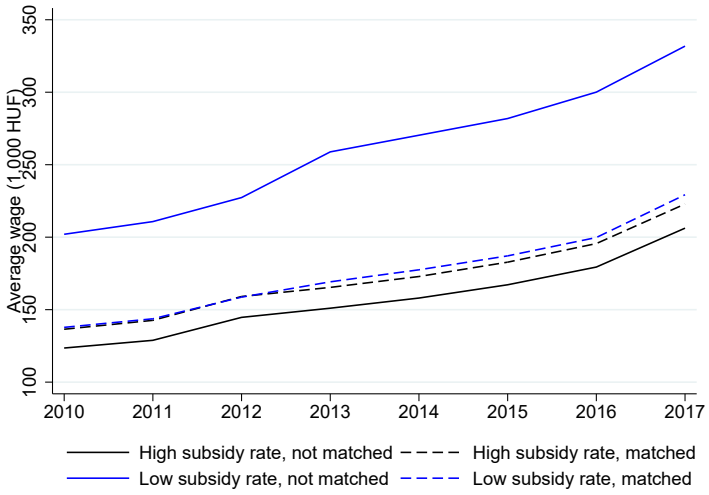
Figure H2 shows the matching results for firm size and firm level average wage. The reported plots do not provide evidence that the payroll tax subsidy had a windfall effect on firms employing a higher share of workers in the subsidized ages.

Appendix Figure H2: Evidence for windfall effects

(a) Firm size



(b) Average wage



Note: The differences between the high subsidy rate group and the matched low subsidy rate group are statistically not significant. Total sample size: 17,825 firms. Sample size in the matched sample: 10,016 firms.

I Treatment effect on job tenure

The outcome here is the binary indicator of working at the same firm three years later. Thus, the sample here is restricted to the employed (private sector, only). The results suggest that the payroll tax subsidy decreases the probability of staying long at the same firm among the young but not among the old.

Appendix Table I1: Effect of the payroll tax cuts on working at the same firm three years later

	Age 22-27	Age 52-57
Treatment effect	-0.0070*	-0.0019
	[0.0037]	[0.0034]

Note: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. The sample is restricted to private sector workers. The table shows estimates from the model in equation (19), where the outcome is the binary indicator of working at the same firm three years later. These are difference-in-differences estimates that compare the change in the outcome between year 2012 and the 2013-2015 period after the 2013 introduction of the payroll tax subsidy. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets. In each regression, we control for age and quarterly date effects

J Calculation of the marginal value of public funds

We follow the method proposed by Hendren and Sprung-Keyser (2020) to calculate the Marginal Value of Public Funds (MVPF) for the age-dependent payroll tax subsidies. Based on Hendren and Sprung-Keyser (2020), we apply the following formula:

$$MVPF = \frac{WTP}{NetCost}, \tag{21}$$

where the Willingness to Pay (WTP) is the sum of individuals' willingness to pay for the policy out of their own income and the net cost is the net impact of the policy on the government budget.

Our calculation is based on the following steps:

1. WTP is the sum of the subsidy and the additional net wage due to increasing employment, minus the benefits a non-employed person receives. (We assume that even if the subsidy goes to the employer, it appears with a weight of one in the WTP.)

2. The net cost is the sum of the subsidy minus the benefits a non-employed person receives minus the taxes paid after the additional net wage due to increasing employment.

Based on the back-of-the-envelope, static calculations presented in Table J1, subsidising the employment of the young by payroll tax cuts has a higher MVPF than subsidising the old, although the difference between the two is moderate. The estimated MVPF values are comparable for instance to the MVPFs of earned income tax credits and top tax rates as reported by Hendren and Sprung-Keyser (2020).

Appendix Table J1: Welfare calculation

	Young	Old
(1) Direct cost (average subsidy)	8,336	6,212
(2) Benefit receipt of the non-employed:		
impact on employment × average age-specific benefits of the non-employed	212	367
(3) Additional net wages:		
impact on employment × average net wages of the additional hires	2,243	681
(4) Additional income tax:		
additional gross wages × tax rate	1,712	566
(1)+(3)-(2) Willingness to pay (WTP)	10,368	6,525
(1)-(2)-(4) Net cost	6,413	5,278
Marginal value of public funds (WTP/Net cost)	1.617	1.236

Note: All amounts are monthly amounts in HUF.

K Young employment and wages by experience

Appendix Table K1: Heterogeneity by firm characteristics: Impact on employment in private sector companies of the young

	Employment of Young (Age 22-27)		
	No restriction	Less than 6 months work at age 18-19	Min 6 months work at age 18-19
Average treatment effect	0.0198***	0.0226***	0.0169**
	[0.0021]	[0.0021]	[0.0074]
Poaching index (PI)			
Below median PI, treatment effect	0.0074***	0.0084***	0.0108
	[0.0016]	[0.0017]	[0.0069]
Above median PI, treatment effect	0.0112***	0.0130***	0.0041
	[0.0016]	[0.0017]	[0.0064]
p-value of equality test	0.133	0.074	0.539
TFP			
Below median TFP, treatment effect	0.0083***	0.0087***	0.0119**
	[0.0013]	[0.0013]	[0.0056]
Above median TFP, treatment effect	0.0048***	0.0061***	0.0034
	[0.0016]	[0.0016]	[0.0063]
p-value of equality test	0.108	0.242	0.364
Firm FE (based on AKM decomposition)			
Below median FE, treatment effect	0.0138***	0.0143***	0.0173***
	[0.0016]	[0.0016]	[0.0065]
Above median FE, treatment effect	0.0053***	0.0077***	-0.0016
	[0.0017]	[0.0017]	[0.0068]
p-value of equality test	0.000	0.010	0.085
Firm level average wage			
Below median, treatment effect	0.0128***	0.0138***	0.0121*
	[0.0016]	[0.0016]	[0.0065]
Above median, treatment effect	0.0068***	0.0087***	0.0046
	[0.0017]	[0.0017]	[0.0068]
p-value of equality test	0.019	0.049	0.491
Foreign ownership			
Domestic firm, treatment effect	0.0184***	0.0201***	0.0151**
	[0.0018]	[0.0019]	[0.0051]
Foreign firm, treatment effect	0.0016	0.0026*	0.0018
	[0.0014]	[0.0014]	[0.0058]
p-value of equality test	0.000	0.000	0.209

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates from the model in equation (19). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2017 period after the 2013 introduction of the payroll tax subsidy. The treated group comprises ages 22-24 and the control group group comprises ages 25-27. Cluster robust standard errors in brackets. In each regression, the outcome is the binary indicator of private sector employment at a firm with the given characteristic. In each regression, we control for age and quarterly date effects. The equality of the coefficients is tested with a Wald-test (using Stata's *suest* command).

Appendix Table K2: Average treatment effect on log wage of the young by firm quality indicators

	Log Wage of Young (Age 22-27)		
	No restriction	Less than 6 months work at age 18-19	Min 6 months work at age 18-19
Average treatment effect	0.0023	0.0013	0.0103
	[0.0043]	[0.0047]	[0.0112]
Poaching index (PI)			
Below median PI, treatment effect	0.0026	0.0034	0.0028
	[0.0052]	[0.0055]	[0.0139]
Above median PI, treatment effect	0.0019	-0.0012	0.0202*
	[0.0048]	[0.0053]	[0.0117]
p-value of equality test	0.885	0.401	0.194
TFP			
Below median TFP, treatment effect	-0.0079	-0.0094	0.0017
	[0.0055]	[0.0060]	[0.0134]
Above median TFP, treatment effect	0.0038	0.0038	0.0097
	[0.0059]	[0.0063]	[0.0161]
p-value of equality test	0.053	0.043	0.622
Firm FE (based on AKM decomposition)			
Below median FE, treatment effect	-0.0091*	-0.0112**	0.0027
	[0.0047]	[0.0052]	[0.0111]
Above median FE, treatment effect	0.0156***	0.0163***	0.0164
	[0.0057]	[0.0060]	[0.0160]
p-value of equality test	0.000	0.000	0.413
Firm level average wage			
Below median, treatment effect	-0.0035	-0.0044	0.0021
	[0.0045]	[0.0050]	[0.011]
Above median, treatment effect	0.0119**	0.0112*	0.0185
	[0.0057]	[0.0061]	[0.0160]
p-value of equality test	0.011	0.015	0.329
Foreign ownership			
Domestic firm, treatment effect	-0.0045	-0.0065	0.0085
	[0.0045]	[0.0050]	[0.0113]
Foreign firm, treatment effect	0.0156**	0.0167**	0.0141
	[0.0063]	[0.0068]	[0.0173]
p-value of equality test	0.001	0.000	0.734

*** p<0.01, ** p<0.05, * p<0.1

Note: The table shows estimates of the model in equation equation (20). We report difference-in-differences estimates of wages allowed to vary with firm quality indicators. The sample is restricted to years 2012 (before the introduction of the payroll tax subsidy) and 2013 (after the introduction of the payroll tax subsidy). Firm quality indicators are measured in 2013. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets. The equality of the coefficients is tested with a t-test.