Firm Heterogeneity and the Impact of Payroll Taxes*

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Abstract

We study the impact of a large payroll tax cut for both younger and older workers in Hungary. Motivated by the prediction of standard equilibrium job search models, we examine the heterogeneous impact of the policy. Employment increases most at low-productivity firms, which tend to hire from unemployment, while the effects are more muted for high-productivity firms, especially for older workers. At the same time, wages only increase for older workers at high-productivity firms. These results point to important heterogeneity in the incidence of payroll tax subsidies by firm type and highlight that payroll taxes can change the composition of jobs in the labor market.

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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 the employment of specific groups with low employment rates. Nevertheless, to date there is no conclusive evidence on whether such policies are successful. Some studies find non-negligible positive effects on employment (Kramarz and Philippon, 2001; Egebark and Kaunitz, 2018; Saez, Schoefer and Seim, 2019), while others find little evidence for employment effects (Boockmann, Zwick, Ammermüller and Maier, 2012; Huttunen, Pirttilä and Uusitalo, 2013). Furthermore, most of the literature ignores heterogeneous impacts.

According to the neoclassical view of labor markets, the impact of tax cuts is driven by market-level labor supply and demand (see e.g. Gruber, 1997; Rothstein, 2010). Firms are price takers and so the incidence of the policy is the same across firms. Nevertheless, recent empirical evidence highlights that wage premium differences across firms are important for understanding key labor market phenomena such as rising wage inequality (Card, Heining and Kline, 2013; Song et al., 2019). In this paper, we explore the impact of payroll taxes on employment and wages in the presence of firm heterogeneity and market frictions.

We start our analysis by introducing a payroll tax subsidy into a standard search and matching model with heterogeneous firms (e.g. Mortensen and Pissarides, 2003; Bagger and Lentz, 2019). We obtain a number of novel and intuitive results. First, the impact of payroll taxes depends on whether a worker is hired from unemployment or poached from another firm. Since unemployed workers' outside option is unaffected by the the payroll tax cut, firms are able to claim the surplus when they are hiring from unemployment. At the same time, when a worker comes from employment, both firms benefit from the tax cut and competition between firms will drive up the worker's wage. The model, therefore, predicts that the incidence of the payroll tax cut will be mainly on firms if the worker is hired from unemployment, and on workers if the worker is poached.

Second, since more productive firms poach larger fraction of their workers the impact of the policy will be heterogeneous across firms. Low-productivity firms, which tend to hire from unemployment, will benefit disproportionately more from the payroll tax cut than high-productivity firms, which tend to poach from other firms. Therefore the model predicts that the share of jobs at low-productivity firms will increase in response to the policy, while wages will increase at high-productivity firms.

Third, the search model also highlights an important difference in how the policy impacts 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 employment responses will dominate and the incidence will be mainly on firms. For older workers, who are already higher up the job ladder and have more stable jobs, the subsidy will affect both hiring intensity and wages.

We illustrate the empirical relevance of these 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 28.5% to 14% for all private sector employees who were younger than 25 and older than 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 and jobs.

We utilize rich administrative data to estimate the impact of the policy in a difference-in-differences framework, comparing younger workers below the age 25 cutoff to workers just above and comparing older workers above the age 55 cutoff to workers just below. We find a large increase in employment in response to the policy for both age groups. The elasticity of employment with respect to labor costs is around 0.66 for younger workers and 0.34 for older workers three years after the policy change.

We also find substantial heterogeneity across firm types for older workers. For a variety of measures of firm quality—including total factor productivity, the poaching index (Bagger and Lentz, 2019), and firm wage premia measured in the AKM framework (Abowd, Kramarz and Margolis, 1999)—the employment-increasing effect of the policy mainly comes from lower-quality jobs and lower-quality firms, while the employment of older workers in higher-quality firms is unchanged. For most younger workers, we find weaker evidence of heterogeneity.

We present several additional pieces of evidence to better understand the impact of payroll taxes. First, we show that firms that tend to hire more subsidized workers do not seem to decrease the hire of non-subsidized ones. This suggests that the employment creation at the targeted groups did not come at the expense of non-targeted workers.

Second, we examine the effect of the policy throughout the entire wage distribution similarly to Cengiz, Dube, Lindner and Zipperer (2019). We find that employment increased mainly at the bottom of the wage distribution, while we find no indication for substantial change in employment in the upper part of the wage distribution where the change in labor cost was limited.[1] This suggests our estimates pick up the effect of the payroll tax cut.

Third, the estimated change in employment is not concentrated at the minimum wage. Even among workers earning twice the minimum wage we find a significant increase in employment. In addition, we find no evidence of differential impacts in the tradable sector,

[1]The maximum amount of the tax cut was capped, which implies that at higher wages the change was smaller relative to total labor costs.

where minimum wage increases lead substantial job losses in Hungary (see Harasztosi and Lindner, 2019), and in the non-tradable sector, where minimum wage do not impact employment significantly. This finding suggests that the employment change does not simply come from some low-quality jobs becoming viable following the payroll tax cut.

Fourth, we find that the employment increases mainly come from non-employment and inactivity. There is no change in self-employment or public sector employment where there was no payroll tax cut.

Fifth, we also study the impact of the policy on wages. The model predicts that wages should increase for incumbent workers at high-productivity firms. For older workers this is exactly what we find: there is a significant increase in wages for them at high-productivity firms, but we find no change in wages for workers at low-productivity firms.

These empirical findings together with our theoretical framework point to interesting (and as far as we know so far undocumented) heterogeneity in the incidence of tax subsidies. Older 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, and older 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 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; Svraka, 2019). 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 by calibrating a search-and-matching model and

point to increased employment among low-skill workers but negative spillovers for high-skill workers.

Our study also relates to the literature on payroll tax incidence in general. 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; Benzarti and Harju, 2021)[2]. Evaluating the incidence of business tax credits, Carbonnier, Malgouyres, Py and Urvoy (2022) find that the incidence of wage gains is on high-skill workers.

The remainder of this paper proceeds as follows. Section 2 introduces a search model with heterogenous firms. 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 Tax Subsidy in Search Models

We study the impact of payroll taxes through the lens of a standard search and matching model. We introduce a tax subsidy in a framework with random search, heterogeneous firms and sequential bargaining on wages (Postel-Vinay and Robin, 2002). We study how changing the tax subsidy affects employment, wages, and the composition of job types in equilibrium. Our goal in this section is to illustrate that tax policies can have heterogeneous impact across different firms and not to model the specific tax policy implemented in Hungary. As a result,we abstract away from the age-specific nature of the tax cut. We also abstract away from worker heterogeneity and assume job search is exogenous. These latter two assumptions can be relaxed without altering the basic predictions of the model.

2.1 Setup

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

Workers are homogeneous. Workers are either unemployed or employed. If unemployed, they receive leisure of value b 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

[2]Bozio, Breda and Grenet (2019) reconcile these seemingly conflicting results by the tax-benefit-linkage explanation.

job exogeneously with probability $\delta \in [0,1]$.[3]

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

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

A searching worker locates an open vacancy with probability $\phi(\theta)$, 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 based on sequential auction a la 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. For simplicity, we also assume that all the bargaining power is at the firms and so they are able to extract all rents from the workers.[4] Note, that even if workers are assumed to have no bargaining power, competition between firms for workers can still result in a very high labor share of firm revenues – this feature of the model is also pointed out by Dey and Flinn (2005). Details of the wage setting are provided in Appendix Section A.4.

2.2 Bellman Equations

The value of unemployment when firms extract all the rents from unemployed workers is the following:

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

where β is the discount factor. Notice that the probability of finding a job does not show up in the above equation as a result of full rent extraction. Even if the unemployed get a job offer, it will not make them better off.

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

$$V(y,\tau) = f(y) + \tau + \delta\beta V_u + (1-\delta)\beta V(y,\tau), \tag{3}$$

[3]We find that besides an increase in entry rate, some of the responses to payroll tax cuts come from a decrease in moving to unemployment. This could be explained within our framework by introducing advance notice layoffs or by introducing endogenous job separation by assuming that with δ probability there is a negative effect on productivity (instead of exogenous separation of the job match). Since our goal is to illustrate some key mechanisms and not match all patterns in the data, we abstract away from advance notice layoffs here.

[4]It is straightforward to introduce some bargaining power of the worker in the model. Nevertheless, empirical studies find usually that bargaining power is quite small and so abstracting away from that will not alter the conclusions made below.

where τ is the employment subsidy. Here, the possibility of the worker being poached by another firm is implicitly included in the $V(y,\tau)$ formula. Note also that if no outside offers arrive then the continuation value of the worker is $V(y,\tau)$. If the worker is poached then she is poached at value $V(y,\tau)$. Either way, the continuation value of the worker who survives the exogenous separation is $V(y,\tau)$, which is the maximum value the firm can deliver (Moscarini and Postel-Vinay, 2018).

Firms need to post vacancies to find workers. When workers have no bargaining power, the value of posting ν vacancies will be the following:

$$V_v(y,\tau,\nu) = -\kappa(\nu(y,\tau)) + \beta\nu(y,\tau)\frac{\phi(\theta)}{\theta}P(u)\Big[V(y,\tau) - V_u\Big] + \\ + \beta\nu(y,\tau)\frac{\phi(\theta)}{\theta}(1-P(u))\int_0^y \Big[V(y,\tau) - V(y',\tau)\Big]d\Gamma(y'). \tag{4}$$

where $\Gamma(y) = \dfrac{\int_0^y \nu(y',\tau)d\Psi(y')}{\int_0^1 \nu(y',\tau)d\Psi(y')}$ is the vacancy distribution function and $P(u) = \dfrac{u}{u+(1-\delta)s(1-u)}$ is the probability that a randomly drawn applicant is unemployed. The first part of the equation captures the cost of vacancy posting, $-\kappa(\nu(y,\tau))$. The second and the third part show the benefits of posting. Posting more vacancies increases the chance of being matched to a worker, which is $\nu(y,\tau)\dfrac{\phi(\theta)}{\theta}$. The second part captures the benefit of matching to an unemployed person. The third part shows the benefit of matching to an employed worker. In both cases, the firm earns the difference between the willingness to pay and the worker's outside option. Notice that the integral goes only to y as there is no benefit from applicants coming from better firms.

Plugging in $V(y,\tau)$ (equation (3)) and V_u (equation (2)) into equation (4), leads to:

$$V_v(y,\tau,\nu) = -\kappa(\nu(y,\tau)) + \beta\nu(y,\tau)\frac{\phi(\theta)}{\theta}P(u)\left[\frac{f(y)+\tau+\dfrac{\delta\beta b}{1-\beta}}{1-\beta+\delta\beta} - V_u\right] + \\ + \beta\nu(y,\tau)\frac{\phi(\theta)}{\theta}(1-P(u))\int_0^y \left[\frac{f(y)-f(y')}{1-\beta+\delta\beta}\right]d\Gamma(y'). \tag{5}$$

This equation highlights the key channels through which payroll taxes affect vacancy posting and employment. Tax subsidies only appear in the second part of this equation, which reflects the benefits of hiring from unemployment. At the same time, the tax subsidy has no impact on the third part of the value of vacancy posting, hiring from employment, as all firms receive the tax subsidy and the competition for workers will imply that the surplus will be enjoyed by the worker.

2.3 Equilibrium

Equilibrium is where firms optimally post vacancies up to the point where the marginal value of posting a vacancy equals its cost – they maximize equation (5). Furthermore, market tightness, θ, and the distribution of vacancies, $\Gamma(y)$, are consistent with firms' choices of vacancies. Finally, the steady state equilibrium unemployment rate is:

$$u = \frac{\delta}{\delta + \phi(\theta)}. \tag{6}$$

In equilibrium more productive firms post more vacancies and as a result will employ more workers. This is because less productive firms can mainly fill their vacancies with unemployed individuals as they cannot poach workers from more productive firms. In addition to that, the poaching index – the fraction of workers hired from other firms (instead of unemployment) – will reveal firm quality (see Bagger and Lentz, 2019).

We derive the formula for the equilibrium wage in Appendix A.4. Assuming CRRA utility function with rate of relative risk aversion ζ ($\zeta \geq 0$ and $\zeta \neq 1$), we can derive the wage at firm y' of an individual arriving from firm y, following Postel-Vinay and Robin (2002):

$$\ln \xi(y+\tau, y'+\tau) = \frac{1}{1-\zeta} \ln \Big[(y+\tau)^{1-\zeta} - \frac{(1-\zeta)\phi(\theta)}{\frac{1-\beta}{\beta} + \delta} \int_{y+\tau}^{y'+\tau} \bar{\Gamma}(x,\tau) x^{-\zeta} dx \Big]. \tag{7}$$

The wage of workers whose wage is the first salary after unemployment is:

$$\ln \xi(b, y+\tau) = \ln \xi_u(y+\tau) = \frac{1}{1-\zeta} \ln \Big[b^{1-\zeta} - \frac{(1-\zeta)\phi(\theta)}{\frac{1-\beta}{\beta} + \delta} \int_{b}^{y+\tau} \bar{\Gamma}(x,\tau) x^{-\zeta} dx \Big]. \tag{8}$$

2.4 Effects of the Employment Subsidy

We now study the effect of changing the tax subsidy. We describe what happens to the steady state equilibrium when we raise the subsidy amount. Here we focus on the intuition and leave further details and proofs to Appendix A.

As expected, the tax subsidy leads to more vacancy posting, tighter labor markets (θ) and lowers the equilibrium unemployment rate u. More importantly, we show that the employment and wage impacts of the tax subsidy vary across firm types. As we discussed before, firms get the surplus from the tax subsidy if they hire from unemployment, but competition between firms imply that the tax subsidy will benefit the workers if they are poached or received an offer from another firm. Consequently, low productive firms, which tend to hire from unemployment, benefit disproportionately more from the tax subsidy, which increases the incentives to post more vacancies. At the same time, the slightly lower overall

unemployment rate in equilibrium implies that it is going to be harder for low productive firms to find an unemployed worker. This dampens the vacancy posting of low productive firms. While we cannot prove analytically which effect will dominate, the latter effect is very small when we solve the model under the parameter values usually applied in the literature.

A similar result holds for wages. Low productive firms do not need to increase wages for most of their workers as they come from unemployment and usually without any outside offer yet.[5]. At the same time, most workers at productive firms are poached from another firm or have received an other offer from another firm, but decided to stay. These workers can use the tax subsidy as the threat point when bargaining, which drives up their wages.

Finally, we note that the tax subsidy does not have positive wage effects on new entrants. This is again a simple consequence of the fact that new entrants are without any outside offer from another firm and so all the rents (including the tax subsidy) will be extracted by the firms.

3 Background

Motivated by these theoretical insights, we study the impact of a large payroll tax cut implemented in Hungary. In 2013, the government halved social security contributions paid by private sector employers from 28.5% to 14% for under-25 and over-55 employees.[6]. The cut applied to both new and ongoing jobs and it was available for private sector employers. Public sector workers and the self-employed were not eligible for the cut.

Besides workers under-25 and over-55 there were certain groups who were eligible for the tax cut independently of their age, including workers in elementary occupations, the long-term unemployed re-entering the labor market, people returning to work after child-care leave, and career starters.[7] In our primary analysis we include all these workers in our sample, but our results are robust to the exclusion of the non-age-specific subsidized groups.

The tax cut was first publicly discussed in Parliament on July 2, 2012 and became official on October 15, 2012. The tax change was effective from January 1, 2013. Due to the relatively short period of time between the discussion and enactment of the reform,

[5]If they had an outside offer, that offer likely came from more productive firms and so they they would have been poached by that firm

[6]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.

[7]For these workers who were returning to employment, the tax cut was 100% for two years and 50% for a third year.

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.

We study the impact of the reform between 2010 and 2015. Throughout this period there were no other major labor market policy changes that affected younger or older workers.[8] Around this period 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 to the OECD average of 16.5% (OECD, 2016).

Besides the social security taxes paid by employers, employees paid a flat-rate tax of 16% and employee social security contributions of 18.5% in 2013. As a result, labor income was taxed heavily in Hungary – the average tax wedge was 49% in 2013, much higher than the OECD average of 35.5% (OECD, 2022).

Figure 1 depicts the average effective payroll tax rate paid by employees 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 fact that some workers could get the tax subsidy independently of age (e.g. those working in elementary occupations).

Furthermore, there is a jump from 16% to 22% from age 24 to 25 and a drop from 25% to 19% from age 54 to 55. (There are no discontinuities in the fraction of the other beneficiary groups at age 25 and 55, see Appendix Figure B1.) 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 2013-2015.

[8] A new pension policy for women introduced in 2011, which grants an early retirement option for women with 40 years of work credits, regardless of age. To make sure our results are not driven by this policy change we focus on men in the main analysis. Nevertheless, we find a very similar result for women. Furthermore, in 2015, the government introduced the Youth Guarantee Program, which targeted workers younger than age 25. The take-up rate of the program was very small, in 2015 there were only a few thousand participants. The exclusion of the participants in the Youth Guarantee Program does not affect our results.

4 Data and Sample

We use linked employer-employee administrative data from Hungary, covering years 2010–2015 on a random 50% sample of the population.[9] For employment, we use monthly data, while for wages, we use data from a representative month (May) of each year. We restrict the sample to men because there was a pension rule change affecting only women throughout the period studied here. Nevertheless, we find very similar estimates for women, as we show in Appendix D.

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.[10] We exclude those employees who work fewer than 20 hours per week. We also exclude very large firms from the analysis (with firm size above 10,000). We observe gross wage, which includes all income that enters the pension benefit calculations.

We generate a set of firm-specific indicators that we use in the heterogeneity analyses. Our baseline indicator of firm quality is the value added-based total factor productivity (TFP).[11] As another indicator of firm quality, we follow Bagger and Lentz (2019) to calculate a poaching index. Using data from years 2010-2015, for each firm we calculate the fraction of hires that are poached from other firms (i.e., who were employed the previous month and the current employer is different from the employer three months ago[12]). We require at least 15 observation of new hires, at least 1 hire from non-employment and a minimum average firm size of 50. We impute missing values of the poaching index with a linear regression using TFP. As further indicators of firm quality, we calculate firm-level average wage (discounted and averaged over 2010-2015) and also classify firms as foreign-owned if foreign ownership is above 50%. We also perform an Abowd, Kramarz, Margolis (AKM) style decomposition of wages (Abowd, Kramarz and Margolis, 1999) and calculate firm wage premia.[13]

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

[9]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.

[10]To ensure that the same sample is used in the employment heterogeneity analyses, we consider only those firms as private sector employers for which the firm quality indicators are not missing.

[11]We use the *prodest* Stata code of Rovigatti and Mollisi (2020), apply the estimation procedure of Wooldridge (2009) and take the firm specific average of the TFP indicator over 2010-2015.

[12]With this definition of the poaching index we ensure that a return within three months to the same firm is not considered as a new hire.

[13]The firm-level correlation coefficients of the TFP indicator in years 2012-2015 with the other quality indicators are the following: poaching index 0.652; AKM firm fixed effect 0.299; firm-level average wage 0.440; foreign ownership 0.212.

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 Effect on Employment

5.1.1 Descriptive Evidence

Figure 2 shows employment in private sector companies for men by age before and after the payroll tax subsidy was introduced in 2013. Panel (a) shows raw employment rates by age before (year 2012, in black) and after (years 2013-2015, 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 rapidly 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 2013-2015 for most age groups, but show some divergence below 26 and above 55.

Panel (b) shows estimates of the age-specific differences in employment at private sector companies for males before vs after the payroll tax subsidy was introduced. It suggests that for ages between 25 and 55 changes in employment rates were close to zero. 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 2 percentage points more likely to be employed shortly after the policy was introduced (years 2013-2015). The gap widens as age decreases. Similarly, among older workers, a 55-year-old worker was 1 percentage points more likely to be employed shortly after the policy was introduced and 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.[14] Appendix Figure B2 shows that there were no similar employment effects in the public sector and among the self-employed, where the payroll tax subsidy did not apply.

[14]Appendix Figure G1 shows employment rates by year and age. The figure shows that at ages 21-24, compared to 2012, the employment gap increased over years 2013-2015 and widened with age. Similarly, at ages 55-57, compared to 2012, the employment difference increased over years 2013-2015 and widened with age. Panel (b) suggests the presence of spillovers to control individuals who aged out of the treatment group previously (e.g. a 25-year-old in 2014 was treated in 2013), suggesting that the employment effects are persistent.

5.1.2 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.

We estimate the equation

$$y_{it} = \alpha_a + \beta_t + \sum_q \delta_q Treated_{it} + \varepsilon_{it} \tag{9}$$

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 $2010 - 2015$. 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 age $\times$ monthly date level.

We also estimate a pooled version of equation (9) where we replace the quarter-specific δ_t terms with a binary indicator $After$ which equals zero for year 2012 and one for years $2013 - 2015$, i.e. after the tax cut:

$$y_{it} = \alpha_a + \beta_t + \delta After_t Treated_{it} + \varepsilon_{it}. \tag{10}$$

Our coefficients of interest are the δ_q and δ terms in the two equations, respectively. The identifying assumption is that conditional on age effects and time effects, the employment rate in the treated and control groups would have evolved similarly without the policy and 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 2013-2015 from 1 percentage point to 2.5 percentage points among younger workers and from 0.5 percentage point to 1 percentage point among older workers. This gradual increase is consistent with other studies in the literature (see e.g. Saez, Schoefer and Seim, 2019) and 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.

The first part of Table 2 shows the baseline difference-in-differences results, corresponding to equation (10). The effective tax cut of 9.0 percentage points for younger workers and 6.6 percentage points for older workers is estimated to increase private sector employment by 1.65 percentage points (4.81%) in the 22-24 age group and 0.64 percentage points (1.79%) in the 55-57 age group over the years 2013-2015. As Table 3 shows, the implied labor demand elasticity is 0.66 (standard error: 0.027) for younger workers and 0.34 (standard error: 0.044) for older workers. The elasticity estimates for older workers are about twice as high as estimates in the literature, while those for younger workers are comparable to prior work, including Laun (2017) (0.22), Egebark and Kaunitz (2018) (0.3), and Saez, Schoefer and Seim (2019) (0.23). Huttunen, Pirttilä and Uusitalo (2013) estimate lower elasticities (0.07-0.13).

5.1.3 Heterogeneity

In this section, we investigate whether the treatment effect differs by firm and job characteristics. Here, we again use equation (10) but replace the outcome variable with a binary indicator of employment in a given type of job or firm.

In Table 2, we show how the impact of the payroll tax cut varies by firm characteristics. Overall, we see positive employment effects for most 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 much more at worse quality firms —firms with below-median TFP, firms with below median poaching index, domestic firms, and worse paying firms (based on the average wage). Among younger workers, the treatment effects are more balanced across firm types. These heterogeneity patterns are present also if we look at the quarterly effects over 2012-2015 (Figure 4) or if we focus on years 2012-2013 only (Appendix Figure G1). Accordingly, the demand elasticity both for younger and older workers is smaller at high quality (above median TFP) firms than at low quality (below median TFP) firms (Table 3, last four columns).

Next, in Table 4, we investigate whether the impact of the payroll tax cut on employment

in private sector companies differs by job characteristics. As a results of the payroll tax cut, among younger workers, the employment probability increases both in blue collar jobs and — slightly less — in white collar jobs but among older workers, we see a significant increase only for blue collar jobs.

Table 5 decomposes our main employment effect into employment where the person was not employed a year earlier (new entrant) and employment where the person was already employed a year earlier (incumbent). Thus, the effects for new entrants and incumbent workers add up to our main effect. The table shows that about two-thirds of the employment effect for younger workers and one-third of the employment effect among older workers stems from new entrants. Table 6 further shows that as employment at private sector firms increased due to the policy, the stock of the inactive or unemployed decreased by about the same magnitude, suggesting that the employment effect comes from new hiring.

5.1.4 Substitution and Windfall Effects

Substitution. A common concern about targeted tax cuts is whether firms substitute non-subsidized individuals with subsidized ones. To assess substitution effects we estimate the firm-level relative growth in employment by age group before and after the tax subsidy. Appendix Figure E1 shows the two-year relative change in employment for both the subsidized and non-subsidized ages prior to (between 2010 and 2012) and after the tax cut (between 2012 and 2014, with the subsidy enacted in 2013). We also add a counterfactual scenario of the period 2012-2014, where the relative change in employment shifts only for the subsidized age group (by the estimated average rate of increase) but remains the same as before the tax cut for the non-subsidized ages. The actual and counterfactual scenarios following the tax cut are closely aligned, which suggests that the substitution between the subsidized and non-subsidized age groups was limited.

Windfall Effects. In addition to that we also study whether windfall income accruing to firms that already employed a large share of subsidized workers impacted their growth (Saez, Schoefer and Seim, 2021). Appendix Figure E2 indicates that firm size and average wage trend similarly for firms with high and low shares of subsidized workers. This suggests that windfall effects were limited in our context.

5.1.5 Robustness

We examine robustness to alternative treatment and control group definitions in Figures 5 and 6. We estimate equation (10) using different age windows and age groups further from

the cutoff age as controls. Our baseline point estimates are shown as the third estimate both in panels (a) and (b) of both figures. The widening of the age window (first three estimates on the plot) has an increasing effect on the employment estimates for the young but has little effect on the estimates for the old. Restricting the control ages away from the cut-off (last two estimates on the plot) increases the estimated heterogeneity slightly for the young but decreases slightly for the old (Figure 5), while the direction of the heterogeneity (stronger employment effects at worse quality firms) persists (Figure 6).

We provide evidence in Appendix C that the estimated employment effects of the payroll tax subsidy are not the consequence of the presence of a minimum wage in Hungary.

5.2 Effect on Wages

The theoretical model presented in Section 2 suggests that wages, especially at high-productivity firms, should increase in response to the policy. Nevertheless, studying the impact of the tax subsidy on wages is not straightforward in the presence of a large change in employment as a simple comparison of wages between treated and untreated workers could simply reflect a composition change.

Therefore, to assess the impact on wages we focus on workers who also worked during the previous year and so we exclude new entrants.[15] We also restrict the attention to the wage changes around the policy change (for the years in 2012 and 2013) to make sure that we only look at workers who had a job before the policy change. Since the effective subsidy rate decreased with wage, the wage effects of the policy are expected to depend on the magnitude of the effective subsidy rate. For each observed wage (also for pre-policy wages) we calculate the subsidy rate, denoted by S and estimate the following regression, which allows for varying treatment intensity:

$$\begin{aligned}\ln w_{it} = \xi_a + S'_{it-1}\boldsymbol{\phi_a} + \eta_1 After_t + \eta_2 S_{it-1} After_t + \theta_0 Treated_{it} + \\ + \theta_1 After_t Treated_{it} + \theta_2 S_{it-1} After_t Treated_{it} + \nu_{it}. \qquad (11)\end{aligned}$$

Here w_{it} is the monthly wage adjusted for working hours of individual i at time t for individuals who work on all days of the month (May of years 2012-2013). We include age effects (ξ_a, where a is either in 22-27 or 52-57) in the model and an indicator ($After_t$) that equals one in year 2013 and zero in 2012. We also include the age- and year-specific effect of the one-year

[15] Among younger private sector workers (age 22-27), 31% are new entrants. Among older private sector workers (age 52-57), 12% are new entrants. We report difference-in-differences estimates for the wage of new entrants in Table G2 in the Appendix. These results suggest positive wage effects for the young, but this positive effect is driven by those who have some work experience from earlier years.

lag of the calculated subsidy rate (S_{it-1}). The rationale for this specification is that lagged subsidy rate captures lagged wage, hence also the best available outside option of the worker in the baseline (beside capturing the worker's unobserved characteristics). The coefficient of primary interest is θ_{2t}, which is the year- and subsidy-specific coefficient of treatment age ($Treated_{it}$). We also calculate the treatment effect at specific values of the subsidy rate.

The results of the wage regressions are reported in Table 7. We use the demeaned subsidy rate, thus the coefficient of $Treat * After$ shows the treatment effect at the average subsidy rate (10.2% for the young and 8.5% for the old). The baseline results suggest that the tax cut has no impact on wages in the short run at the mean. Among the young, the estimated treatment effect at the average subsidy rate is even negative, which then turns to positive at higher subsidy rates – as expected, lower wages are more responsive to the corresponding higher effective subsidy rate.

In addition to estimating the subsidy-specific treatment effect on wages, we also allow the treatment effect (and all other coefficients in the model) to vary with indicators of firm quality. These results are reported in the last five columns of Table 7. Heterogeneity results by TFP, poaching index, firm fixed effects, firm-level average wage and foreign ownership show that among older workers, the positive wage effect is stronger and mostly statistically significant at higher-quality firms. These results are in line with the predictions of the search model. Pass-through rates are between 0.477 and 0.910 for higher-quality firms depending on the quality measure used. Among younger workers, the heterogeneity patterns are mixed, which might be due to the fact that a higher share of young workers are new entrants or have limited employment histories, among whom the theoretical model predicts little or even negative wage effects of the subsidy.

We also report heterogeneous wage effects by firm quality in Table 8, where we show the average treatment effects at the median and maximum subsidy rate, corresponding to higher and lower wages respectively. Among older workers the patterns are similar – as a result of the subsidy, the wages increase only at high-productivity firms both at the median (0.08) and maximum (0.145) effective subsidy rate. Among younger workers the results vary by wage level – the wages decrease at the median (0.10) but increase at the maximum (0.145) subsidy rate, though, except for the heterogeneity by TFP, the increase is significant only at low-productivity firms.

Figure 7 shows the predicted treatment effects at different values of the lagged subsidy rate. Panel (a) shows that among the young, the treatment effect is mostly negative but increases with the rate of the subsidy and these patterns are similar at low and high quality firms. Panel (b) shows that among the old, the treatment effect is mostly positive and increases with the rate of the subsidy at high quality firms.

As a robustness check, we estimate the wage effects by firm quality with alternative control ages. Figure 8 shows that the estimated patterns remain similar if we make the treated and control age windows narrower and also if we use control ages further from the cut-off age, both among older and younger workers. Accordingly, the wages of the old increase only at high quality firms even if we use 2-year or 1-year age windows or compare our treatment group (ages 55-57) to control groups further away from the age cut-off (ages 52-53 or age 52 only, instead of the original 52-54).

Finally, as a placebo test, we estimate the wage effects at pre-reform (hypothetical) treatment years. Figure 9 suggests that the effect is specific to the actual treatment year and as expected, we see no effects in previous years in general. Note, that among the old, the wage effects also return to zero in years after 2013, suggesting that the wage adjustment occurred within one year after the introduction of the subsidy, after which the wage dynamics of the treatment and controls group became similar again. Among the young, we estimate positive treatment effects even two years after the introduction of the policy.

5.3 Welfare Analysis

Following Hendren and Sprung-Keyser (2020), we calculate the tax subsidy's marginal value of public funds (MVPF), defined as the ratio of the recipients' willingness to pay and the policy's net cost. Using the estimated causal effects reported in Sections 5.1 and 5.2 we calculate the MVPF of the policy separately for younger and older workers and for low-productivity and high-productivity firms. The details of the calculations are explained in Appendix F.

Without differentiation by firm quality, the MVPF of the payroll tax subsidy for the young is 1.02 and 0.15 for the old. The difference between the two is mostly due to the bigger employment effect of the subsidy among the young. The MVPF for the young is close to the calculations of Paradisi (2021) for the payroll tax cut of Sweden, based on the analysis of Saez, Schoefer and Seim (2019).

The MVPF of the payroll tax subsidy targeting high quality firms is higher both for younger and older workers (0.89 versus 1.34 for the young, 0.11 versus 0.28 for the old, for below median TFP and above median TFP firms, respectively). Among the young, this difference is primarily driven by the higher wages paid to the non-negligible number of new hires at high quality firms, whereas among the old, the difference is mainly due to the higher pass-through rate of the subsidy to workers at high quality firms.

6 Conclusion

This paper provides theoretical and empirical evidence for heterogeneities in the impact of payroll tax subsidies on employment and wage by firm types. Based on an equilibrium search model we show that the effect of a 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.

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 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 at lower-quality firms, while the wage effect is stronger at higher-quality firms.

Overall, our results highlight that at lower-quality firms, the incidence of payroll tax cuts mainly falls on firms, while at higher-quality firms, the incidence mainly falls on workers.

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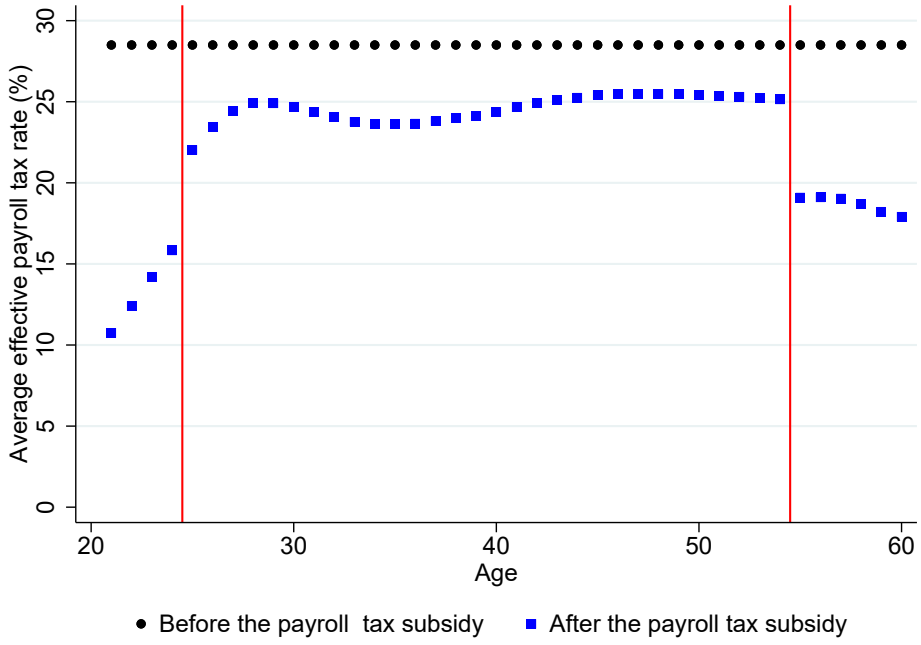
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Figures and Tables

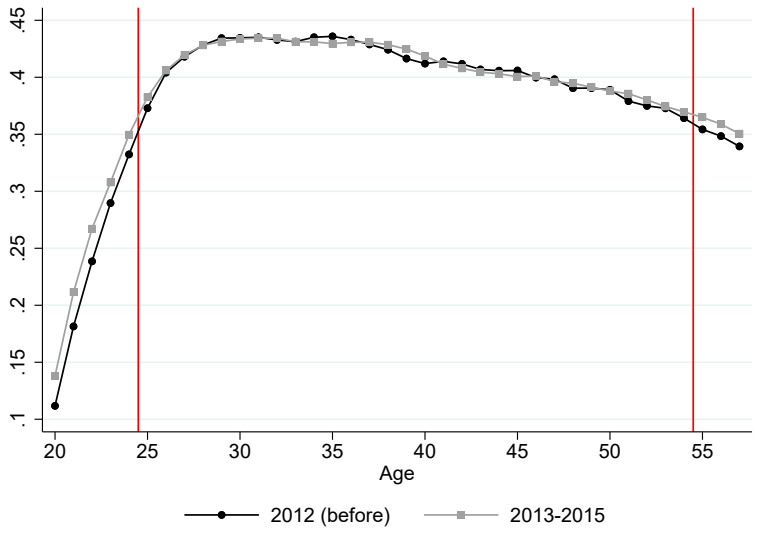
Figure 1: Average payroll tax rate (males)



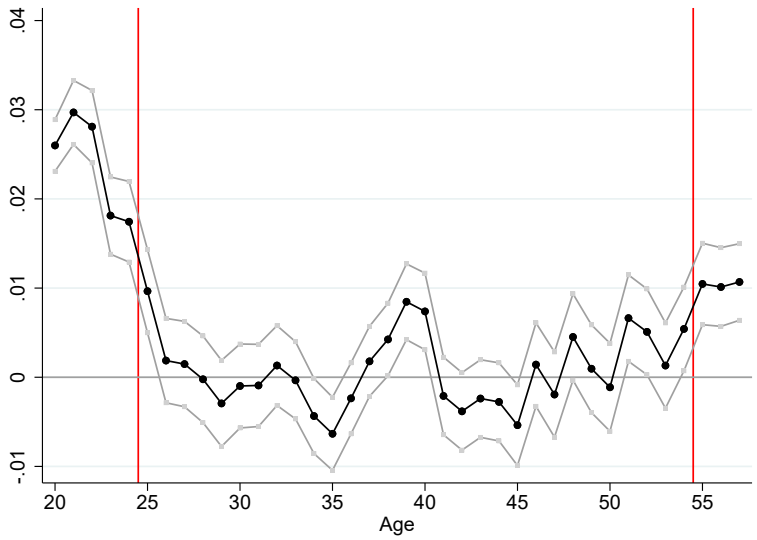
Notes: This figure shows the average payroll tax rate by worker age. Before the implementation of the payroll tax subsidy, the payroll tax rate was a flat 28.5%. Between 2013-2015 (after the implementation of the subsidy), the payroll tax rate was 28.5% minus the subsidy. Using the observed gross wages in years 2013-2015 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. Appendix Figure B1 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



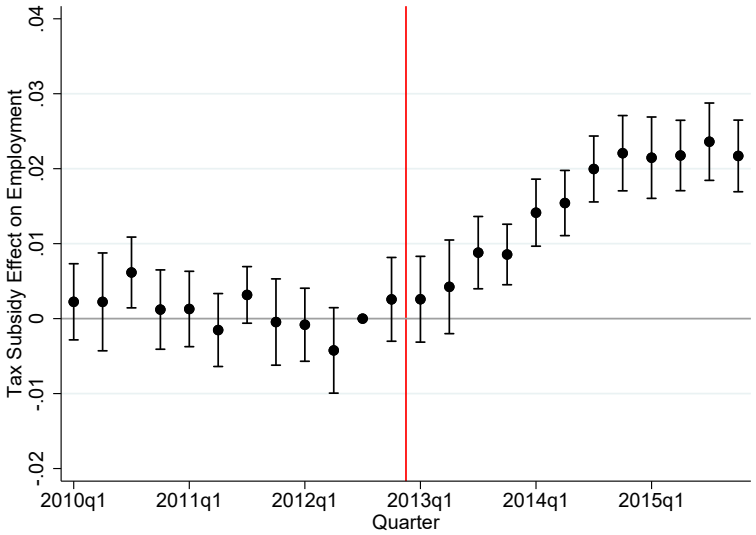
(b) Change in Employment Rate



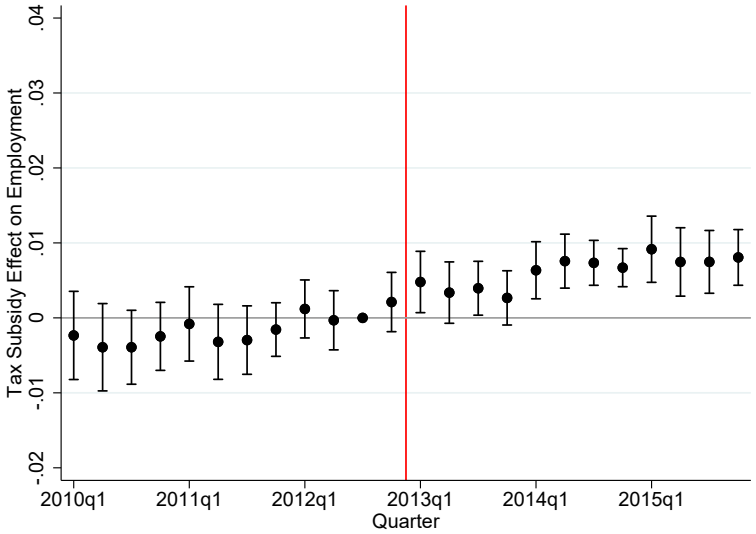
Note: Panel (a) shows the employment rate in private sector companies by age separately for year 2012 (before the implementation of the payroll tax subsidy) and for years 2013-2015 (after the implementation of the payroll tax subsidy). Panel (b) shows the differences between years 2013-2015 and 2012, with the 95% confidence interval (standard errors clustered on the individual-level). 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 (males)

(a) Young



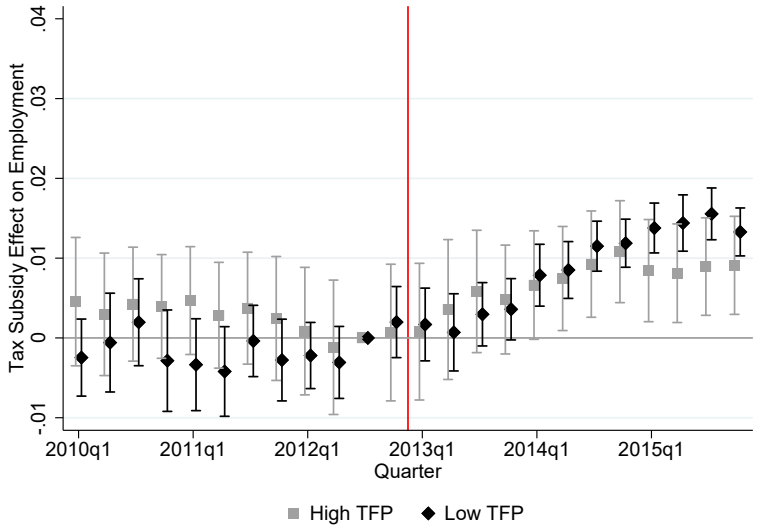
(b) Old



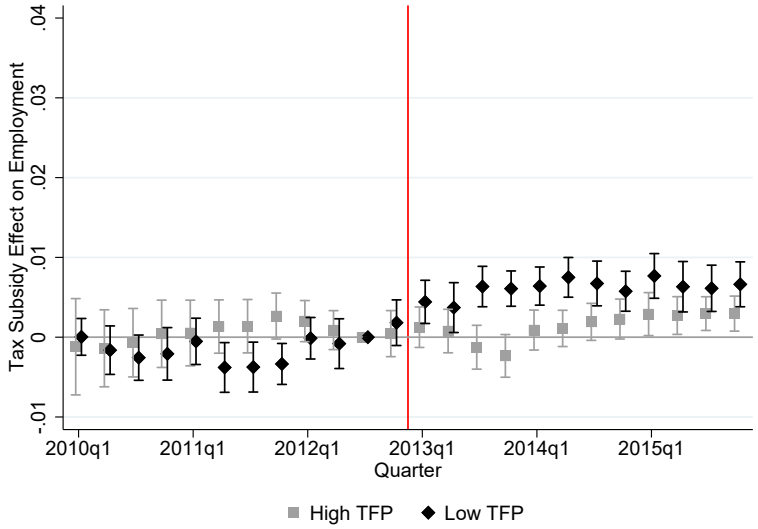
Notes: The figures show the change in employment for treated age groups (affected by the payroll tax subsidy) relative to the control age groups (similar age group, but unaffected by the tax subsidy) before and after the reform. In particular, we plot the δ_q from equation (9). Panel (a) shows the estimates 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 age $\times$ period level.

Figure 4: Employment effects: heterogeneity by TFP, males

(a) Young



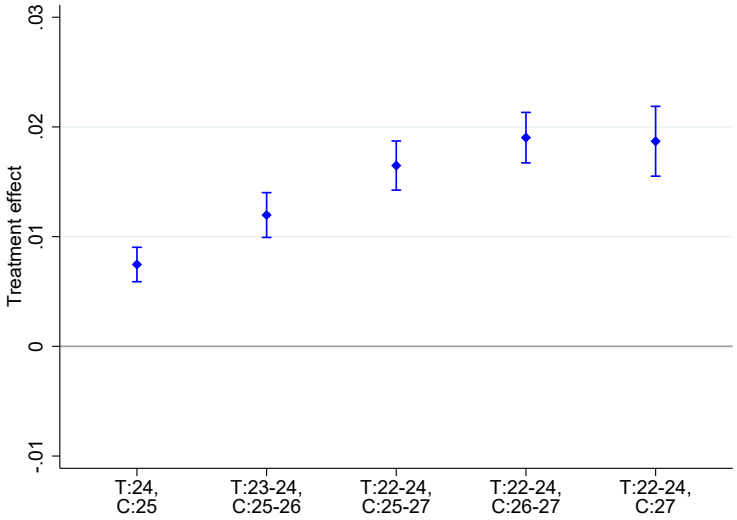
(b) Old



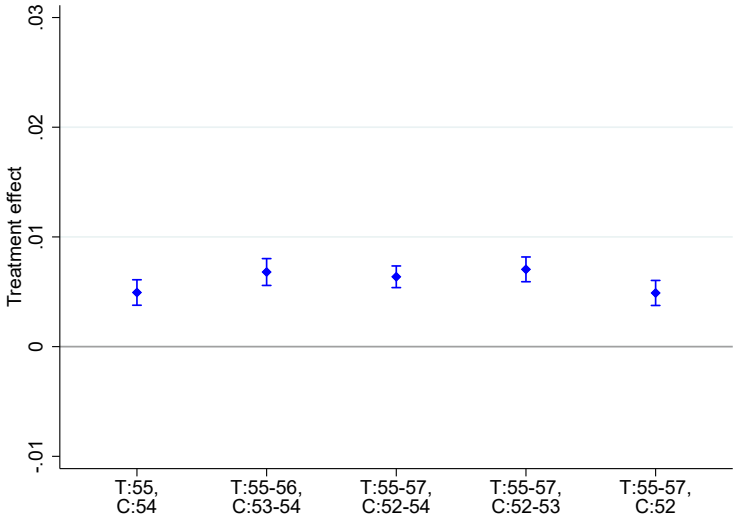
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Figure 5: Private sector employment by TFP: alternative control and treatment ages (males)

(a) Young



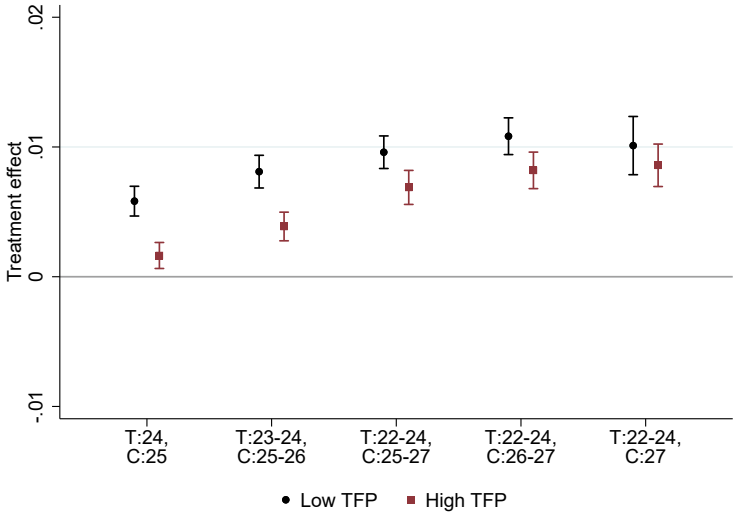
(b) Old



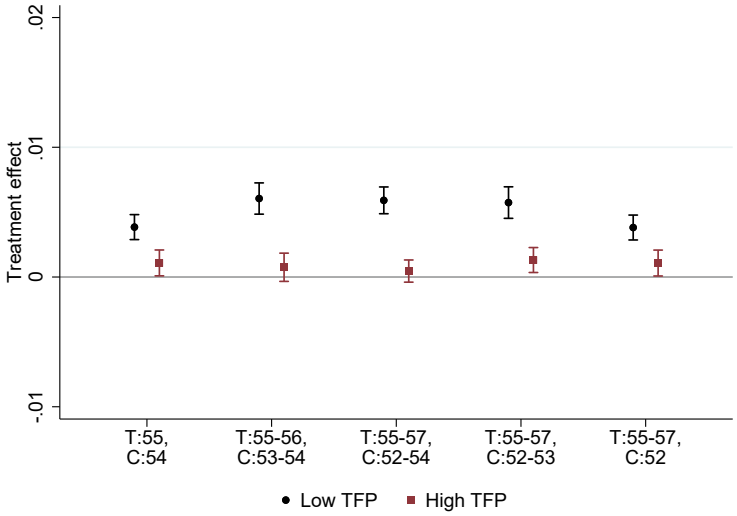
Notes: The figures show estimated employment effects with the corresponding 95% confidence intervals, based on equation (10), where the standard errors are clustered at the age × period level. These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2015 period (after the introduction of the payroll tax subsidy in 2013). "T" denotes treatment group ages, "C" denotes control group ages.

Figure 6: Private sector employment by TFP: alternative control and treatment ages (males)

(a) Young



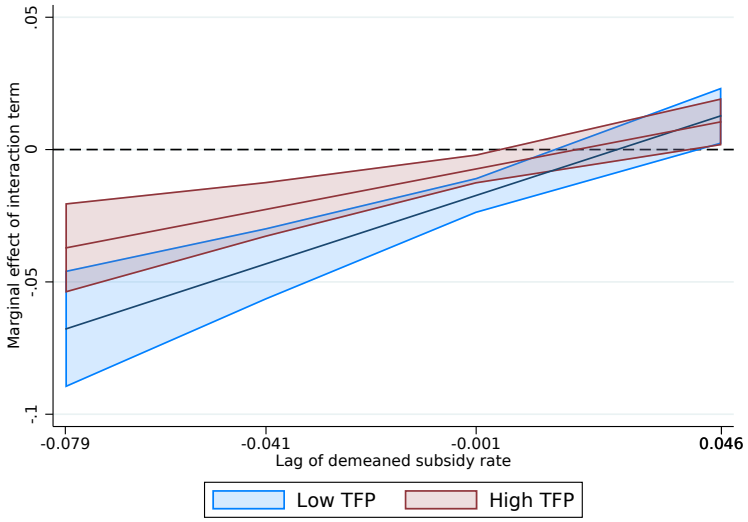
(b) Old



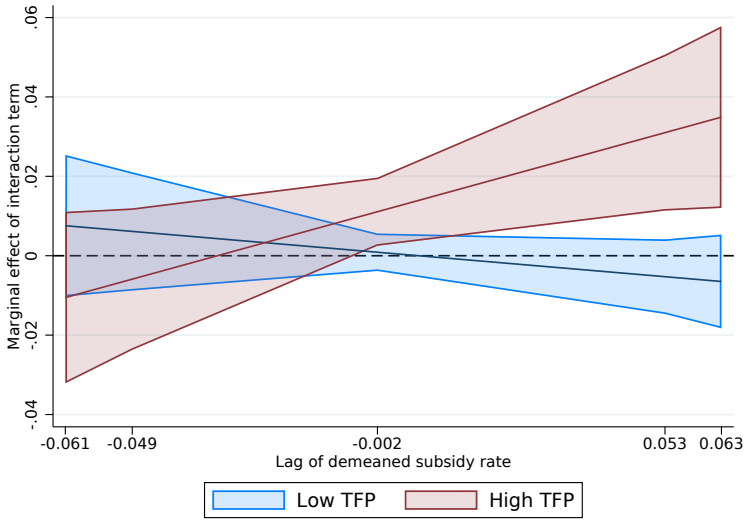
Notes: The figures show estimated employment effects with the corresponding 95% confidence intervals, based on equation (10), where the standard errors are clustered at the age × period level. These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2015 period (after the introduction of the payroll tax subsidy in 2013). "T" denotes treatment group ages, "C" denotes control group ages.

Figure 7: Wage effects: heterogeneity by TFP at different subsidy rates, males

(a) Young



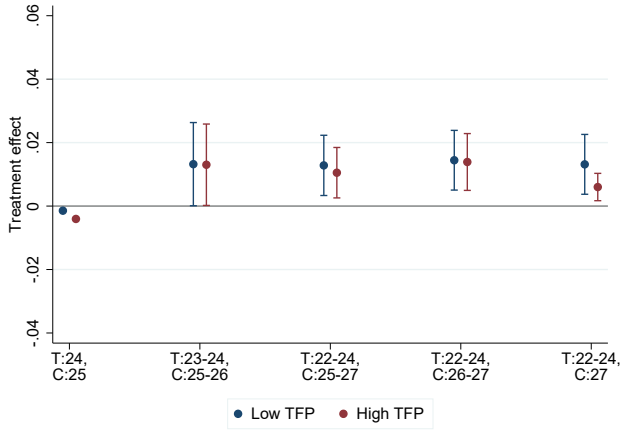
(b) Old



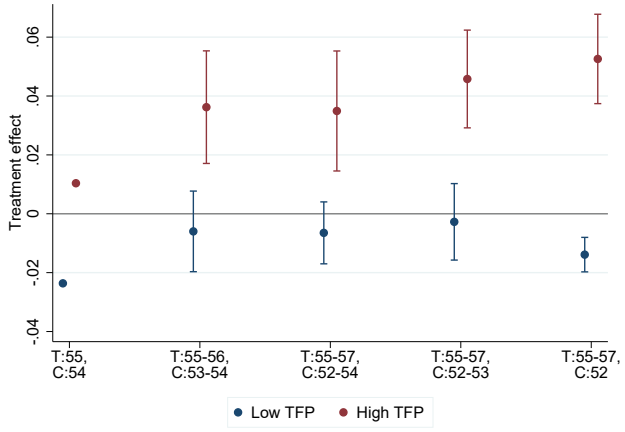
Notes: The figures show the predicted treatment effects by lagged demeaned subsidy rate based on equation (11). The figures correspond to the estimation results shown in Table 7 and Table 8. The predicted average treatment effects are calculated at the minimum, maximum, 10^{th}, 50^{th} and 90^{th} percentiles separately for the young and old group. The confidence intervals are extrapolated using these values. In case of the young group, the maximum and the 90^{th} percentile is the same. Mean subsidy rate for the young is 0.102, for the old it is 0.085.

Figure 8: Private sector wages by TFP: alternative control and treatment ages (males)

(a) Controls: Young



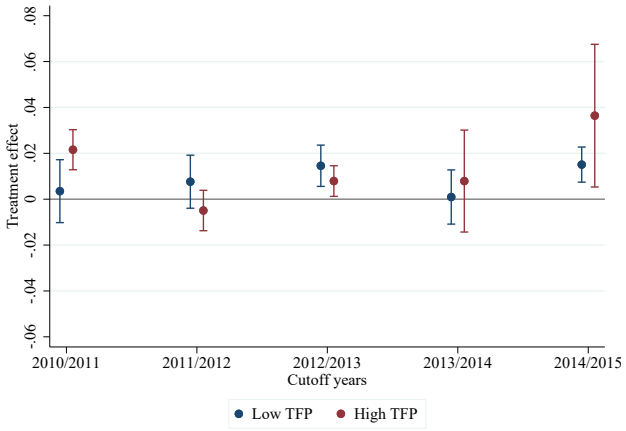
(b) Controls: Old



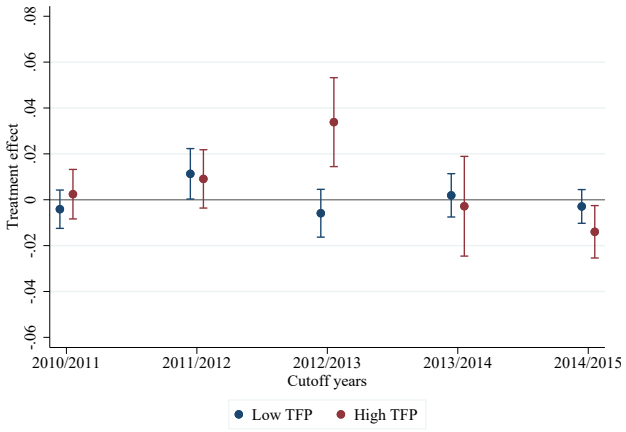
Notes: The figures show predicted treatment effects on log(wage) in private sector companies with the corresponding 95% confidence intervals at maximal value of subsidy rate (0.145), based on equation (11). "C" denotes control group ages while treatment ages are denoted by "T". The standard errors of the first two estimation points are close to zero due to the clustering at the age × period level.

Figure 9: Private sector wages by TFP over years (males)

(a) Young



(b) Old



Notes: The figures show predicted treatment effects on log(wage) in private sector companies with the corresponding 95% confidence intervals at maximal value of subsidy rate (0.145), based on equation (11). We use a hypothetical treatment year of 2011 and 2012 and also include our baseline results.

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	0.294	0.391	0.361	0.342
Monthly private sector wage (HUF)	167,513	203,526	244,876	239,179
White collar job (private sector workers)	0.318	0.444	0.303	0.301
Firm quality (private sector workers)				
Above median poaching index	0.467	0.528	0.491	0.478
Above median TFP	0.520	0.559	0.487	0.472
Above median firm FE	0.501	0.539	0.498	0.499
Above median firm level average wage	0.467	0.534	0.519	0.519
Foreign ownership	0.347	0.376	0.233	0.221
Industry (private sector workers)				
Agriculture	0.040	0.035	0.078	0.086
Manufacturing	0.373	0.353	0.334	0.333
Construction	0.080	0.075	0.105	0.103
Wholesale and retail trade	0.138	0.146	0.114	0.107
Accommodation and food service	0.053	0.041	0.016	0.015
Transportation and storage	0.048	0.054	0.109	0.106
Financial and insurance activities	0.012	0.020	0.012	0.011
Administrative and support	0.113	0.086	0.053	0.056
Other	0.142	0.192	0.177	0.183
Total number of observations	4,313,257	4,311,514	4,298,777	4,705,668

Notes: The table shows summary statistics for treated and and control group workers over years 2012-2015. 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 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 a month ago). We impute missing values of the poaching index using other firm-specific indicators (average wage, logarithm of firm size, TFP, foreign ownership, industry) and then extrapolate the poaching index to years 2013-2015. We calculate total factor productivity (TFP) using the "prodest" Stata code of Rovigatti and Mollisi (2020) and applying the estimation procedure of Wooldridge (2009). 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
Employment at private firms	0.0165***	0.0064***
	[0.0011]	[0.0005]
TFP		
Below median TFP, treatment effect	0.0096***	0.0059***
	[0.0006]	[0.0005]
Above median TFP, treatment effect	0.0069***	0.0005
	[0.0007]	[0.0004]
p-value of equality test	0.000	0.000
Poaching index (PI)		
Below median PI, treatment effect	0.0096***	0.0043***
	[0.0007]	[0.0005]
Above median PI, treatment effect	0.0069***	0.0021***
	[0.0006]	[0.0006]
p-value of equality test	0.000	0.009
Firm FE (based on AKM decomposition)		
Below median FE, treatment effect	0.0110***	0.0057***
	[0.0007]	[0.0004]
Above median FE, treatment effect	0.0055***	0.0007
	[0.0005]	[0.0004]
p-value of equality test	0.000	0.000
Firm level average wage		
Below median, treatment effect	0.0117***	0.0054***
	[0.0008]	[0.0004]
Above median, treatment effect	0.0048***	0.0009**
	[0.0005]	[0.0004]
p-value of equality test	0.000	0.000
Foreign ownership		
Domestic firm, treatment effect	0.0147***	0.0071***
	[0.0010]	[0.0004]
Foreign firm, treatment effect	0.0018***	-0.0007**
	[0.0004]	[0.0003]
p-value of equality test	0.000	0.000

Note: Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (10). 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. 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: Elasticity of employment

	All firms		Low TFP		High TFP	
	Young	Old	Young	Old	Young	Old
Labor cost $(1+\tau_{ss})$						
—Without subsidy	1.24	1.26	1.22	1.25	1.25	1.27
—With subsidy	1.15	1.20	1.13	1.18	1.17	1.22
—Percent change in labor cost	-7.28%	-5.24%	-7.79%	-5.89%	-6.51%	-4.49%
Employment rate						
—Without subsidy	0.343	0.358	0.148	0.174	0.176	0.159
—With subsidy	0.359	0.364	0.157	0.180	0.183	0.160
—Percent change in employment	4.81%	1.79%	6.50%	3.38%	3.91%	0.31%
Implied elasticity	0.66	0.34	0.83	0.57	0.60	0.07

Note: The elasticity estimations are based on the results reported in Table 2, corresponding to years 2012-2015 (with 2012 as the pre-policy year and 2013-2015 as post-policy years). The young ages are 22-27 (22-24 as treated, 25-27 as control ages). The old ages are 52-57 (52-54 as control, 55-57 as treated ages). Low (high) TFP firm have below (above) median TFP.

Table 4: Heterogeneity by occupation categories: impact on employment in private sector companies

	Employment of Young Age 22-27	Employment of Old Age 52-57
Blue collar job, treatment effect	0.0064***	0.0056***
	[0.0007]	[0.0006]
White collar job, treatment effect	0.0101***	0.0008
	[0.0006]	[0.0006]
p-value of equality test	0.000	0.000

Note: Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (10). 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. 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 5: Employment in private sector companies: new entrants and incumbents

	Young (age 22-27)	Old (age 52-57)
All	0.0165***	0.0064***
	[0.0011]	[0.0005]
New entrants	0.0089***	0.0022***
	[0.0008]	[0.0003]
Incumbents	0.0076***	0.0041***
	[0.0007]	[0.0005]
By TFP		
New entrants, below median TFP	0.0043***	0.0021***
	[0.0005]	[0.0002]
New entrants, above median TFP	0.0046***	0.0002
	[0.0004]	[0.0001]
Incumbents, below median TFP	0.0053***	0.0039***
	[0.0004]	[0.0004]
Incumbents, above median TFP	0.0023***	0.0003
	[0.0005]	[0.0004]

Note: Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. The outcome is either employment conditional on less than 12 months employment the past 12 months (new entrants) or employment conditional on 12 months employment the past 12 months (incumbents). 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. In each regression, we control for age and quarterly date effects.

Table 6: Effect of the payroll tax cut by employment categories

	Young (age 22-27)	Old (age 52-57)
Employment at private firms	0.0165***	0.0064***
	[0.0011]	[0.0005]
Public sector	0.0009***	0.0017***
	[0.0002]	[0.0003]
Self-employed	-0.0002	-0.0013***
	[0.0003]	[0.0003]
Inactive/unemployed	-0.0172***	-0.0068***
	[0.0012]	[0.0007]

Note: Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (10). These are difference-in-differences estimates that compare the change in the employment in the given category 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.

Table 7: Impact of the tax subsidy on wages in private sector companies

Outcome variable: log(wage)						
Young (age 22-27)						
	Baseline	TFP	Poaching	AKM FE	Mean firm wage	Foreign ownership
Treat * After	-0.0060**	-0.0170***	0.0002	-0.0271**	-0.0061	-0.0093***
	[0.0015]	[0.0030]	[0.0033]	[0.0080]	[0.0066]	[0.0008]
Treat * After * Subsidy rate	0.4788***	0.6465***	0.3661	0.8922**	0.3504	0.4641**
	[0.1070]	[0.1088]	[0.2307]	[0.2410]	[0.1723]	[0.1074]
High quality * Treat * After		0.0099*	-0.0121**	0.0089	-0.0103	-0.0019
		[0.0035]	[0.0031]	[0.0095]	[0.0095]	[0.0032]
High quality * Treat * After * Subsidy rate		-0.2641**	0.0004	-0.7372**	-0.1836	-0.0990
		[0.0842]	[0.2728]	[0.2065]	[0.1558]	[0.2112]
Observations	66,166					

Old	Baseline	TFP	Poaching	AKM FE	Mean firm w	Foreign ownership
Treat * After	0.0014	0.0006	-0.0020	0.0016	-0.0058	0.0001
	[0.0027]	[0.0020]	[0.0037]	[0.0051]	[0.0058]	[0.0036]
Treat * After * Subsidy rate	0.0846	-0.1126	-0.0416	-0.1978	0.0194	-0.0408
	[0.1199]	[0.1058]	[0.1561]	[0.1754]	[0.1807]	[0.1343]
High quality * Treat * After		0.0112***	0.0096	0.0198	0.0268*	0.0211**
		[0.0023]	[0.0044]	[0.0104]	[0.0088]	[0.0060]
High quality * Treat * After * Subsidy rate		0.4769*	0.2869*	0.9095**	0.6337***	0.7796***
		[0.1648]	[0.1019]	[0.2431]	[0.1264]	[0.0917]
Observations	103,647					

Note: Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. Outcome variable is log(wage) winsorized at the 98th percentile. Baseline result is from a three-way difference-in-differences model with age groups (22-24 or 55-57 as treated group, 25-27 or 52-54 as control group), time (2012 is baseline year, 2013 is after the intervention) and the continuous variable of demeaned subsidy rate relative to last year's wage, as written in Equation 11. For the demeaned subsidy rate the mean of lagged subsidy rate in the treatment ages in 2013 is subtracted from the variable. Subsidy rate is simplified subsidy rate that takes into account only the age-based subsidy. The other columns report heterogeneity results, where everything is interacted with a binary indicator showing whether the firm is above median with respect to firm-level variables for firm quality ("high quality"), except for foreign ownership, in which case a binary indicator of foreign ownership being above 50% is used.

Table 8: Predicted treatment effects on wages in private sector companies at different values of the subsidy rate

Median subsidy rate					
Young	TFP	Poaching	AKM FE	Mean firm w	Foreign ownership
S.R. = 0.10; low quality	-0.0173***	0.0000	-0.0277***	-0.0063	-0.0096***
	[0.0030]	[0.0034]	[0.0081]	[0.0067]	[0.0007]
S.R. = 0.10; high quality	-0.0073**	-0.0121***	-0.0183***	-0.0165***	-0.0114***
	[0.025]	[0.0017]	[0.0041]	[0.0037]	[0.0034]
Old	TFP	Poaching	AKM FE	Mean firm w	Foreign ownership
S.R. = 0.08; low quality	0.0009	-0.0019	0.0020	-0.0059	0.0002
	[0.0021]	[0.0040]	[0.0055]	[0.0061]	[0.0039]
S.R. = 0.08; high quality	0.0111**	0.0071**	0.0200**	0.0196***	0.0197***
	[0.0039]	[0.0029]	[0.0070]	[0.0053]	[0.0034]
Maximum subsidy rate					
Young	TFP	Poaching	AKM FE	Mean firm w	Foreign ownership
S.R. = 0.145; low quality	0.0128**	0.0171*	0.0140**	0.0101***	0.0121**
	[0.048]	[0.0087]	[0.046]	[0.0031]	[0.0054]
S.R. = 0.145; high quality	0.0105**	0.0050	-0.0111	-0.0087	0.0056
	[0.0041]	[0.0061]	[0.0046]	[0.0084]	[0.0095]
Old	TFP	Poaching	AKM FE	Mean firm w	Foreign ownership
S.R. = 0.145; low quality	-0.0065	-0.0046	-0.0109	-0.0046	-0.0024
	[0.0054]	[0.0064]	[0.0063]	[0.0061]	[0.0060]
S.R. = 0.145; high quality	0.0349***	0.0231**	0.0665**	0.0623***	0.0680***
	[0.0104]	[0.0083]	[0.0246]	[0.0181]	[0.0134]

Note: S.R. denotes subsidy rate. The table shows the predicted treatment effects, using the results reported in Table 7. Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. Outcome variable is log(wage) winsorized at the 98th percentile. Heterogeneity is with respect to a binary indicator showing whether the firm is above median with respect to firm-level variables for firm quality ("high quality"), except for foreign ownership, in which case a binary indicator of foreign ownership being above 50% is used.

Appendix

A The Effect of Tax Subsidies in Search Models

A.1 Setup

Firms are heterogeneous characterized by productivity $y \in [0, \infty]$, with cumulative distribution function $\Psi()$. A job offer is a draw of a firm productivity from the vacancy distribution $\Gamma()$ with probability distribution function $\gamma()$. The production function is $f()$, increasing in y.

Workers are homogeneous. Workers are either unemployed or employed. If unemployed, they receive leisure of value b 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 increasing and convex cost $\kappa()$. Job market tightness is the ratio between total vacancies (v) and total search effort by the unemployed (u) and employed ($(1-\delta)(1-u)$):

$$\theta = \frac{v}{u + s(1-\delta)(1-u)}. \tag{12}$$

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. For simplicity, we also assume that all the bargaining power is at the firms and so they are able to extract all rents from the workers.[16]

A.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:

$$V_u = b + \beta V_u, \tag{13}$$

where β is the discount factor. Thus,

$$V_u = \frac{b}{1-\beta}. \tag{14}$$

[16]It is straightforward to introduce some bargaining power of the worker in the model. Nevertheless, empirical studies find usually that bargaining power is quite small and so we do not miss a lot by abstracting away from that.

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

$$V(y,\tau) = f(y) + \tau + \delta\beta V_u + (1-\delta)\beta V(y,\tau), \tag{15}$$

where τ is the employment subsidy. Here, the possibility of the worker being poached by another firm is implicitly included in the $V(y,\tau)$ formula. Note also that if no outside offers arrive then the continuation value of the worker is $V(y,\tau)$. If the worker is poached then she is poached at value $V(y,\tau)$. Either way, the continuation value of the worker who survives the exogenous separation is $V(y,\tau)$, which is the maximum value the firm can deliver (Moscarini and Postel-Vinay, 2018).
After rearrangement:

$$(1-\beta+\delta\beta)V(y,\tau) = f(y) + \tau + \frac{\delta\beta b}{1-\beta}. \tag{16}$$

The value of posting ν vacancies is, using that workers have no bargaining power:

$$V_v(y,\tau,\nu) = -\kappa(\nu(y,\tau)) + \beta\nu(y,\tau)\frac{\phi(\theta)}{\theta}P(u)\Big[V(y,\tau) - V_u\Big] + \\ + \beta\nu(y,\tau)\frac{\phi(\theta)}{\theta}(1-P(u))\int_0^y \Big[V(y,\tau) - V(y',\tau)\Big]d\Gamma(y'). \tag{17}$$

Using equation (16), equation (4) can be rewritten:

$$V_v(y,\tau,\nu) = -\kappa(\nu(y,\tau)) + \beta\nu(y,\tau)\frac{\phi(\theta)}{\theta}P(u)\left[\frac{f(y)+\tau+\dfrac{\delta\beta b}{1-\beta}}{1-\beta+\delta\beta} - V_u\right] + \\ + \beta\nu(y,\tau)\frac{\phi(\theta)}{\theta}(1-P(u))\int_0^y \left[\frac{f(y)-f(y')}{1-\beta+\delta\beta}\right]d\Gamma(y'), \tag{18}$$

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

$$P(u) = \frac{u}{u+(1-\delta)s(1-u)}. \tag{19}$$

As in Bagger and Lentz (2019), the sampling distribution from the vacancy pool is the recruitment intensity weighted firm-type distribution:

$$\Gamma(y) = \frac{\int_0^y \nu(y',\tau)d\Psi(y')}{\int_0^1 \nu(y',\tau)d\Psi(y')}. \tag{20}$$

The total amount of vacancies is $v = \int_0^1 \nu(y',\tau)d\Psi(y')$.

A.3 Equilibrium

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

$$L(y) = (1-\delta)\Big[1 - s\phi(\theta)(1-\Gamma(y))\Big]L(y) + \phi(\theta)\Gamma(y)u. \tag{21}$$

Employment at firms with productivity y is:

$$l(y) = (1-\delta)\left[\Big[1 - s\phi(\theta)(1-\Gamma(y))\Big]l(y) + s\phi(\theta)\gamma(y)\int_0^y l(y')dy'\right] + \phi(\theta)\gamma(y)u. \tag{22}$$

The steady state rate of unemployment is:

$$u = (1-\phi(\theta))u + \delta(1-u). \tag{23}$$

Thus,

$$u = \frac{\delta}{\delta + \phi(\theta)}. \tag{24}$$

Firms maximize their profit and so they post vacancies up to the point where the marginal value of a vacancy is zero.

$$\begin{aligned}\kappa'(\nu(y,\tau)) = \beta\frac{\phi(\theta)}{\theta}P(u)\left[\frac{f(y)+\tau+\dfrac{\delta\beta b}{1-\beta}}{1-\beta+\delta\beta} - V_u\right] + \\ + \beta\frac{\phi(\theta)}{\theta}(1-P(u))\int_0^y \left[\frac{f(y)-f(y')}{1-\beta+\delta\beta}\right]d\Gamma(y').\end{aligned} \tag{25}$$

The equilibrium solution of Θ and $\Gamma(y)$ satisfies equations (1), (19), (20), (21), (6) and (25).

A.4 Wage

This section is based on Postel-Vinay and Robin (2002).

Contracts can be renegotiated by mutual consent. 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 $y' > y$ 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 $q(w,y) < y' + \tau < y + \tau$, where $q(w,y)$ is the threshold productivity, defined by $\xi(q(w,y),y) = w$. I.e., $q(w,y)$ is the lowest productivity y' such that the Bertrand competition between firm y and firm

y' raises the wage above w Importantly, 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.

$U(x)$ is the instantaneous utility flow from income x. The value of employment at firm of type y and paid wage w is $V_e(w, y+\tau)$. The type-y firm optimally offers to the unemployed worker the wage $\xi_u(y+\tau)$ that exactly compensates this worker for his opportunity cost of employment:

$$V_e(\xi_u(y+\tau), y+\tau) = V_u. \tag{26}$$

A worker moves to a potentially better match with a firm type-y' if it offers at least the wage $\xi(y, y')$ defined by:

$$V_e(\xi(y, y'), y') = V_e(y, y). \tag{27}$$

Lower offers are outbid by the type-y incumbent firm.

The Bellman equation for the value of employment is the following:

$$\begin{aligned}
&\Big(\delta + \frac{1-\beta}{\beta} + \phi(\theta)\bar{\Gamma}(q(w, y+\tau), \tau)\Big)V_e(w, y+\tau) = \\
&= U(w) + \phi(\theta)\Big[\Gamma(y+\tau, \tau) - \Gamma(q(w, y+\tau), \tau)\Big]E_\Gamma\{V_e(X, X)|q(w, y+\tau) \le X \le y+\tau\} + \\
&+ \phi(\theta)\bar{\Gamma}(y+\tau, \tau)V_e(y+\tau, y+\tau) + \delta V_u,
\end{aligned} \tag{28}$$

where $q(w, y+\tau)$ is the threshold productivity, defined by $\xi(q(w, y), y) = w$. The second term in the right hand side of equation (28) captures the employment value after a wage increase at the current firm, whereas the third term captures the value of employment at a higher productivity firm (after being poached).

Assuming CRRA utility function with ζ rate of relative risk aversion ($\zeta \ge 0$ and $\zeta \ne 1$), we can derive the expression of wages, following Postel-Vinay and Robin (2002):

$$\ln \xi(y+\tau, y'+\tau) = \frac{1}{1-\zeta} \ln \Big[(y+\tau)^{1-\zeta} - \frac{(1-\zeta)\phi(\theta)}{\frac{1-\beta}{\beta} + \delta} \int_{y+\tau}^{y'+\tau} \bar{\Gamma}(x, \tau) x^{-\zeta} dx\Big]. \tag{29}$$

The wage of workers whose wage is the first salary after unemployment is:

$$\ln \xi(b, y+\tau) = \ln \xi_u(y+\tau) = \frac{1}{1-\zeta} \ln \Big[b^{1-\zeta} - \frac{(1-\zeta)\phi(\theta)}{\frac{1-\beta}{\beta} + \delta} \int_{b}^{y+\tau} \bar{\Gamma}(x, \tau) x^{-\zeta} dx\Big]. \tag{30}$$

Note, that the direct effect of the tax subsidy τ on $\xi(b, y+\tau)$ is zero. The negative terms in the above two equations capture the option value of employment: workers accept lower wages to work at more productive firms because workers trade a lower wage now for increased chances of higher wages. tomorrow (Postel-Vinay and Robin, 2002).

The derivation of equations (29) and (30) is based on Postel-Vinay and Robin (2002). We start from equation (28). Plugging in $w = y+\tau$ into equation (28), using that $q(y, y) = y$ gives

$$V_e(y+\tau, y+\tau) = \frac{U(y+\tau) + \delta V_u}{\frac{1-\beta}{\beta} + \delta}. \tag{31}$$

We plug this expression in to equation (28) and use that by definition, $V_e(w, y+\tau) = V_e(q(w, y+\tau), q(w, y+\tau))$:

$$\begin{aligned}
&\Big(\delta + \frac{1-\beta}{\beta}\Big)V_e(w, y+\tau) = U(w) + \delta V_u - \\
&- \phi(\theta)\bar{\Gamma}(q(w, y+\tau), \tau)V_e(q(w, y+\tau), q(w, y+\tau)) + \phi(\theta)\bar{\Gamma}(y+\tau, \tau)V_e(y+\tau, y+\tau) + \\
&+ \phi(\theta)\int_{q(w,y+\tau)}^{y+\tau} \frac{U(x) + \delta V_u}{\frac{1-\beta}{\beta} + \delta} d\Gamma(x) = U(w) + \delta V_u - \\
&- \phi(\theta)\bar{\Gamma}(q(w, y+\tau), \tau)V_e(q(w, y+\tau), q(w, y+\tau)) + \phi(\theta)\bar{\Gamma}(y+\tau, \tau)V_e(y+\tau, y+\tau) + \\
&+ \phi(\theta)[V_e(x, x)\Gamma(x)]_{q(w,y+\tau)}^{y+\tau} - \phi(\theta)\int_{q(w,y+\tau)}^{y+\tau} \frac{U'(x)}{\frac{1-\beta}{\beta} + \delta}\Gamma(x)dx = U(w) + \delta V_u - \\
&- \phi(\theta)V_e(q(w, y+\tau), q(w, y+\tau)) + \phi(\theta)V_e(y+\tau, y+\tau) - \phi(\theta)\int_{q(w,y+\tau)}^{y+\tau} \frac{U'(x)}{\frac{1-\beta}{\beta} + \delta}\Gamma(x)dx = \\
&= U(w) + \delta V_u - \phi(\theta)V_e(q(w, y+\tau), q(w, y+\tau)) + \phi(\theta)V_e(y+\tau, y+\tau) - \\
&- \phi(\theta)[V(x, x)]_{q(w,y+\tau)}^{y+\tau} + \phi(\theta)\int_{q(w,y+\tau)}^{y+\tau} \frac{U'(x)}{\frac{1-\beta}{\beta} + \delta}\bar{\Gamma}(x)dx = \\
&= U(w) + \delta V_u + \phi(\theta)\int_{q(w,y+\tau)}^{y+\tau} \frac{U'(x)}{\frac{1-\beta}{\beta} + \delta}\bar{\Gamma}(x)dx.
\end{aligned} \tag{32}$$

It follows that

$$\begin{aligned}
&\Big(\delta + \frac{1-\beta}{\beta}\Big)V_e(q(w, y+\tau), q(w, y+\tau)) = U(q(w, y+\tau)) + \delta V_u = \\
&= U(w) + \delta V_u + \phi(\theta)\int_{q(w,y+\tau)}^{y+\tau} \frac{U'(x)}{\frac{1-\beta}{\beta} + \delta}\bar{\Gamma}(x)dx,
\end{aligned} \tag{33}$$

and after rearrangement,

$$U(w) = U(q(w, y+\tau)) - \phi(\theta)\int_{q(w,y+\tau)}^{y+\tau} \frac{U'(x)}{\frac{1-\beta}{\beta} + \delta}\bar{\Gamma}(x)dx. \tag{34}$$

Next, we use that $q(\xi(y+\tau, y'+\tau), y'+\tau) = y+\tau$ and $q(\xi(b, y+\tau), y+\tau) = b$, giving the

following results:

$$U(\xi(y+\tau, y'+\tau)) = U(y+\tau) - \phi(\theta)\int_{y+\tau}^{y'+\tau} \frac{U'(x)}{\frac{1-\beta}{\beta}+\delta}\bar{\Gamma}(x)dx, \tag{35}$$

$$U(\xi(b, y+\tau)) = U(b) - \phi(\theta)\int_{b}^{y+\tau} \frac{U'(x)}{\frac{1-\beta}{\beta}+\delta}\bar{\Gamma}(x)dx. \tag{36}$$

Using the utility function $U(x) = x^{1-\zeta}$ immediately gives equations (29) and (30).

The equilibrium within-firm distribution of wages has two components, the employer effect (y) and a random effect (q) that characterizes the most recent wage mobility. We denote with $G(q|y,\tau)$ the cumulative distribution function of the conditional distribution of bargaining position within the pool of workers within type-y firms.

$$G(w|y,\tau) = \tilde{G}(q|y,\tau) = \frac{(1+\Upsilon\bar{\Gamma}(y,\tau))^2}{(1+\Upsilon\bar{\Gamma}(q,\tau))^2} \tag{37}$$

for all $q \in [0,y]$, where $\Upsilon = \phi(\theta)s/\delta$ and $\bar{\Gamma} = 1-\Gamma$.

Equation (37) is derived through the following steps (based on Postel-Vinay and Robin, 2002) – to simplify notation, we omit the subsidy parameter here. Let $\tilde{L}(y)$ denote the fraction of workers at firms with productivity less than y. Hence, $\tilde{L}(y)(1-u)$ is the number of workers at firms with productivity less than y. The density of workers at type y firms is denoted by $\tilde{l}(y)$.

In equilibrium,

$$u\phi(\theta)\Gamma(y) = \big[\delta + \phi(\theta)s(1-\Gamma(y))\big]\tilde{L}(y)(1-u). \tag{38}$$

After rearrangement and plugging in the equilibrium value of y,

$$\tilde{L}(y) = \frac{\Gamma(y)}{1+\frac{\phi(\theta)s}{\delta}\bar{\Gamma}(y)}. \tag{39}$$

Differentiation of this term with respect to y gives:

$$\tilde{l}(y) = \frac{1+\frac{\phi(\theta)s}{\delta}}{(1+\frac{\phi(\theta)s}{\delta}\bar{\Gamma}(y))^2}\gamma(y). \tag{40}$$

There are $G(w|y)\tilde{l}(y)(1-u)$ workers employed at firms of type y, and paid at most w. Workers leave this category either because they are laid off or because they receive an offer from a firm with productivity $y \geq q(w,y)$ that grants them a wage increase or induces them to leave their current firm. On the inflow side, workers enter this category either from a firm less productive than $q(w,y)$, or they come from unemployment. The steady-state equality

of inflow and outflow is:

$$\left[\delta + \phi(\theta)s\bar{\Gamma}(q(w,p))\right]G(w|y)\tilde{l}(y)(1-u) = \phi(\theta)u\gamma(y) + \phi(\theta)s\tilde{L}(q(w,p))(1-u)\gamma(y). \quad (41)$$

Using $\phi(\theta)u = \delta(1-u)$, plugging in equations (39) and (40) to equation (41) and using the notation $\Upsilon = \phi(\theta)s/\delta$ gives equation (37).

A.5 Effects of the Employment Subsidy

As in Bagger and Lentz (2019), hiring intensity increases in firm productivity y because both the output $f(y)$ and the acceptance rate increase with y in the right hand side of equation (25). Using that $\kappa()$ is increasing in ν leads us to Result 1.

Result 1 *Hiring intensity is increasing in firm productivity ($\nu_y(y,\tau) > 0$).*

Our next result follows directly from equation (25), using that $\kappa()$ is increasing and convex in the amount of vacancies.

Result 2 *The direct effect of the employment subsidy on vacancy posting is positive.*

Result 2 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.

It follows directly from equation (6) 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 (19) can be rewritten as:

$$P(u) = \frac{\delta}{\delta + (1-\delta)s\phi(\theta)}. \quad (42)$$

Using that $\phi(\theta)$ increases in θ, which in turn increases in τ, Result 3 immediately follows.

Result 3 *The equilibrium value of unemployment and $P(u)$ decrease in τ.*

Looking at the firms' optimality condition – equation (25), the direct effect of the subsidy (τ) on the right hand side of the equation is the same for all firms. Based on the convexity of the vacancy cost function $\kappa()$ and using that $\nu(y,\tau)$ increases in y, it follows that the increase in vacancies ($\nu(y,\tau)$) is smaller at higher values of y and approaches zero as $y \to \infty$.

Based on equation (22) and using that $\Gamma(0) = 0$, and $\int_0^0 l(y')y' = 0$:

$$l(0) = \frac{\phi(\theta)\gamma(0)u}{1-(1-\delta)[1-s\phi(\theta)(1-\gamma(0))]} = \frac{\phi(\theta)\gamma(0)u}{\delta + (1-\delta)s\phi(\theta)(1-\gamma(0))}. \quad (43)$$

Using Result 2, the direct effect of the tax subsidy (i.e., considering only the effect on posted vacancies and not the effect on job market tightness and unemployment) on $l(0)$ is positive.

Also based on equation (22) and using that $\lim_{y\to\infty}\Gamma(y) = 1$, and $\int_0^\infty l(y')y' = u$, it follows that

$$\lim_{y\to\infty} l(y) = \lim_{y\to\infty} \frac{(1-\delta)s\phi(\theta)\gamma(y)(1-u) + \phi(\theta)\gamma(y)u}{\delta}. \quad (44)$$

This leads us to Result 4.

Result 4 *The direct effect of employment subsidy on the value of vacancy decreases with firm productivity and approaches zero at the highest productivity levels. The direct effect of employment subsidy on employment is positive at the lowest productivity firm and approaches zero at the highest productivity levels.*

Using equations (43) and (44) and plugging in equation (24) for u gives the ratio of employment at the lowest and highest quality firm:

$$\lim_{y\to\infty}\frac{l(0)}{l(y)}=\lim_{y\to\infty}\frac{\gamma(0)}{\gamma(y)}\cdot\frac{\delta}{\delta+(1-\delta)s\phi(\theta)(1-\gamma(0))}\cdot\frac{\delta}{\delta+(1-\delta)s\phi(\theta)}. \tag{45}$$

The direct effect of the tax subsidy on the first ratio on the right hand side is positive due to the vacancy distribution shifting towards less productive firms (Result 4). If the equilibrium effects of the subsidy on $P(u)$ are small then the positive effect on $\lim_{y\to\infty}\frac{\gamma(0)}{\gamma(y)}$ remains (based on equation (25)).

Note that the last ratio in equation (45) equals $P(u)$ (see equation (42)) and the term before differs only by the $(1-\gamma(0))$ term.

It follows that if the equilibrium effects of the subsidy on $P(u)$ are small then the impact of the subsidy on $\lim_{y\to\infty}\frac{l(0)}{l(y)}$ is positive.

Result 5 *In equilibrium, the effect of the tax subsidy on the ratio of employment at the lowest and highest quality firm is positive if the equilibrium effects on the probability of a randomly drawn job applicant being unemployed are small.*

In section A.6 we present simulation results for the equilibrium employment (and wage) effects of the tax subsidy.

Turning to the impact of the subsidy on wages, equation (29) leads to Result 6.

Result 6 *The direct effect of the subsidy on wages if positive for workers whose wage is not the first wage after unemployment.*

The wages at the lowest productivity firm are determined by equation (30), because once an employer receives an alternative offer she is the poached by the competing (more productive) firm. As the subsidy has no direct effect on wages under equation (30), the direct effect of the subsidy on wages is zero for workers at the lowest productivity firms.

At firms above the lowest productivity level a non-zero fraction of workers (determined by equation (37)) earn wage that is not the first wage after unemployment, on which the impact of the subsidy is positive (see Result 6).

Result 7 *The direct effect of the subsidy on wages is zero for workers at the lowest productivity firms. The direct effect of the subsidy on wages is positive at firms above the lowest productivity level.*

The indirect effect of the tax subsidy on wages cannot be derived analytically. First, its positive effect on $\phi(\theta)$ increases the negative wage implications of the option value in equations (29) and (30). On the other hand, we know from from Result 4 that the subsidy shifts the distribution of vacancies towards less productive firms, thus $\bar{\Gamma}$ decreases as a consequence of the tax subsidy but this decreasing effect varies with firm productivity.

Note also that the direct effect of the employment subsidy on the wages of new entrants is zero, as it follows from equation (30). Intuitively, young workers enter the labor market as non-employed, thus, essentially, poaching and wage renegotiation 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.

A.6 Simulations

The functional forms used in the simulations are the following.

The cost function, based on Bagger and Lentz (2019) is:

$$\kappa(v(y,\tau)) = \frac{v(y,\tau)^{(1+1/c_v)}}{1+1/c_v}.$$

The job-finding rate is similar to Moscarini and Postel-Vinay (2018): $\phi(\theta) = A\theta^{\alpha}$.

The parameters used in the simulations are the following:

- $\tau = \bar{w}_0 \times 0.15$ – 15% of the average wage without subsidy tax.
- $f(y|\lambda, lb)$ has $Pareto(\lambda)$ distribution, where λ is the scaling parameter and lb is a drift that shifts the original Pareto distribution, such that the lower bound is equal to lb. During the simulations $\lambda = 1.25$ and $lb = 1000$ and $\psi(y)$ is uniform.
- $\zeta = 0$ – the exponent in CRRA utility function, implying linear utility. The simulation results are robust to different ζ values.
- $A = 1/4$.
- $\alpha = 1/2$ – similar to Moscarini and Postel-Vinay (2018).
- Employment-to employment transition rate – $EE = 0.041$, which is in line with the empirical data for Hungary (12-month transition rate between employers among the continuously working old workers). The searching intensity is a direct mapping of this parameter, see the derivations in Moscarini and Postel-Vinay (2018).

$$\text{Solve for } s: \ \phi(\theta)(1-\delta)\delta s \int_0^1 \frac{1-s}{\delta + (1-\delta)s\phi(\theta)s} ds = EE. \tag{46}$$

- $\beta = 0.95$ – which matches the monthly value of $0.95^{1/12}$ by Moscarini and Postel-Vinay (2018).

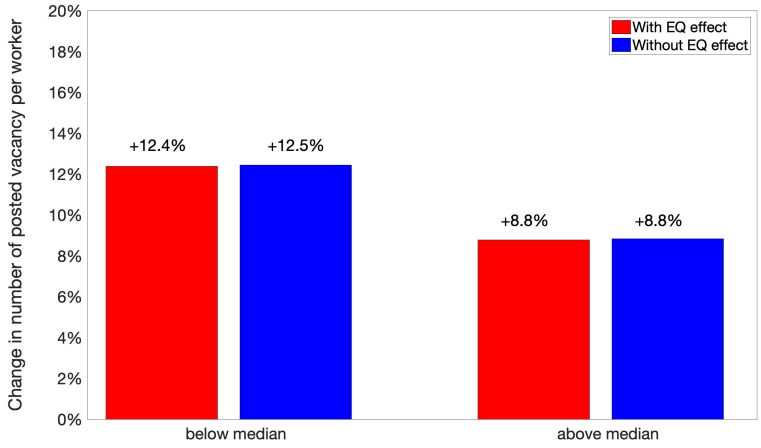
- $b = lb = 1000$, thus the workers' outside option is the same as the output of the lowest productivity firm.
- $c_v = 0.006$ – similarly to Bagger and Lentz (2019).
- Job destruction rate $\delta = 0.1$.

Appendix Table A1: Steady-state parameters

Tax subsidy rate	0%	15%	Δ (15%)
Unemployment	0.223	0.205	-0.018
Job market tightness (θ)	1.935	2.402	0.467
Job finding rate	0.348	0.387	0.039

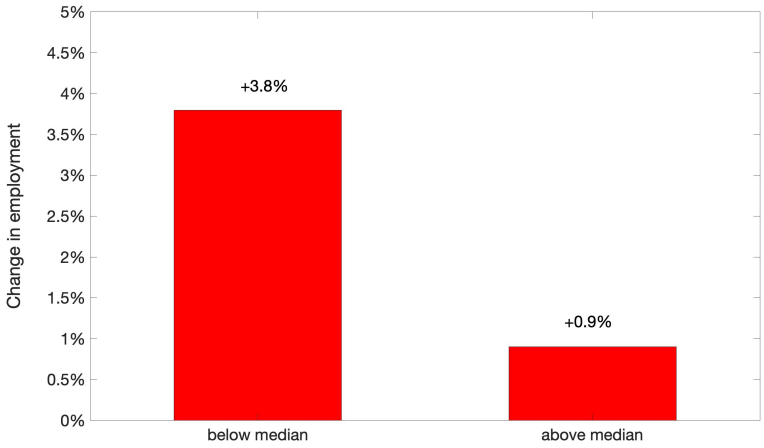
Note: The table shows the steady-state unemployment rate (defined by equation (24)), job market tightness (θ, defined by equation (12) and job finding rate ($\phi(\theta)$).

Appendix Figure A1: Simulation results: vacancies by firm productivity



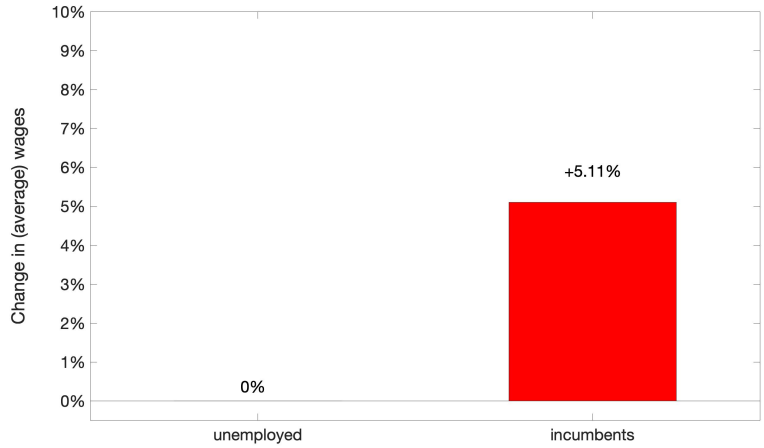
Note: The figure shows the impact of the subsidy on the number of posted vacancies per worker by productivity category of the employer (below or above median productivity). The red bars show the impact with equilibrium (EQ) effects, the blue bars show the impact without equilibrium effects.

Appendix Figure A2: Simulation results: employment by firm productivity



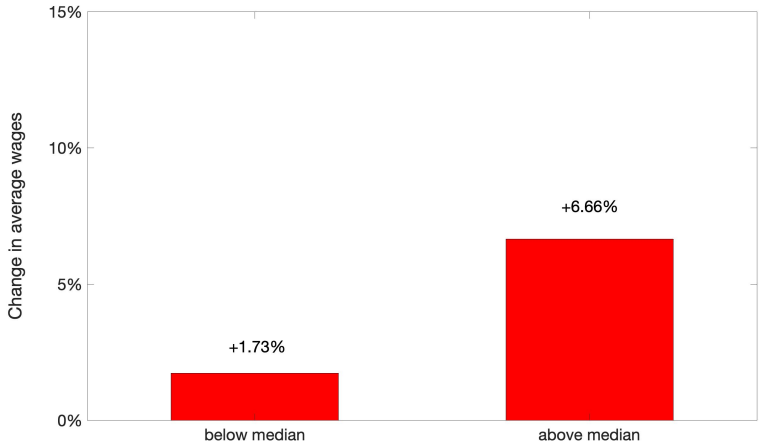
Note: The figure shows the impact of the subsidy on the employed workers in percentage changes by productivity category of the employer (below or above median productivity).

Appendix Figure A3: Simulation results: wage by previous labor force status



Note: The figure shows the impact of the subsidy on the wage of workers who were not employed ("unemployed") or were employed ("incumbents") the previous period. The latter group includes workers who earn the first wage since unemployment and also those who already had a wage bargaining.

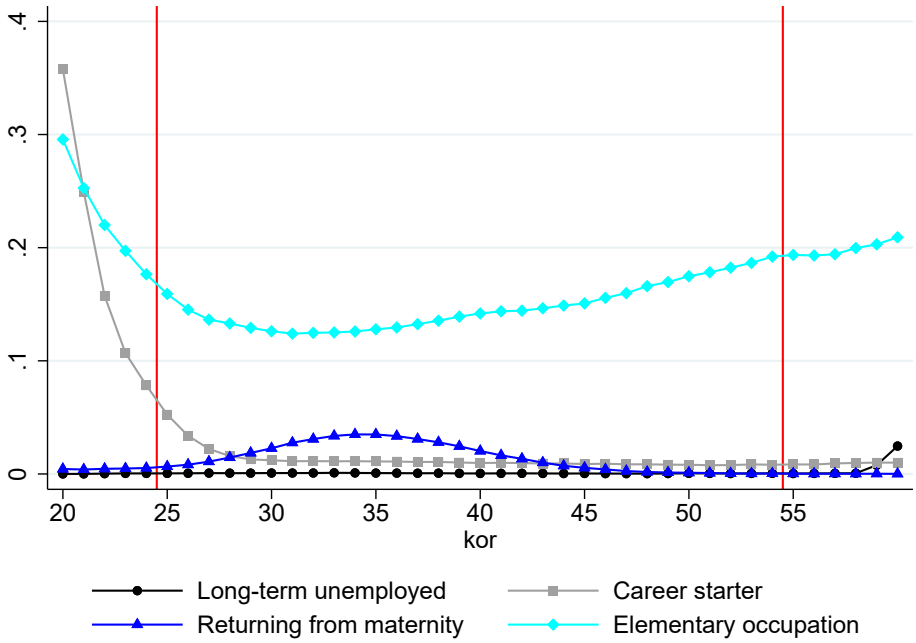
Appendix Figure A4: Simulation results: wage of the incumbent workers by firm productivity



Note: The figure shows the impact of the subsidy on the wage of incumbent workers by productivity category of the current employer (below or above median productivity). The group of incumbent workers consists of workers who earn the first wage since unemployment but were already working the previous period and workers who already had a wage bargaining.

B Non-age-dependent Beneficiary Groups

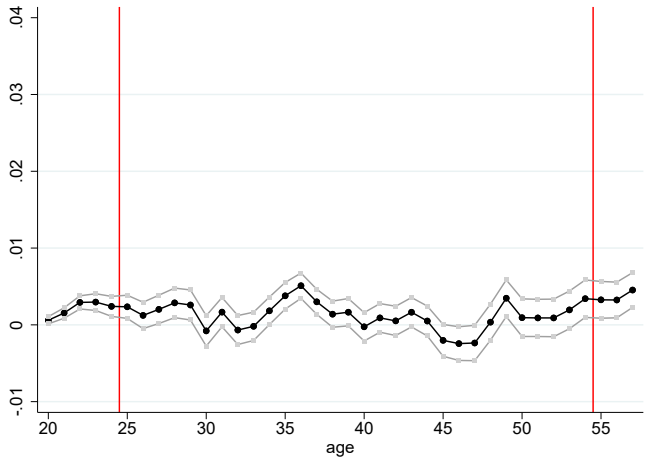
Appendix Figure B1: Fraction of not age-dependent beneficiary groups among private sector workers



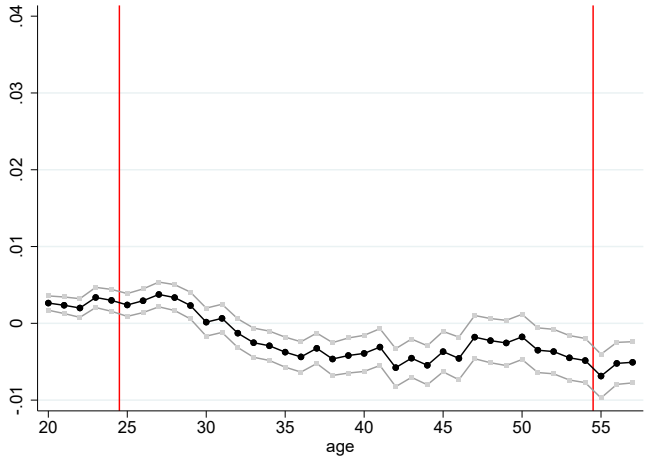
Note: The table shows the fraction of not age-dependent beneficiary groups among private sector workers over years 2013-2015 both for males and females. The long-term unemployed were registered unemployed for at least 6 months during the previous 9 months. Career starters had at most 180 days of prior employment. People returning from maternity are those who start an employment after receiving maternity payments. Elementary occupations correspond to ISCO code 9.

Appendix Figure B2: Change in employment rate in placebo groups

(a) Public sector employment rate



(b) Self-employment rate



Note: Panel (a) refers to employment in the public sector where the payroll tax subsidy did not apply. Panel (b) refers to the self-employed who were not eligible for payroll tax subsidy. Both panels show the difference between years 2013-2015 and 2012, with the 95% confidence interval (standard errors clustered on the individual-level). 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.

C Role of the Minimum Wage

In this section, we provide indicative evidence that the estimated employment effects of the payroll tax subsidy are not the 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 C1 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.

We also report in Table C1 how the employment effect varies with firm quality in the specific industries, using the industry specific median of TFP as a cut-off between high and low quality firms. In most of the industries the overall heterogeneity holds. The difference between the employment effects among high and low TFP firms tend to be negative or small, especially among the old.

Similarly, the estimated effect of the subsidy is smaller at exporting firms (Table C2, 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 C2, bottom panel).

Figure C1 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 Table C1: 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 workers	% change in employment	Diff by firm quality (pp)	Employment effect	% of workers	% change in employment	Diff by firm quality (pp)
Agriculture	-0.0005*** [0.0002]	3.5	-4.2	-0.12	0.0015*** [0.0005]	8.6	5.0	-0.12
Manufacturing	0.0032*** [0.0004]	36.4	2.6	-0.30	-0.0036*** [0.0004]	34.2	-3.0	-0.12
Construction	0.0019*** [0.0002]	7.4	7.5	-0.03	0.0001 [0.0002]	9.9	0.3	0.08
Wholesale and retail trade	0.0040*** [0.0004]	14.0	8.4	0.02	0.0011*** [0.0003]	10.2	3.1	-0.05
Accommodation and food service	0.0015*** [0.0002]	4.1	10.6	-0.05	0.0002** [0.0001]	1.5	3.9	0.03
Transportation and storage	0.0010*** [0.0002]	4.9	5.9	-0.01	0.0062*** [0.0005]	10.7	16.6	-0.09
Financial and insurance activities	0.0020*** [0.0001]	1.8	32.2	0.07	-0.0004*** [0.0001]	1.1	-10.7	0.00
Administrative and support services	0.0021*** [0.0002]	8.7	7.0	0.08	-0.0001 [0.0002]	5.3	-0.5	0.02
Other industry	0.0012*** [0.0003]	16.1	2.2	0.04	0.0013*** [0.0003]	17.0	2.2	-0.01

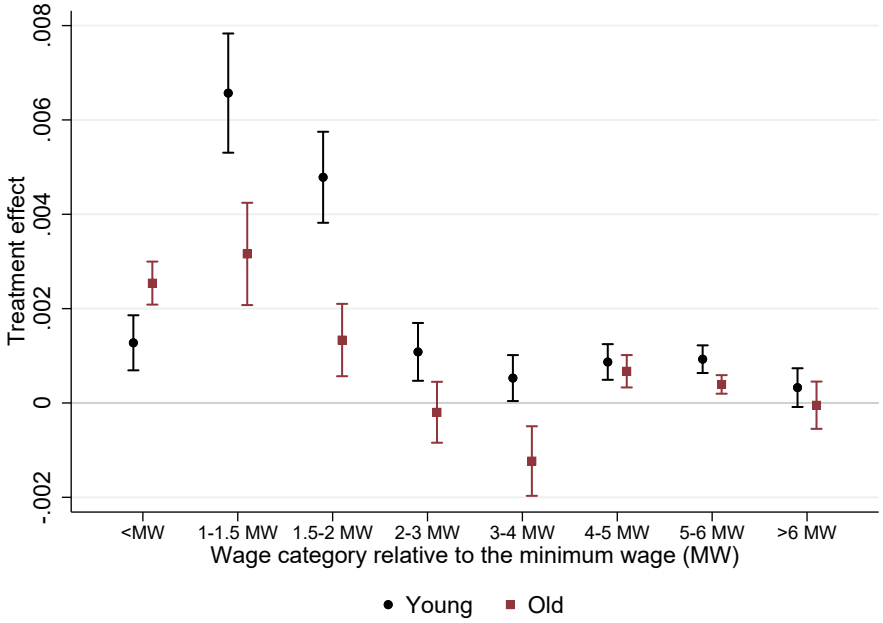
Note: Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (10). These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2015 period after the 2013 introduction of the payroll tax subsidy. 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 workers indicator is measured in 2012 and indicates the % of private sector employees. The % change in employment shows the increase in employment relative to the population employed in the given industry. The difference by firm quality column shows the percentage point (pp) difference between the change in employment rate at above median TFP firms minus the change in employment rate at below median TFP firms.

Appendix Table C2: Treatment effect on employment in private sector companies by exporting activities of firms

	Employment of young Age 22-27	Employment of old Age 52-57
Treatment effect, not exporting firm	0.0113***	0.0056***
	[0.0007]	[0.0004]
Treatment effect, exporting firm	0.0052***	0.0008***
	[0.0006]	[0.0004]

Note: Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (10). 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. 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.

Appendix Figure C1: Effect of the payroll tax cuts on employment in private sector companies by wage categories

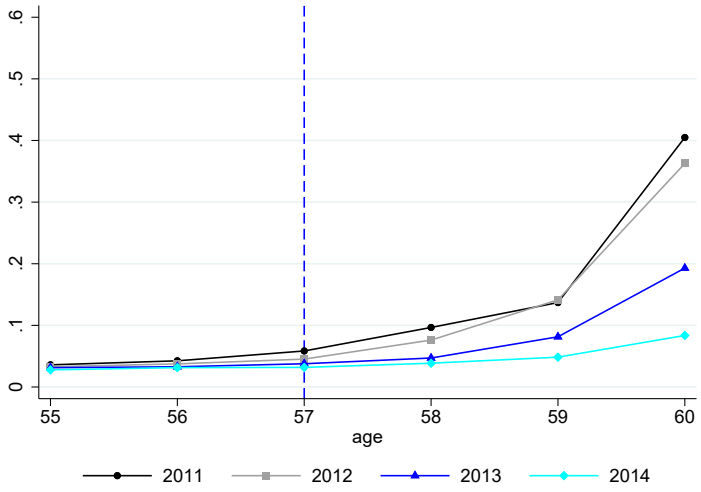


Note: The figure shows the estimated employment effects with the corresponding 95% confidence intervals, based on equation (10), with clustering at the age × period level. These are difference-in-differences estimates that compare the change in employment between year 2012 and the 2013-2015 period (after the introduction of the payroll tax subsidy in 2013).

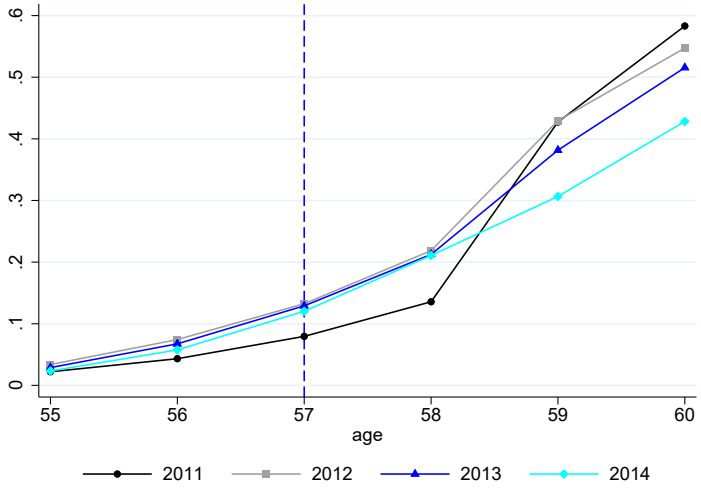
D Gender Specific Results

Appendix Figure D1: Old-age Pension Rate by Gender

(a) Males



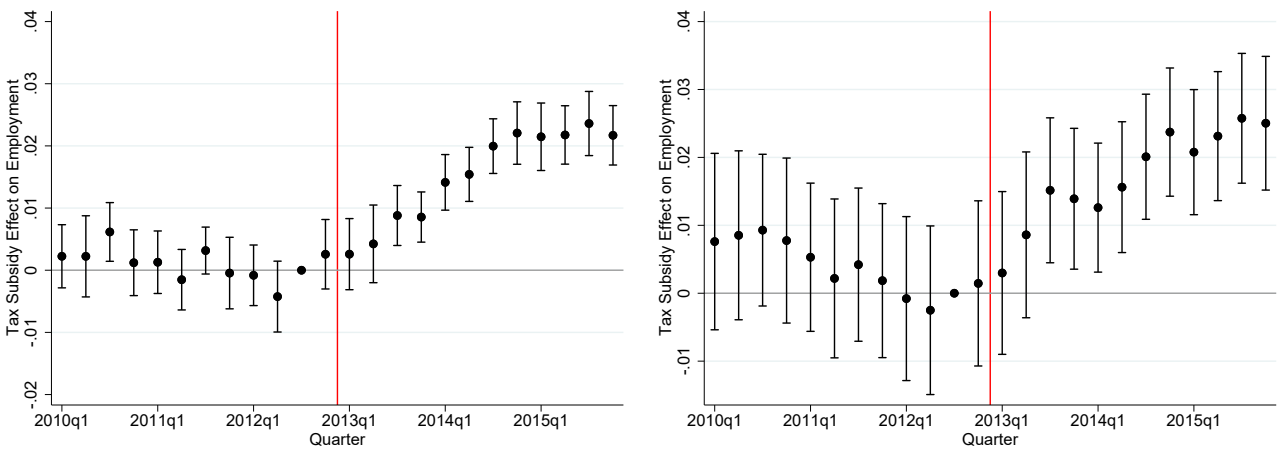
(b) Females



Appendix Figure D2: Effect of the payroll tax subsidy on employment in private sector companies by gender

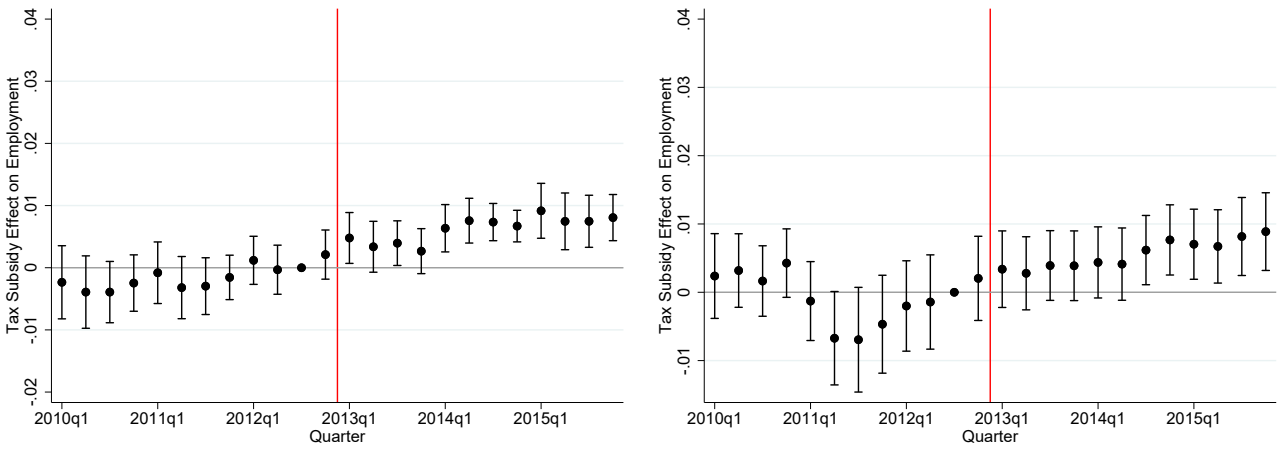
(a) Young, males

(b) Young, females



(c) Old, males

(d) Old, females



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 (9). 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 age $\times$ period level.

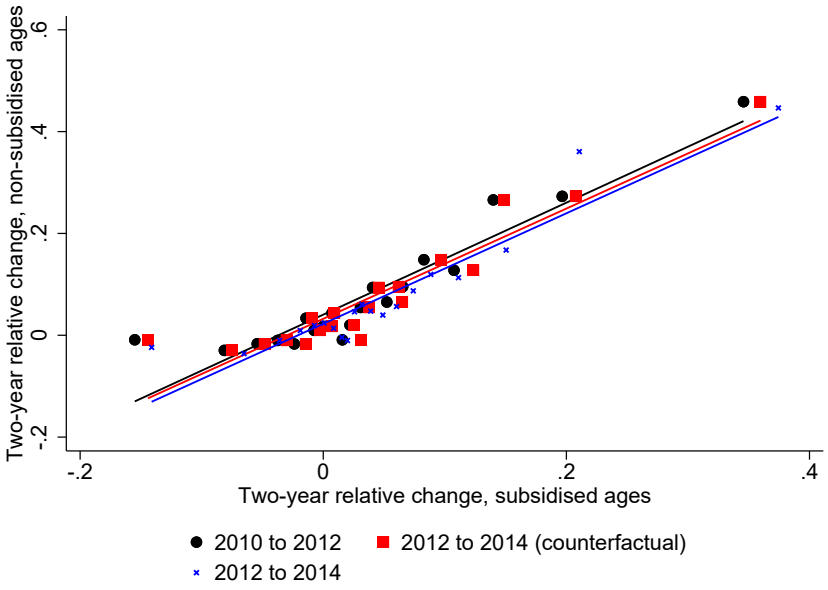
Appendix Table D1: Impact on employment in private sector companies: Gender specific results

	Employment of Young Age 22-27		Employment of Old Age 52-57	
	Males	Females	Males	Females
Average treatment effect	0.0165***	0.0176***	0.0064***	0.0058***
	[0.0011]	[0.0012]	[0.0005]	[0.0007]
TFP				
Below median TFP, treatment effect	0.0096***	0.0048***	0.0058***	0.0044***
	[0.0006]	[0.0006]	[0.0005]	[0.0006]
Above median TFP, treatment effect	0.0069***	0.0128***	0.0005	0.0015***
	[0.0007]	[0.0007]	[0.0004]	[0.0005]
Skill				
Blue collar job, treatment effect	0.0064***	0.0030***	0.0056***	0.0043***
	[0.0007]	[0.0004]	[0.0006]	[0.0005]
White collar job, treatment effect	0.0101***	0.0147***	0.0008	0.0016***
	[0.0006]	[0.0010]	[0.0006]	[0.0005]

Note: Cluster robust standard errors in brackets, clustering at the age × period level, *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates from the model in equation (10). 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. 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.

E Firm-level Evidence for Substitution and Windfall Effects

Appendix Figure E1: Firm-level relative growth in employment by age group



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 3.4%, 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) 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.

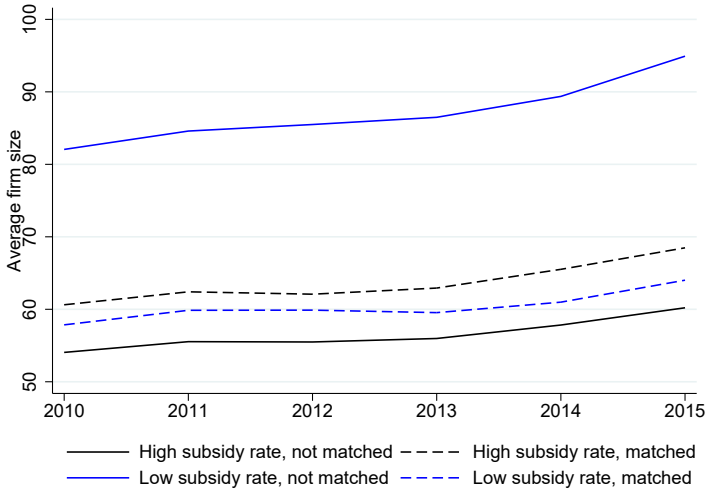
3. Based on the effective subsidy rate in 2013, we group firms into two categories according to whether the subsidy rate was below or above its median in 2013. We extrapolate these groups to the other sample years. The treatment (control) group is the group with the above (below) median subsidy rate.

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).

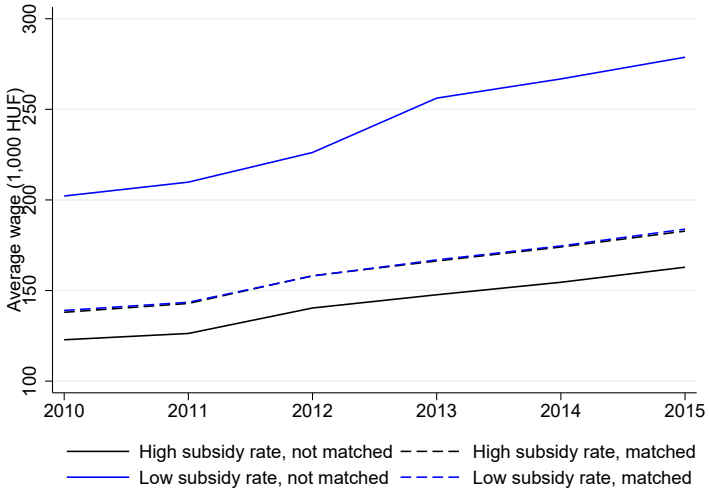
Figure E2 shows the matching results for firm size and firm level average wage. The reported plots do not provide evidence that the payroll tax subsidy had a windfall effect on firms employing a higher share of workers in the subsidized ages.

Appendix Figure E2: 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: 17,838 firms. Sample size in the matched sample: 9,914 firms.

F 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:

$$MVPF = \frac{WTP}{NetCost}, \tag{47}$$

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. The WTP consists of three parts:

   (a) With positive sign, the part of the subsidy that is received by workers. To calculate this, we first calculate the per capita average amount of the subsidy (using the employment rate and average effective subsidy rates). Then, based on Tables 7 and 8, we determine the fraction of the subsidy that goes to the workers, assuming the maximum rate of the subsidy.

   (b) With negative sign, the lost benefit of workers who gain employment as a results of the tax subsidy. Here, we rely on the estimated treatment effects on employment (Table 2) and the average unemployment benefit as observed in our data.

   (c) With positive sign, the net wage income of workers who gain employment as a results of the tax subsidy. To calculate this amount, we use the estimated employment effect by wage categories (as presented in Table C1 and the same estimations repeated by firm quality).

   Note, that unlike Paradisi (2021), we do not incorporate producer surplus to WTP, assuming perfect competition and/or zero social marginal utility on the employers.

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 wage due to increasing employment.

Based on the back-of-the-envelope calculations presented in Table F1, subsidizing the employment of the young by payroll tax cuts has a higher MVPF than subsidizing the old, and payroll tax cuts targeting high productivity firms have higher MVPF than payroll tax cuts targeting low productivity firms. The estimated MVPF value for the young is close to the MVPF of the payroll tax cut of Sweden analyzed by Saez, Schoefer and Seim (2019), and its MVPF calculated by Paradisi (2021).

Appendix Table F1: Marginal Value of Public Funds

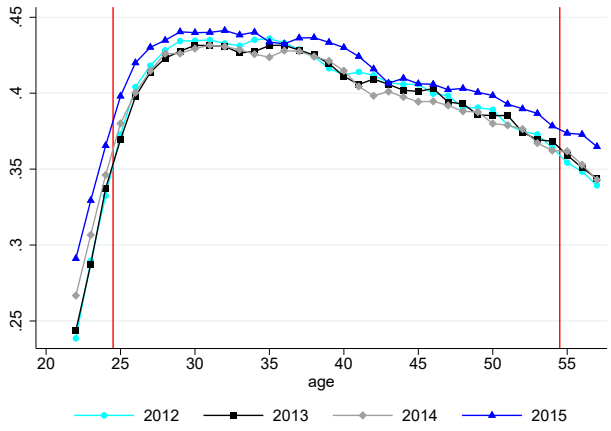
	All firms		Low TFP		High TFP	
	Young	Old	Young	Old	Young	Old
(1) Direct cost	4512	4900	2036	2335	2263	1977
(2) Subsidy going to workers	454	219	180	-105	164	476
(3) Benefit receipt of non-employed who become employed	1022	396	595	365	427	31
(4) Additional net wages of non-employed who become employed	2262	744	985	630	1306	81
(5) Additional tax revenue	1832	615	798	520	1058	67
(2)+(4)-(3) Willingness to pay (WTP)	1694	566	570	159	1043	525
(1)-(3)-(5) Net cost	1659	3888	643	1449	778	1879
MVPF	1.02	0.15	0.89	0.11	1.34	0.28

Note: All amounts are monthly amounts in HUF.

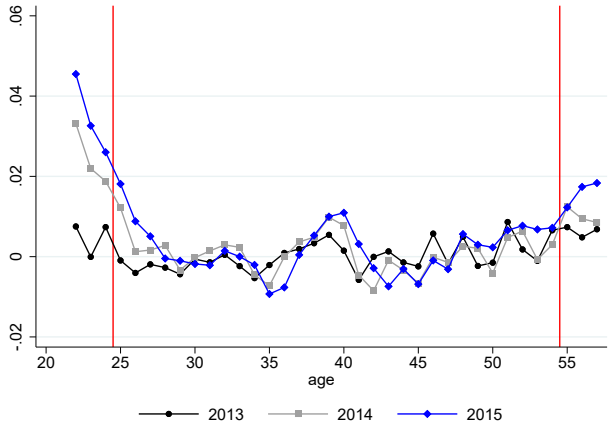
G Additional Figures and Tables

Appendix Figure G1: Employment in private sector companies by age (males)

(a) Employment rate



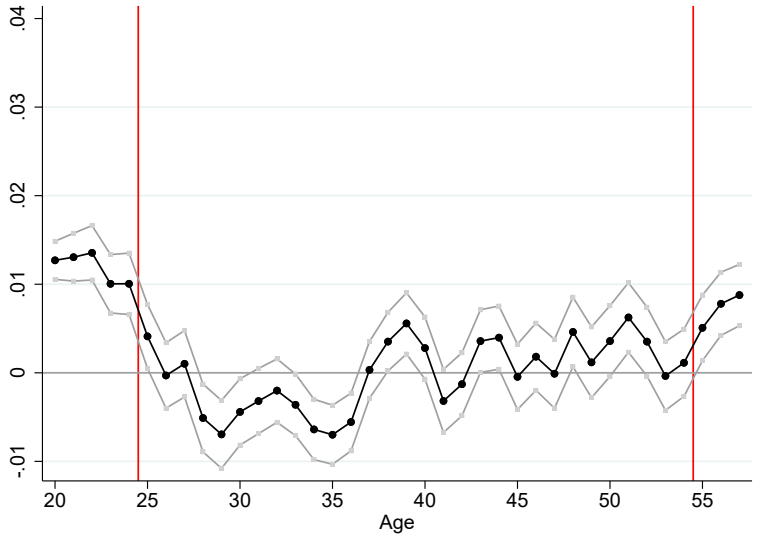
(b) Change in employment rate



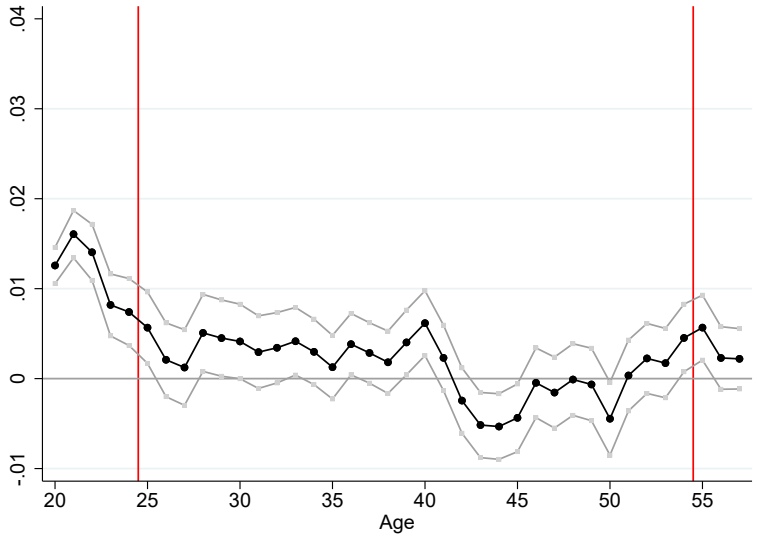
Note: Panel (a) shows the employment rate in private sector companies by age for years 2012-2015. Panel (b) shows the difference between years 2013-2015 and 2012, adjusted to mean zero at ages 28-51 (i.e., at ages that are neither in the treatment nor in the control groups in the difference-in-differences 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 G2: Change in Employment Rate by TFP (males)

(a) Employment at firms with below median TFP



(b) Employment at firms with above median TFP



Note: The figures show the differences between years 2013-2015 and 2012, with the 95% confidence interval (standard errors clustered on the individual-level). 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 G1: Heterogeneity by firm characteristics, short run estimates (years 2012-2013): Impact on employment in private sector companies

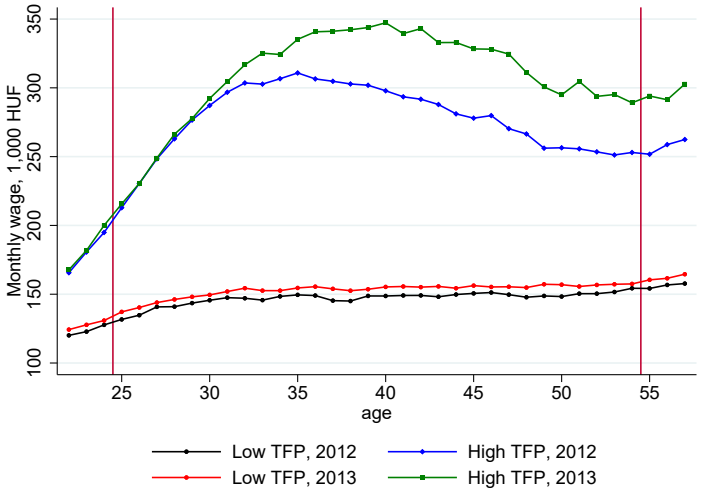
	Employment of Young Age 22-27	Employment of Old Age 52-57
Employment at private firms	0.0069***	0.0037***
	[0.0009]	[0.0006]
TFP		
Below median TFP, treatment effect	0.0031***	0.0049***
	[0.0005]	[0.0005]
Above median TFP, treatment effect	0.0038***	-0.0012***
	[0.0006]	[0.0005]
Poaching index (PI)		
Below median PI, treatment effect	0.0036***	0.0040***
	[0.0007]	[0.0005]
Above median PI, treatment effect	0.0033***	-0.0003
	[0.0005]	[0.0007]
Firm FE (based on AKM decomposition)		
Below median FE, treatment effect	0.0041***	0.0044***
	[0.0006]	[0.0004]
Above median FE, treatment effect	0.0028***	-0.0007
	[0.0005]	[0.0006]
Firm level average wage		
Below median, treatment effect	0.0048***	0.0035***
	[0.0006]	[0.0004]
Above median, treatment effect	0.0021***	0.0002
	[0.0005]	[0.0005]
Foreign ownership		
Domestic firm, treatment effect	0.0072***	0.0043***
	[0.0008]	[0.0004]
Foreign firm, treatment effect	-0.0003	-0.0006*
	[0.0004]	[0.0003]

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

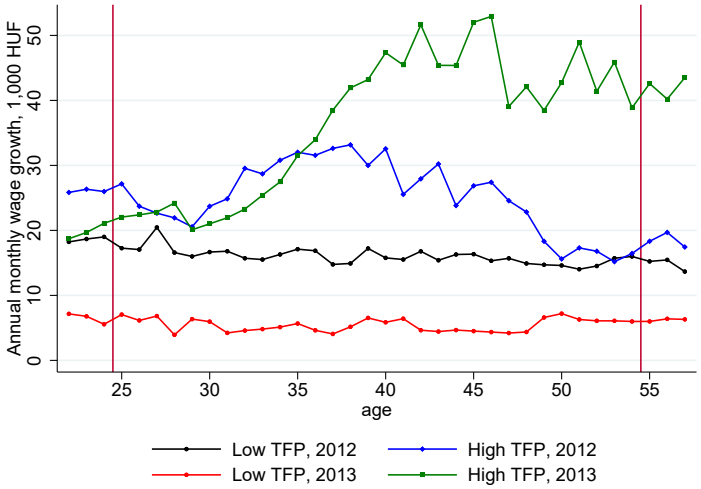
Note: The table shows estimates from the model in equation (10). These are difference-in-differences estimates that compare the change in employment between year 2012 and 2013. Among younger workers, the treated group comprises ages 22-24 and the control group group comprises ages 25-27. Among older workers, the treated group comprises ages 55-57 and the control group comprises ages 52-54. Cluster robust standard errors in brackets, clustering at the age × period level. 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.

Appendix Figure G3: Wages at private sector companies

(a) Wage level



(b) First differenced wage



Note: Panel (a) shows the average monthly gross wage at private sector companies, by TFP being below or above the median. Panel (b) shows the one-year difference in the average monthly gross wage at private sector companies.

Appendix Table G2: Average treatment effect on log wage of new entrants

	Non-employed a year ago		Non-employed past 2 years	
	Young (age 22-27)	Old (age 52-57)	Young (age 22-27)	Old (age 52-57)
All Firms	0.0172**	0.0027	0.0047	0.0066
	[0.0068]	[0.0211]	[0.0087]	[0.0220]
Low TFP	-0.0007	0.0240**	-0.0068	0.0394**
	[0.0057]	[0.0078]	[0.0051]	[0.0154]
High TFP	0.0180	0.0096	0.0028	-0.0409
	[0.0116]	[0.0345]	[0.0109]	[0.0468]
Observations	26,133	9,041	20,163	4,640

Note: Years 2012-2013. In the first two columns, new entrants are defined as being non-employed (having no wage earnings) 12 months ago. In the last two columns, new entrants are defined as being non-employed both 12 months and 24 months ago. The table reports the coefficient of the interaction term between year 2013 (after the introduction of the tax subsidy) and belonging to the treatment ages. Age and year effects are included as regressors. In the bottom part of the table, the year and age effects and their interaction term are further interacted with the binary indicator of firm quality (TFP below or above the median). Cluster robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.