Firm Heterogeneity and the Impact of Payroll Taxes*

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Abstract

We study the impact of a large payroll tax cut for older workers on employment and wages in Hungary. By exploiting administrative data and applying a difference-in-differences empirical strategy, we document a modest employment increase equivalent to a labor demand elasticity of -0.3 and a pass-through rate of 22%. These average effects mask large heterogeneity across different firms. Employment mainly increases at low-productivity, low-paying firms, while no jobs are created at high-productivity, high-paying firms. At the same time, the tax cut is passed through to wages only at high-productivity, high-paying firms, while low-productivity, low-paying firms do not share the benefits of the tax cut with their workers. These results point to important heterogeneity in the incidence of payroll tax cuts across firms, highlighting that workers at different firms benefit differently from payroll taxes. They also demonstrate that payroll taxes can have a significant impact on the composition of jobs in the labor market.

Keywords: payroll tax; tax incidence; firm heterogeneity
JEL codes: H24; H32; J23; J31

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1 Introduction

Payroll taxes and employer social security contributions account for just under 40% of the tax wedge in developed countries (OECD, 2022*a*) and there is a longstanding interest in understanding the impact of these policies on employment and wages. The standard approach in public finance suggests that the market-level elasticities of labor supply and demand determine the employment and wage impacts and the incidence of payroll taxes (see e.g. Gruber, 1997; Rothstein, 2010). This approach typically assumes that firms passively accept market-level wages and so the incidence of the payroll tax will be homogeneous across firms and workers. However, a growing number of empirical studies highlight that firms play an active role in wage determination and significant wage premium differences are present across employers (see for review Card, Cardoso, Heining and Kline, 2018).

In the presence of job heterogeneity and variation in rents across firms, the evaluation of tax policies should take into account their effect on the composition of jobs (Katz and Summers, 1989; Rodrik and Stantcheva, 2021; Rodrik and Sabel, 2022). The standard theory does not consider whether the incidence of a policy varies across different firm types or whether tax policies affect the composition of jobs, and contribute to the creation of "low wage, bad jobs" or "high wage, good jobs" (Katz and Summers, 1989).[1]

The lack of good jobs and the potential role of tax policies have been featured prominently in recent policy discussions (see e.g. Blanchflower, 2021). While unemployment rates are at historically low levels, wage inequality is growing and firms are a key driver of those trends (Card, Heining and Kline, 2013). Workers are often concerned more about the types of jobs they can find than unemployment. Recent evidence has suggested that having a poor-quality job can be worse than simply being unemployed (Chandola and Zhang, 2018). Creating more good jobs has also become a central goal for many governments (see e.g., "The Good Jobs Initiative" of the Biden-Harris administration[2]). Thus, understanding whether tax policies trickle down to workers and whether the effects on workers vary by firm types has first-order importance for policy making.

Still, the large body of evidence on the impact of tax policies on employment and wages ignores what types of jobs are created and whether the incidence of policies varies by firm type. In this paper, we fill this important gap in the literature by assessing the impact of a large reduction in payroll taxes on the composition of jobs in the economy and on workers' wages. To illustrate the important role firms could play in shaping the impact of

[1] The definition of "good" jobs is necessarily slippery (Rodrik and Sabel, 2022). Here we use various proxies for good jobs including firm-level productivity, firm-level wage premium (Abowd, Kramarz and Margolis, 1999), and measures based on revealed preferences (Bagger and Lentz, 2019).

[2] `https://www.dol.gov/general/good-jobs`

tax policies, we discuss how the effect of tax cuts depends on the structure of the labor market. We highlight that deviating from standard perfectly competitive labor markets leads to rich predictions about the impact of tax cuts and it is a priori unclear whether a policy contributes to the creation of good jobs, or it creates bad jobs at the expense of good ones. In addition, it is also an empirical question whether workers share the benefits of the wage increase resulting from a tax cut equally or the pass-through of the tax cut to workers is substantial only at certain firms. In the presence of imperfect competition in the labor market, the incidence of the policy could be heterogeneous across firm types, while in many other models (e.g., under perfect competition) the incidence of the policy will be the same across firm types.

Motivated by these predictions and questions, we study the heterogeneous impact of an age-specific payroll tax cut in Hungary. In 2013 the monthly social security contribution decreased by HUF 14,500 ($66) for all over-55 private sector employees.[3] This led to a 5.3% decrease in the labor cost for an average over-55 private sector employee. Using rich administrative data, we estimate the impact of the policy in a difference-in-differences framework, comparing men above the age cutoff to men below it.[4] We find a large increase in employment in response to the policy. In response to the 5.3% decrease in labor costs, employment of the treated workers increased by 1.6%, implying a labor demand elasticity of -0.30 (s.e. 0.03).[5] We also calculate that the net present value of labor cost decreased by 7.5% for workers at the treated ages, which implies an employment elasticity of -0.21 (s.e. 0.02). At the same time, the change in self-employment and public sector employment was limited, consistent with the ineligibility of these workers for the payroll tax cut.

In line with the prediction of models with labor market imperfections, we also find substantial heterogeneity across firm types. For a variety of measures of firm quality, the employment-increasing effect of the policy comes from low-quality firms and low-quality jobs, while the employment of older workers in high-quality firms is unchanged. The differential response to the policy by firm type cannot be explained by the lower relative value of the tax cut at high-quality firms. Even if the relative decline in labor cost is somewhat larger at low-quality firms, it is still non-negligible at high-quality firms (6% at low-quality firms

[3]The average monthly net wage (wage net of employer payroll tax) was HUF 230,700 ($1,045) in Hungary in 2013 (Hungarian Central Statistical Office, 2022), so the tax cut is about 6.3% of the average wage in 2013. A tax cut of equivalent size in the U.S. context would be $3500 per year based on the average salary in 2022 (US Bureau of Labor Statistics, 2022).

[4]We focus on men in the main analysis as for women there was a slight change in retirement rules that could have affected treated and untreated workers differently. We present the estimates for women in the Appendix C and find similar firm heterogeneity as for men.

[5]We estimate that around one-third of the employment increase comes from elevated hiring from non-employment and two-thirds come from lower exit rates.

vs. 4.5% at high-quality firms). The implied employment elasticity with respect to labor cost is statistically different between low-quality firms (-0.53, s.e. 0.05) and high-quality firms (0.01, s.e. 0.06).

We present several additional pieces of evidence to highlight that our results reflect firm heterogeneity and not other factors. First, 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 at low-quality firms, while we find no indication for substantial change in employment in the upper part of the wage distribution where the relative change in labor cost was limited.[6] This suggests that our estimates pick up the effect of the payroll tax cut. Furthermore, we show that heterogeneity in responses is present even if we restrict the sample to similar workers. Even among low-paid workers in low-paying occupations and among less-educated workers, we find different responses to the policy by firm type. This suggests that the differential responses to the payroll tax cut reflect firm heterogeneity and not simply the fact that better workers tend to work at better firms.

We also study the impact of the policy on wages. We estimate that the overall pass-through of the policy is small: out of $1 only 22 cents (s.e. 9 cents) benefit workers, while 78 cents (s.e. 9 cents) go to firms. We also find heterogeneous incidence by firm productivity: there is a significant increase in wages at high-productivity firms, but we find no change in wages at low-productivity firms. At high-quality firms the pass-through rate is 60 cents (s.e. 13 cents) on the dollar, while at low-quality firms the pass-through rate is close to zero and statistically insignificant. We also show that the pass-through rate difference across firms is present for workers with low and high levels of education, though it is more prominent for the latter group.

We present several robustness checks to underscore these results. First, we vary the control group definition to make sure that our main estimates are not muted or exaggerated by the variation of the age-window used in the estimation and by potential spillovers to the control group (i.e., SUTVA violation). The main conclusions are unaffected by the choice of the control group.

Second, the comparison of the firm-level relationship between hiring treated workers and untreated workers before and after the reform suggests that firms that hired more treated workers after the reform did not cut their hiring of untreated workers. Accordingly, the policy is likely to have improved overall employment and not just led to substitution of treated workers for untreated ones.

[6] Note that the tax cut was lump sum, which implies that at higher wages the change was smaller relative to total labor costs.

Third, we also study how firms' responses depend on the windfall effects found to be important in the context of tax cuts affecting young Swedish workers (Saez, Schoefer and Seim, 2019). In particular, we show that the change in wages and the incidence differences across firm types do not depend on the size of windfall shocks firms experience and so our findings are robust to controlling for windfall shocks.

Fourth, our results are unlikely to reflect wage rigidities that could potentially bind low-quality and high-quality firms differently. Union membership is very low in Hungary and industry-level agreements are rare and set only weak requirements. Furthermore, we find that the heterogeneity between high- and low-quality firms is present even if we look at employment changes among similarly sized firms. Our estimates do not simply reflect the presence of a binding minimum wage either. The estimated change in employment is not concentrated at the minimum wage. Even among workers earning more than 150% of the minimum wage we find a significant increase in employment at low-productivity firms. This suggests that the employment change does not only come from some low-quality jobs becoming viable following the payroll tax cut.

Fifth, even if we exploit only within-industry variation in productivity we find similar responses to the policy. This highlights that our approach does not simply pick up cross-industry heterogeneity in the impact of the policy, and the incidence is heterogeneous across firms within the same industry.

These empirical findings together with our theoretical considerations point to interesting (and as far as we know so far undocumented) heterogeneity in the incidence of tax cuts. Workers employed by productive firms are able to extract more of the surplus from the tax cut and so the incidence of the tax cut (partly) falls on them. At the same time, older workers who are employed by less productive firms are benefiting from the tax cut through increased hiring, while firms capture a larger share of the surplus for these workers.

Finally, we discuss how the documented heterogeneous incidence of the policy alter the welfare assessment of payroll taxes by applying the Marginal Value of Public Funds (MVPF) framework (Hendren and Sprung-Keyser, 2020). We consider two scenarios: 1) when policy makers care only about the workers; 2) when policy makers care about the total welfare including firms' profit. Since a large share of the tax cut ends up at employers, particularly at low-quality firms, the policy has a relatively low MVPF if the policy maker only cares about worker welfare. The MVPF is significantly higher at high-quality firms with high pass-through rates than at low-quality firms with pass-through rates close to zero. If we also include the part of the tax cut that goes to employers, then the MVPF is higher. Importantly, in this case targeting low-quality firms with the tax cut has a higher MVPF than targeting high-quality firms because the employment creation effect dominates the wage effect. Our welfare analysis, therefore, highlights that it is important to take into account how payroll taxes affect the prevalence of good and bad jobs in the economy.

Since parallel to the tax cut for older workers, a tax cut affecting workers under 25 was also introduced, we can compare our estimated responses for older workers to impacts among younger workers. We find that the payroll tax cut increased employment of younger workers with little impact on wages. We also find heterogeneity patterns similar to those documented for older workers though contrary to older workers, we also find some job creation at higher quality firms. Furthermore, we find no indication for differential wage responses of treated and untreated cohorts for the young. The lack of wage responses could be explained by wage rigidities, which are more prevalent in the labor market of young workers.[7] This result is also consistent with a limited scope for wage negotiations at labor market entry (see Caldwell and Oehlsen, 2018).

Our paper relates to several strands of the literature. First, our study contributes 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; Ku, Schönberg and Schreiner, 2020; Benzarti and Harju, 2021).[8] Our results highlight that the incidence of payroll taxes depends on the types of firms and workers studied. Carbonnier, Malgouyres, Py and Urvoy (2022) evaluate the incidence of business tax credits and Fuest, Peichl and Siegloch (2018) the incidence of corporate income taxes and document some heterogeneity in incidence by worker type, but firm heterogeneity and the effects of the policy on the composition of jobs is mainly ignored in the literature so far.

The paper is also 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). Studying the labor market consequences of such policies is particularly interesting given that they target vulnerable groups with relatively low employment rates. Improving the employment and wage prospects of these workers is a policy priority for many govern-

[7] Minimum wages are more binding for younger workers. In addition, wage setting constraints might be more important when workers age out from the subsidy. If the tax cut were fully passed through at younger ages, once workers age out of the subsidy they could experience a wage cut. Notice that for older workers aging into the subsidy, increasing wages above the age threshold is easier.

[8] Bozio, Breda and Grenet (2019) reconcile these seemingly conflicting results by the tax-benefit linkage explanation. In our case, tax-benefit linkages are not directly affected by the reform as the payroll tax did not affect workers' future benefits, which were calculated based on wages and not based on social security contributions, a common feature of payroll tax cut policies.

ments. 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). Our main contribution to this literature is that we focus on heterogeneity across firm types and offer a potential explanation for the inconsistencies found in the literature.

Finally, our paper is also related to the recent rent sharing literature that studies the impact of various firm-level and market-level shocks on wages and employment (see Card, Cardoso, Heining and Kline, 2018 and more recently Kline, Petkova, Williams and Zidar, 2019; Jäger, Schoefer, Young and Zweimüller, 2020; Lamadon, Mogstad and Setzler, 2022; Garin and Silvério, 2023). The documented interaction between worker and firm heterogeneity in pass-through rates has not been fully appreciated in this recent literature.

The remainder of this paper proceeds as follows. Section 2 studies the effect of payroll taxes in different models of the labor market with heterogeneous firms. In Section 3, we provide background on the payroll tax reform we study and describe the Hungarian administrative data used for our empirical analysis. We present our employment results in Section 4 and wage results in Section 5. We discuss welfare effects in Section 6. In Section 7 we provide results for younger workers. Section 8 concludes.

2 Tax Cuts in Different Models of the Labor Market

We study the impact of payroll taxes under various assumptions about the structure of labor markets. We highlight that tax cuts do not only affect unemployment but could also change the composition of jobs in the economy. In some cases, tax cuts could create goods jobs partly at the expense of bad jobs, which could be an unintended consequence of the policy. Furthermore, the incidence of tax policies can be heterogeneous across firm types if we deviate from the standard assumption of perfectly competitive labor markets. Our results are summarized in Table 1, where we discuss the predictions of various models for employment and wages, and whether those differ by firm productivity. In each case, we rely on the standard model commonly applied in the literature. We study the impact of a lump-sum tax cut as this is what was introduced in Hungary. Nevertheless, we abstract away from the age-specific nature of the tax cut and worker heterogeneity. These assumptions allow us to illustrate the impact of the policy in a more tractable environment, but our results do not hinge on those assumptions. We discuss the main intuitions underlying the various models here and provide further details including formal derivations in Appendix E and in the Supplementary Material document. In Appendix E, we also implement a quantitative exercise and show that the size of the observed employment and wage responses are in line with the predictions of the standard sequential bargaining search models.

Search and matching with sequential bargaining. We start our discussion by applying a search and matching model with on-the-job search and sequential bargaining à la Postel-Vinay and Robin (2002). In that model, firms need to put costly effort into meeting workers by posting vacancies. Once a firm and worker are matched there is a negotiation between them over wages that takes into account the worker's outside option. Individuals coming from unemployment use their unemployment benefits and the value of not working as an outside option. Individuals with jobs can use their current job in the negotiation. As a result, workers participate in a sequential bargaining process over their job ladder, which allows them to extract more and more rent in the negotiations.

Table 1: Overview of the Effect of Tax Cuts in Different Models of the Labor Market

	Effect of tax cut on allocation			**Incidence of the tax cut**		
Model	Low TFP		High TFP	Low TFP		High TFP
Sequential bargaining search (Cahuc, Postel-Vinay and Robin, 2006)	Positive	$>$	Positive	Positive	$<$	Positive
Wage posting search (Burdett and Mortensen, 1998)	Zero	$=$	Zero	Positive	$<$	Positive
Monopsonistic competition, constant elasticity of firm-level labor supply	Positive	$>$	Negative	Positive	$=$	Positive
Monopsonistic competition (Card, Cardoso, Heining and Kline, 2018)	Positive	$>$	Negative	Positive	$<$	Positive
Perfectly competitive labor market (Melitz, 2003)	Positive	$>$	Negative	Positive	$=$	Positive

Note: Table summarizes the impact of payroll tax cuts under various assumptions about the structure of labor markets. In each case, we study the impact of a lump-sum tax cut in the presence of firms with heterogeneous productivity. We provide the intuition behind the results in Section 2, and we provide detailed derivation in Appendix E.

When the bargaining power of workers is low, the model predicts that low-quality, low-productivity firms can hire mainly from unemployment, but earn large rents on those workers as their outside options are weak. At the same time, high-quality, high-productivity firms can employ more workers as they do not only hire from unemployment, but can also poach workers from low-productivity firms. Poached workers can get a larger share of the surplus or rent as they can use their previous job as an outside option in wage negotiations.

That structure of the labor market implies that the impact of the payroll tax cut is heterogeneous across firms. This heterogeneity comes from the fact that the payroll tax cut mainly benefits firms hiring from unemployment. On the other hand, whenever firms poach workers from other firms, competition drives up wages and so the tax cut will be passed through to workers, leaving no benefit at the firm. As a result, the tax policy will disproportionately encourage low-productivity firms to put more effort in hiring as those firms tend to hire from unemployment. At the same time, workers at high-productivity firms benefit from poaching and outside offers and so their wages will increase. Therefore, there is a natural heterogeneity in the incidence of tax policy across firm types in this framework. In addition to that, there is no guarantee that the equilibrium (without tax intervention) is optimal, so tax policy interventions can increase efficiency.

Search and matching with wage posting. In a different type of search and matching environment, firms post take-it or leave-it wage offers. Once workers meet firms, they can decide whether to accept the wage offered by the firm or search further instead. In this framework, there are no individual-level negotiations over wages, and firms need to commit to higher wages to be able to poach workers from other firms. We derive the effect of the tax cut in the standard Burdett and Mortensen (1998) model. Firms meet searching workers randomly, and they cannot influence the probability of being met (e.g., by posting more vacancies). They only have one instrument to attract more workers: posting higher wages, which increases the probability that the randomly chosen worker accepts the offer once the firm and the worker have met. In equilibrium, more productive firms post higher wages and they can poach more workers from other firms. Nevertheless, the allocation of employment will be solely based on the ranking of firms. The tax cut does not affect that ranking and so employment will be unaffected in equilibrium.

At the same time, wage responses will depend on firm productivity. Lower productivity firms will post the same wage as before as they set wages close to the unemployment benefit. More productive firms, on the other hand, compete with each other for workers and will pass through part of the tax cut to workers. Therefore, similarly to the search and matching framework with sequential bargaining, we expect some heterogeneity in the incidence of the policy.

Monopsonistic competition. We also derive the impact of the tax cut in the presence of monopsonistic competition in the labor market. We follow Card, Cardoso, Heining and Kline (2018) and study the impact of the policy in the presence of monopsonistic competition. In that framework, firms face an upward-sloping labor supply function, which implies that they have to pay more to attract more workers. In response to the tax cut, the marginal benefit of hiring workers increases, which leads to firms' expansion. In the model, firms can only expand if they set higher wages. The relative size of the wage and employment responses depends on the elasticity of labor supply and how it varies across different firm types.

When the elasticity of labor supply is the same for all firms, there is full pass-through of the tax cut for all firms. As a result, wages will increase and we expect no heterogeneity in the incidence of the policy. Furthermore, the lump-sum nature of the tax cut also implies that wages will increase more in relative terms at low-productivity firms, which will induce a stronger employment response at those firms. In the model, aggregate labor supply is assumed to be inelastic, and so the stronger employment response at low-productivity firms will come at the expense of high-productivity firms.[9]

Card, Cardoso, Heining and Kline (2018), on the other hand, apply a different parametrization of the firm-level labor supply as full-pass through of income shocks would not be consistent with the existing evidence on rent sharing. Under their parametrization, the elasticity of firm-level labor supply decreases with wages.[10] Low-productivity firms face more elastic labor supply, and so a small wage change allows them to expand more. At the same time, high-productivity firms face less elastic labor supply and need to increase wages more, so their expansion is more costly. Low-productivity firms as a result will only implement a small wage increase and expand. Assuming constant aggregate labor supply, this will come at the expense of high-productivity firms. High-productivity firms, on the other hand, increase wages more, but the less elastic labor supply implies that employment will still reallocate from them towards low-productivity firms. Such reallocation reflects that the lump-sum shock is larger (in relative terms) for low-paying than for high-paying firms. The differences in the elasticity of firm-level labor supply, therefore, lead to the heterogeneous incidence of the policy. At high-productivity firms, employment will decrease, but those firms will pass through a larger share of the payroll tax cut.

Perfectly competitive labor market. Finally, we discuss the effect of the policy in the presence of perfect competition in the labor market. We apply a model with heterogeneous firms with some entry costs à la Melitz (2003). In this model, firms pay the same wage to workers but only the most productive firms enter the market. When the tax cut is introduced, some firms that were not viable before enter the labor market. This increases labor demand. With an inelastic labor supply, the main margin of adjustment is wages, while aggregate employment is unaffected. In that framework, there is reallocation from high-productivity firms to low-productivity firms entering the market. Furthermore, in the

[9] With an elastic aggregate labor supply curve, we can get a positive employment impact throughout the firm productivity distribution

[10] Berger, Herkenhoff and Mongey (2022) derives such an elasticity structure from labor market power and strategic interactions: larger firms face more elastic labor supply as they need to attract workers from other labor markets as well.

presence of perfect competition, there is no heterogeneity in the wage response across firms with different productivity. When labor supply is allowed to be elastic, the margin of adjustment can shift to employment and the pressure on wages will be more limited. Still the incidence of the policy will not be heterogeneous across firms.

Summary. Imperfect competition in the labor market leads to heterogeneous pass-through of tax cuts to wages across firm types in most cases. The models usually predict that higher productivity firms will pass through a larger share of the tax cut. This is in stark contrast to models with perfect competition. At the same time, we find no clear pattern on whether the payroll tax cut changes the composition of jobs or not, which highlights the need for empirical assessment. The models also emphasize different margins of adjustment (e.g. firm entry under perfect competition), which we will also explore. Motivated by these examples, we study the heterogeneous impact of a payroll tax cut on employment and wages in the next sections.

3 Institutional Setting and Data

3.1 Institutional Setting

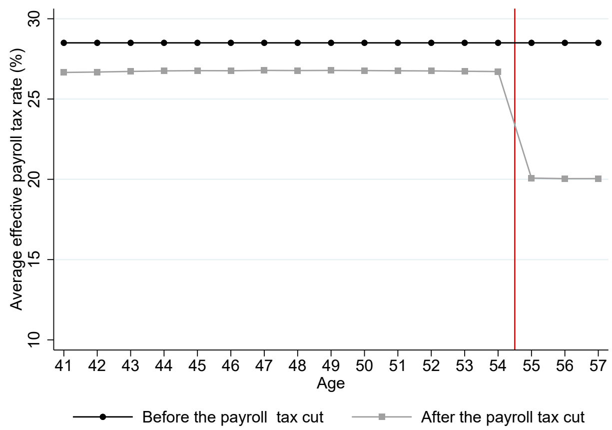
We study the impact of a large age-specific payroll tax cut instituted in Hungary in 2013. Before 2013, employers paid 28.5% of wages in social security contributions. In 2013, the government decreased the social security contributions of employers by around 14,500 Hungarian Forints (HUF, $66) per month for every employee older than 55. The average monthly salary net of employer payroll tax but before income tax and employee social security contributions was HUF 230,700 ($1,045) (Hungarian Central Statistical Office, 2022) so the payroll tax cut was 6.3% of the average salary.[11] The cut applied to both new and ongoing private sector jobs. Workers in the public sector and the self-employed were not eligible for the cut.

Besides workers aged over 55, workers under the age of 25 were also eligible for the tax cut. We discuss the impact of the policy on them in Section 7. Furthermore, workers in

[11] The exact rules were the following. The social security contribution paid by employers was decreased from 28.5% to 14%, but the total amount of the tax cut was capped at HUF 14,500. As the minimum wage in 2013 was HUF 98,000 ($444), almost everybody hit the cap. For the few workers who earned exactly the minimum wage at HUF 98,000 in 2013, the tax cut was HUF 14,250. In 2014, the minimum wage was raised to HUF 101,500 ($460).

elementary occupations[12] received the tax cut independently of their age.[13] In our primary analysis we include workers in elementary occupations, but our results are robust to the exclusion of those workers from the definition of private sector employment (see Appendix Table A4).

Figure 1: Employers' Social Security Contribution Rate by Workers' Age



Note: Figure shows the average employer social security contribution rate by worker age for male workers in the private sector. After the reform all individuals over age 55 experienced a lump-sum tax cut. Certain individuals were also eligible for the tax cut independently of their age.

Figure 1 depicts the average effective payroll tax rate paid by employers by employee age before and after the payroll tax cut was implemented. It shows the discontinuity at age 55 after the policy took effect (in gray) compared to the constant rate of 28.5% before (in black). After the policy took effect the average tax rate is lower than 28.5% (rate without cut) at all ages due to the fact that workers in elementary occupations could get the tax cut independently of age. Furthermore, there is a drop from 26.3% to 20% or by about 6.3 percentage points from age 54 to 55. It is worth highlighting that such a drop in the tax rate does not create a discontinuity in hiring incentives at age 55. From the firm's perspective, hiring someone one day short of age 55 is almost the same as hiring someone at exactly age 55 as the difference is simply the one day for which higher taxes need to be paid, while once age 55 is reached, the same amount of tax cut is received. That is why we apply a difference-in-differences empirical strategy described in detail in Section 4, instead of a regression discontinuity strategy. In addition, we also calculate the change in incentives that

[12]Elementary occupations correspond to level 9 of International Classification of Occupations ISCO-08. According to the definition of the International Labour Organization (`https://www.ilo.org/public/english/bureau/stat/isco/isco88/9.htm`), elementary occupations consist of simple and routine tasks which mainly require the use of hand-held tools and often some physical effort. Some examples are washing, cleaning, delivering goods, simple farming and manufacturing tasks, hand packing.

[13]Long-term unemployed re-entering the labor market, people returning to work after child-care leave, or younger workers entering the labor market received the tax benefit for 2 years independently of their age. The prevalence of these other beneficiary groups is close to zero for those aged 52-57.

take into account dynamic considerations, i.e., the fact that the control group will age into the treatment group at some point (see the elasticity results based on net present value).

The reform only affected the social security contributions paid by employers, while the part paid by the employees was unaffected. Employees before and after the reform paid a 16% flat-rate tax and employee social security contributions of 18.5%. Furthermore, the reform did not affect the link between social security contributions and future benefits (such as pensions) as those are calculated based on net wages and not based on contributions to the social security funds.

The tax cut was first publicly discussed in the Parliament on July 2, 2012, shortly after it was announced. The legislation was passed on October 15, 2012, and the tax change was effective from January 1, 2013. Due to the relatively short period of time between the announcement and enactment of the reform, anticipatory effects appearing before the implementation of the tax cut are likely to be negligible and we find no evidence of such effects in our empirical analysis.

In the main analysis, we study the impact of the reform among older men between 2010 and 2015. Throughout this period there were no other major labor market policy changes that affected older men. For women only there were some minor changes in early retirement rules and early retirement rate was non-negligible at age 55-57. Therefore, we focus on men to make sure that our results are not driven by changes in the pension system but when we apply our difference-in-differences estimation we find very similar results for women (shown in Appendix Section C).

Around this period the overall employment rate in Hungary was 64%, slightly below the OECD average (66%). The employment rate of older people (age 55-64) was only 46%, substantially below the OECD average (58%). The unemployment rate decreased steadily between 2012 and 2015, which reflected a substitution of welfare programs with a public work scheme (Cseres-Gergely and Molnár, 2015). At the same time, employment in the private sector was relatively stable: the prime-age population share employed in the private sector increased slightly from 38% to 39% between 2012 and 2015. To make sure our results are not driven by the improvement of labor market conditions, we show robustness to restricting the sample to local labor markets with stable prime-age employment.

Since our primary focus is on the heterogeneous impact of the policy, it is worth discussing whether different types of firms face different labor market institutions. In Hungary, it is relatively easy to hire or dismiss workers (Tonin, 2009). Wage bargaining takes place mostly at the individual level. The rare collective wage bargaining is based on firm-level agreements and the coverage of these policies is low. The unionization rate was around 10% in this period, one of the lowest in the OECD (OECD, 2022*b*). The weak labor market institutions and the lack of any size-specific regulations imply that firms with different size or productivity face similar institutional constraints in setting wages and employment.

3.2 Data

We use linked employer-employee administrative data from Hungary covering years 2010–2015 on a random 50% sample of the 2003 population. Since our sample is drawn from the whole population (and not just those who have a job) our data can be used to study changes in employment in response to the policy. An individual is defined to be a private sector employee if the individual is employed on the 15th of a month at a private sector firm with double-entry bookkeeping.[14] We include part-time workers and calculate full-time equivalent employment (e.g., working 20 hours per week is considered as 0.5 employment).[15] Our data include both fixed-term and permanent contracts, but we do not directly observe the contract type in the administrative data. According to the Hungarian LFS, fixed-term contracts in this age group are rare (less than 10% of all employment contracts are fixed-term). Our main outcome in the wage regression is the (full-time equivalent) net wage as of May of each year. We define net wage (sometimes abbreviated to wage) as wage earnings net of employer payroll tax. This net wage measure is calculated before income tax and employee social security contributions are deducted and includes base payment, bonuses and overtime pay.

Appendix Table A1 provides a comparison of employment statistics based on the administrative data we use with official statistics which are based on the Hungarian Labor Force Survey. These statistics are very similar, indicating the reliability of the employment indicators we define based on the administrative data.

We generate 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).[16]

[14] We focus on firms with double-entry bookkeeping as most quality measures (e.g. TFP) are only available for them. In 2012, 5.7% of men aged 52-57 worked at single-entry bookkeeping firms, while 36.2% worked at double-entry bookkeeping firms. In addition to that we exclude from the benchmark analysis seven firms which have more than 10,000 workers—very large and unique firms in the Hungarian context—to avoid outliers driving the results. In 2012, 3.2% of men aged 52-57 worked at firms with more than 10,000 workers. Appendix Table A2 shows that our results are robust to the inclusion of the largest firms and single-entry bookkeeping firms—the estimated employment effects and heterogeneity results by firm quality are stronger under the extended definition.

[15] The share of part-time jobs was very low in this period. Among men, around 90% of all private sector jobs were full-time.

[16] We use the *prodest* Stata module of Rovigatti and Mollisi (2020) and apply the estimation procedure of Wooldridge (2009). We regress the logarithm of value added (gross revenue minus the cost of goods sold) on year effects, the logarithm of firm size (variable input) and the logarithm of subscribed capital (state variable), while using material and service costs as proxies for unobserved productivity. The TFP is the residual estimated from this regression.

As another indicator of firm quality, we perform an Abowd, Kramarz, Margolis (AKM) style decomposition of wages (Abowd, Kramarz and Margolis, 1999) and calculate firm wage premia.[17] We calculate the poaching index, the share of new hires coming from employment instead of unemployment following Bagger and Lentz (2019).[18] We classify firms as foreign-owned if foreign ownership is above 50%. In the Hungarian context foreign ownership is a strong predictor of firm productivity, export orientation, and quality (Kaminski, 1999).

In our main empirical analysis, we restrict the sample to men and use workers aged between 52-57 (with workers aged 52-54 serving as the control group and workers aged 55-57 comprising the treatment group). We do not study the employment change of workers older than age 58 as early retirement starts to play a role then.[19] We restrict our sample to the non-retired population to ensure that the estimated employment effects are not driven by the aging-out of already retired individuals from our sample. Appendix Table A5 shows that the estimated employment change and the heterogeneity patterns remain similar if we include retired individuals in the sample. For the workers in our sample, the retirement age was 65 (and 64 for some older cohorts). We find no evidence that the cohorts with slightly older normal retirement age behave differently at age 52-57 so our main estimates are not driven by anticipation effects stemming from extending the retirement age.

Table 2 provides summary statistics on our data. The top panel suggests that the treatment and the control age groups are remarkably similar in terms of employment, wages and share of white collar jobs. The middle panel summarizes the distribution of treatment and control workers across high- and low-quality firms. For each measure (except for foreign ownership), we divide firms into above-median and below-median groups, taking the median based on all private sector workers, irrespective of their age. The share of workers at high-quality firms is very similar in the treatment and control groups. Finally, in the bottom panel we examine the industry composition of treatment and control workers. Again, we find very small differences suggesting that the treatment and the control groups are similar.

[17]To estimate the firm wage premia, we use all sample years of the linked employer-employee administrative data. We regress wages on individual and firm effects, controlling for year effects, age squared, age cubed, and firm size.

[18]We collect all hires made during 2003-2015 for each firm and define the poaching index (PI) as the share of these hires that come directly from other firms. To make sure that a firm ID change does not lead to a false high poaching rate we apply the worker-flow method of detecting ID changes as in Saygin, Weber and Weynandt (2021). This method can only be reliably applied for firms with at least 10 workers (corresponding, on average, to 5 observed workers in our 50% sample). We calculate the PI for firms with at least 15 hires in our sample between 2003-2015. For the rest of the firms, we impute the PI-based quality using linear and quadratic TFP and AKM firm fixed effects as predictors.

[19]The earliest age to retire was age 58 until 2011, but that possibility was abolished then. To retire at age 58, someone needed to have a long-term employment relationship and at least 37 years of employment history. Note that all workers aged between 52 and 57 between 2012 and 2015 (our main estimation sample) could only retire at the normal retirement age.

Table 2: Summary Statistics

	(1) Age 52-54 (Control)	(2) Age 55-57 (Treated)
Panel A: Labor market characteristics		
Private sector employment	0.34	0.32
Monthly private sector wage (HUF)	218,529	217,000
White collar job (private sector workers)	0.31	0.31
Panel B: Firm quality composition		
Above-median TFP	0.49	0.48
Above-median PI	0.34	0.34
Above-median AKM firm effect	0.49	0.48
Above-median firm-level average wage	0.51	0.51
Foreign-owned	0.23	0.22
Panel C: Industry composition		
Agriculture	0.08	0.08
Manufacturing	0.35	0.36
Construction	0.10	0.10
Wholesale and retail trade	0.11	0.10
Accommodation and food service	0.02	0.02
Transportation and storage	0.12	0.10
Administrative and support	0.05	0.06
Number of individuals	123,154	141,875

Note: The treatment group comprises ages 55-57 and the control group comprises ages 52-54. Panel A reports the share of workers employed in the private sector, the average monthly (full-time equivalent) wage of workers employed in the private sector, and the share of workers employed in the private sector in white collar jobs. Panel B reports share of workers at firms with above-median firm quality and at foreign-owned firms. Details on quality measures are provided in Section 3.

4 Effect on Employment

4.1 Descriptive Evidence

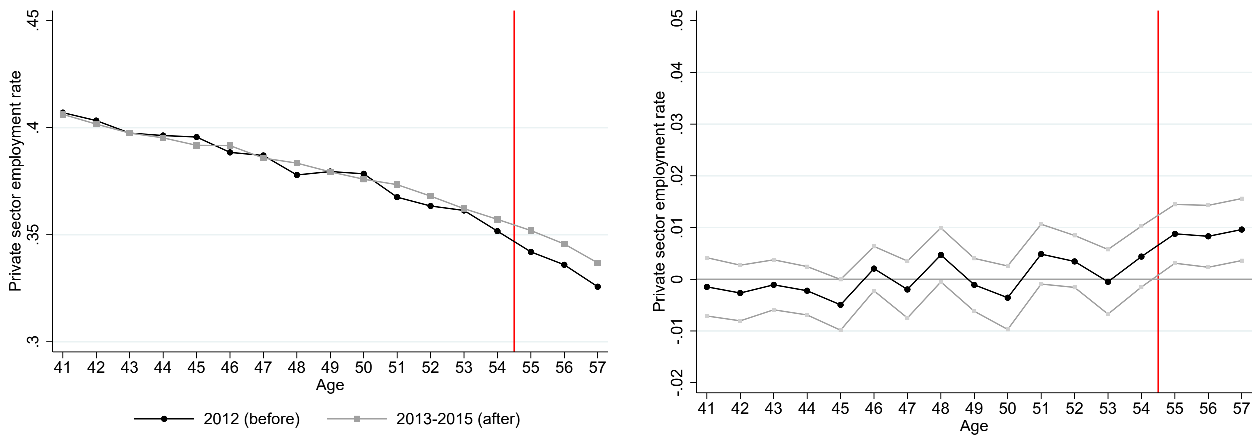
Figure 2 shows the share of men working at private sector companies by age before and after the payroll tax cut was introduced in 2013. Panel (a) shows raw employment rates by age before (year 2012, in black) and after (years 2013-2015, in gray) the policy took effect. The figure highlights that employment rates in the private sector gradually decline with age from 41% to 33%. Furthermore, employment rates were similar in 2012 and 2013-2015 for workers younger than 55, which highlights that private sector employment was relatively stable in this period.[20] Finally, there is a clear divergence for workers 55 and older who are affected by the tax cut.

[20] The average private sector employment rate between ages 41 and 54 in 2013-2015 is 38.4, while it is 38.3 in 2012.

Panel (b) shows the change in employment at private sector companies for men at each age—the difference between the 2012 (black line) and the 2013-2015 employment rate (gray line) shown in Panel (a). In the spirit of our difference-in-differences strategy, we subtracted the average employment change between 2012 and 2013-2015 for the workers between ages 41 and 54. The figure highlights that the employment change was significantly higher above the age 55 cutoff: a 55-year-old worker was 1 percentage point more likely to be employed shortly after the policy was introduced.

Figure 2: Employment in Private Sector Companies by Age

(a) Private Sector Employment Rate (b) Change in Private Sector Employment Rate



Note: Panel (a) shows the private sector employment rate by age before and after the payroll tax cut. The black line shows the employment rate in year 2012 (before the implementation of the payroll tax cut) and the gray line for years 2013-2015 (after the implementation of the payroll tax cut). Panel (b) shows the difference in employment rates between years 2012 and 2013-2015 relative to the average change between ages 41 and 54, with the 95% confidence interval (standard errors clustered at the age × period level). The vertical red line shows the age threshold where the tax cut became effective from 2013.

4.2 Main Results

To study the impact of the payroll tax cut in a difference-in-differences framework, we focus on workers aged 55-57 as our treatment group and workers aged 52-54 as our control group. As we discussed above, the labor market characteristics and the employment composition across firm types and industries are quite comparable across the two groups. We also explore below the sensitivity of the estimates to changing this treatment/control definition.

To study the impact of the tax cut on employment, we estimate the following equation

$$Emp_{it} = \theta_t + \sum_{k=52}^{k=57} \alpha_k \mathbb{I}[age_{it} = k] + \beta \mathbb{I}[t \geq t_{reform}] \cdot \mathbb{I}[age_{it} \geq 55] + \varepsilon_{it}, \quad (1)$$

where Emp_{it} measures private sector employment of individual i in month t, θ_t are monthly time effects, $\mathbb{I}[age_{it} = k]$ are age effects, $\mathbb{I}[age_{it} \geq 55]$ is a dummy for the eligibility cut-off, which is age 55 in our context, and $\mathbb{I}[t \geq t_{reform}]$ is the post reform dummy, where t_{reform} is January 2013. In the baseline specification the t index runs from January 2012 to December 2015 and we restrict the sample to individuals who are between 52 and 57 years old. We cluster the standard errors at the age×period level.

Table 3: Employment Effects of the Tax Cut

	(1) All firms	(2) Low TFP	(3) High TFP
Panel A: Change in private sector employment probability			
— Post × Treated	0.0053***	0.0053***	-0.0001
	[0.0005]	[0.0005]	[0.0004]
Panel B: Percent change in employment			
—Employment without tax cut	0.330	0.167	0.163
—Employment with tax cut	0.335	0.172	0.163
—Percent change in employment	1.59%	3.18%	-0.03%
Panel C: Percent change in labor cost $(1+\tau_{ss})$			
—Labor cost without tax cut	1.27	1.26	1.28
—Labor cost with tax cut	1.20	1.18	1.22
—Percent change in labor cost	-5.27%	-6.02%	-4.45%
Panel D: Implied elasticity (Panel B/Panel C)			
— Elasticity based on percent change in labor cost	-0.30	-0.53	0.01
	[0.03]	[0.05]	[0.06]
Panel E: Elasticity based on net present value			
—Percent change in net present value of labor cost	-7.49%	-8.82%	-5.98%
—Implied elasticity	-0.21	-0.36	0.01
	[0.02]	[0.03]	[0.04]

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

Note: Panel A of the table shows difference-in-differences estimates of the impact of the payroll tax cut on private sector employment for all firms (column 1) and separately for below-median (column 2) and above-median (column 3) TFP firms in Panel A. We report the β coefficient from regression equation (1) with the outcome variable being employed at a private sector firm (column 1), at a private sector firm with below-median productivity (column 2) and at a private sector firm with above-median productivity (column 3). Panel B calculates the percent change in employment using the difference-in-differences estimates from Panel A. The first row shows the employment rate in the treatment and control age groups in 2012 (before the reform). The second row adds to that baseline the estimated change from Panel A. The third row shows the percent change in employment relative to the baseline. Panel C calculates the percent change in labor cost analogously. Firms' labor cost is net wage times $(1+\tau_{ss})$, where τ_{ss} is the employer social security contribution. Panel D calculates the implied employment elasticity with respect to the wage change by taking the ratio of the percent change in employment (Panel B) and labor cost (Panel C). Panel E calculates the percent change in the labor cost caused by the tax cut, taking into account tax cuts realized in the future (see Appendix B for further details). The implied elasticity based on net present value of labor cost is the ratio of the percent change in employment (Panel B) and labor cost (Panel E). Standard errors are reported in brackets, clustered at the age × period level. ($N = 9,003,984$ individual-months)

Our coefficient of interest is the β term which captures the differential change in private sector employment between the periods before and after the tax cut for treated workers relative to control workers. Panel A of Table 3 reports the baseline estimates of β—the difference-in-differences estimate of the impact of the tax cut on employment. We measure full-time equivalent private sector employment (Emp_{it}). Column (1) shows that private sector employment increased by 0.53 percentage points from a baseline of 33% or by 1.59 percent as a result of the payroll tax cut. In Table 3, we also calculate the implied labor demand elasticity. The effective tax cut was 6.6 percentage points (a 5.27% decrease relative to the baseline labor cost including the pre-employment payroll tax), which implies that the increase in employment corresponds to an employment elasticity of -0.30 (s.e. 0.03). Appendix Table A3 shows that these results are virtually identical if instead of adjusting employment for working hours, we use a binary employment indicator.

Our elasticity estimate for overall employment is close to what others have found in the literature. For instance, Laun (2017) finds an employment elasticity of -0.22 for older workers in Sweden, while Huttunen, Pirttilä and Uusitalo (2013) find an elasticity of -0.1 in Finland. For younger workers, Saez, Schoefer and Seim (2019) find an employment elasticity of -0.23 in Sweden, while Egebark and Kaunitz (2018) estimate an elasticity of -0.3 in response to the young worker tax cut instituted during the Great Recession in Sweden.

We also investigate whether responses to the policy differ by firm type. Columns (2) and (3) of Table 3 summarize the key results. We use regression equation (1) with an outcome variable of being employed by a firm with below (column 2) or above (column 3) median total factor productivity. The results show that virtually all the employment increase comes from low-productivity firms, while the employment change is close to zero at high-productivity ones.

Table 3 also highlights that differences in employment responses cannot be fully explained by the differential impact of the policy on the change in labor cost. Since the amount of tax cut was the same for every worker, the proportional change in labor cost is slightly lower at high-productivity firms, which tend to pay more to their workers. Indeed, we calculate that the labor cost decreases more at low-TFP firms than at high-TFP firms (6.02% vs. 4.45%). Still, the change in labor cost was considerable even at high-TFP firms, with an 4.45 percent decline in labor cost. As a result, the employment elasticity with respect to cost of labor is precisely estimated for the high-TFP firms as well. The estimated elasticity is -0.53 (s.e. 0.05) at low-productivity firms and 0.01 (s.e. 0.06) at high-productivity ones, and the difference in responses to the tax cut between the two firm types are both statistically and economically significant.

Elasticity calculations based on the net present value of labor cost. Forward-looking firms might make hiring and firing decisions based on the net present value of labor cost. In our case, this implies that firms might consider that workers in the control group could reach age 55 and become eligible and benefit from the tax cut. To see whether this would alter our results, we calculate the net present value of the tax cut in the treated and control ages separately by taking into account worker age, the typical separation rate, and the discount rate. Panel E of Table 3 shows the net present value reduction in the treatment group (relative to the control group) in labor cost using a discount rate of 7% and retirement age 62. We calculate that the tax cut leads to a 7.49% reduction in labor cost in the treated age group. The implied elasticity is -0.21 (s.e. 0.02). This elasticity is somewhat lower (-0.21 vs. -0.30) than the elasticity based on the current change in labor cost.

In columns (2) and (3) of Table 3 we also calculate the net present value reduction in labor cost separately at low- and high-TFP firms. Since separation rates are lower at high-TFP firms, we apply different separation rates for the two groups. We calculate an 8.82% reduction in labor cost at low-TFP firms and 5.98% reduction at high-TFP firms. The implied elasticities are -0.36 (s.e. 0.03) and 0.01 (s.e. 0.04), respectively, a statistically and economically significant difference. In Appendix B we provide further details about the calculation of the net present value of labor cost and we also show that the implied elasticity is not sensitive to the discount rate, separation rate, and retirement age applied.

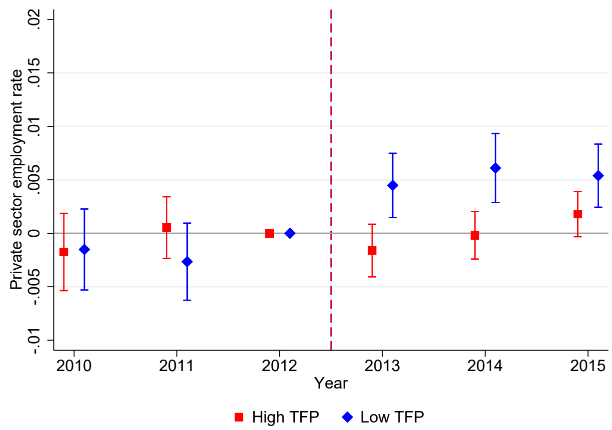
4.3 Robustness and Credibility Checks

Parallel trends. The standard identifying assumption in difference-in-differences regressions is that employment in the treatment and control groups would have evolved similarly in absence of the policy change. While this assumption cannot be tested directly, we can study whether the assumption holds pre-policy. To do that we estimate the evolution of the difference between the treatment and control groups over time using the following regression:

$$Emp_{it} = \theta_t + \sum_{k=52}^{k=57} \alpha_k \mathbb{I}[age_{it} = k] + \sum_{\substack{h=2010 \\ h \neq 2012}}^{h=2015} \beta_h \mathbb{I}[Year_t = h] \cdot \mathbb{I}[age_{it} \geq 55] + \varepsilon_{it}, \qquad (2)$$

where the variable definitions are the same as for equation (1). In this regression the β_h coefficients show the difference between treatment and control workers in year h and we report those in Figure 3. The red squares show the change in employment at high-TFP firms, where we use employment at above-median TFP firms as the dependent variable. The blue diamonds show the estimates at low-TFP firms, where we use employment at below-median TFP firms as the dependent variable. The figure highlights that prior to the introduction of the policy, the employment rates of treated and control workers evolved similarly both at high- and low-TFP firms, suggesting that the control workers are likely a good counterfactual for the treatment workers. At low-TFP firms, employment among treatment workers increased relative to the control group exactly when the reform was introduced in 2013. The impact on employment was around 0.5-0.6 percentage point over years 2013-2015 at low-productivity firms. At the same time, employment at high-productivity firms stayed similar among control and treatment workers.

Figure 3: Evolution of Employment at Low- and High-Productivity Firms



Note: We report the difference in employment between the 55-57 age group that was affected by the payroll tax cut and the 52-54 age group that was not affected by the tax cut relative to the difference in 2012. We report β_h coefficient of the regression equation (2) where the outcome variable is being employed at an above-median (in red) or at a below-median (in blue) TFP firm. 95% confidence intervals are reported with standard errors clustered at the age $\times$ period level.

SUTVA and changing the treatment and control definitions. Another key assumption in difference-in-differences style regressions is that the treatment does not affect the control group—the so-called stable unit treatment value assumption (SUTVA). The SUTVA can be violated if firms move away from hiring workers not eligible for the tax cut and replace them by hiring workers who are eligible for the tax cut. This substitution would have only a small effect on untreated workers as long as the share of treated workers is small in the economy.[21] Below we directly assess whether such substitution takes place by studying firms' hiring behavior before and after the policy and show that firms that hired more treated workers do not decrease their hiring of untreated workers.

SUTVA could also be violated as we move closer to the age threshold. This is because those close to the age threshold age into the treatment, which could affect their labor market opportunities.[22] This spillover effect of the treatment on the control group should be less important as we move further away from the age 55 cut-off. Indeed, Panel (b) of Figure 2 shows that relative to the average employment rate between ages 41 and 54, we estimate a slightly larger treatment effect, than relative to the average employment rate of those closer to the age cut-off. In Figure 4 we further explore the robustness of our employment results to

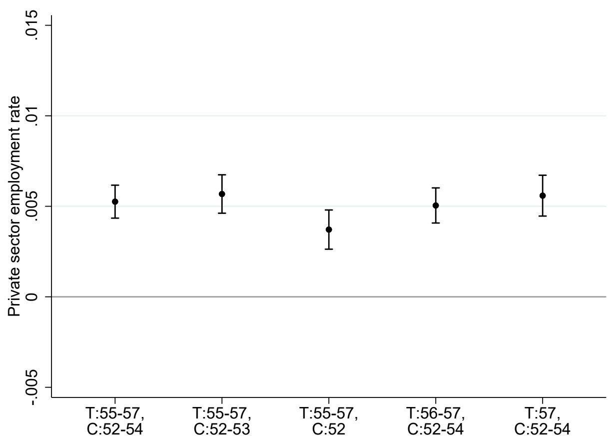
[21]In the standard neoclassical framework, the effect of price change of one input on the demand for another input depends on the share of the first input in the production process and the elasticity of substitution between the two inputs (see Hicks, 1932). Therefore, the change in demand for untreated workers will be small if the share of treated workers is small in the economy.

[22]The difference in incentives disappears as we go closer to the age 55 cut-off. This is why we do not apply a regression discontinuity approach here.

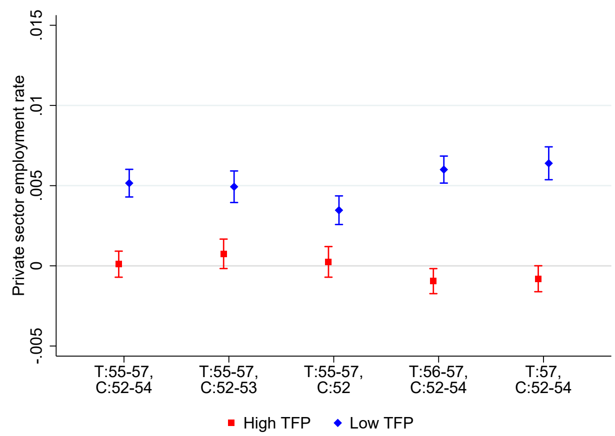
alternative definitions of the treatment and control age groups. Panel (a) shows the estimates for overall employment, while Panel (b) shows the estimates for employment at low- and high-TFP firms separately. The first three estimates from the left keep the benchmark treatment definition (age 55-57), but use control groups farther away from the age 55 cut-off, defining as control group first those who are between 52 and 53 years old and then only 52-years-old individuals. Both the overall employment effect and the estimated difference between the low- and high-TFP firms are similar in these specifications. Next, we show estimates when the treatment group is narrowed, while keeping constant the benchmark control definition. We show estimates first when the treatment group covers only those between 56 and 57 and then when it covers only 57-year-old individuals. The estimated effects are virtually identical in all these specifications suggesting that our estimates are not sensitive to changing the age window in the estimation.

Figure 4: Employment Estimates Using Alternative Control and Treatment Definitions

(a) Employment at all Private Sector Firms



(b) Employment by Productivity



Note: We report estimates of the impact of the payroll tax cut on private sector employment based on equation (1) for alternative control and treatment definitions. The estimates show the the change in employment in the treatment age group relative to the change in employment in the control age group. In both panels, the first estimate replicates our baseline results and the subsequent estimates change the age composition of the control ("C") or treatment ("T") groups. 95% confidence intervals are reported with standard errors clustered at the age × period level.

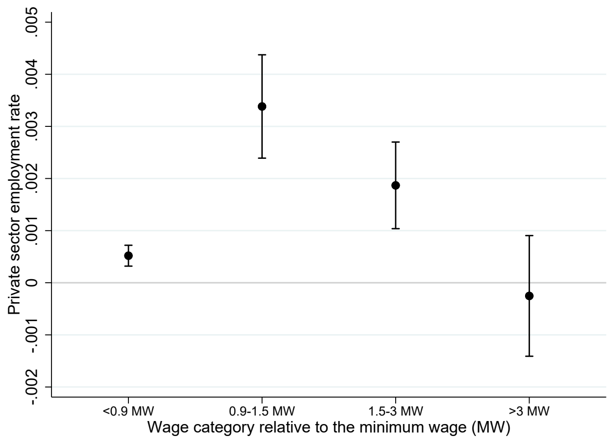
Finally, it is worth highlighting that the differences in separation rates between high-TFP and low-TFP firms could contribute to the heterogeneity in the estimated employment effects—if separation rates are lower at high-TFP firms then they are more willing to hire workers just under the cut-off age, therefore spillover effects may be more substantial at high-TFP firms. Still, as we discussed above when presenting elasticity calculations based on the net present value of the tax cut, we find a clear reduction in labor cost at high-TFP firms even if we take into account these differences in separation rates. Panel E of Table 3 shows that the reduction in labor cost is 8.82% at low-TFP firms and 5.98% at high-TFP firms implying an elasticity of -0.36 (s.e. 0.03) for low-TFP and 0.01 (s.e. 0.04) for high-TFP firms. Therefore, the lower separation rate at high-quality firms cannot explain the differential employment responses.

Effects across the wage distribution. We estimate the change in employment throughout the entire distribution of wages, similarly to the approach of Cengiz, Dube, Lindner and Zipperer (2019). Since the payroll tax cut was lump-sum, we expect that employment would be mainly affected at the bottom of the wage distribution, while the employment effect would be close to zero in the upper part of the wage distribution, where the lump-sum tax cut only introduces a small (relative) change in labor cost. Panel (a) of Figure 5 shows the change in employment at all firms. The estimates show that the largest employment effects arise for workers earning between 90% and 150% of the minimum wage, but that there are also substantial effects for workers between 150% and 300% of the minimum wage. In line with the lump-sum nature of the tax cut, we do not find any change in employment above 300% of the minimum wage. Panel (b) of Figure 5 shows the employment changes separately for low- and high-productivity firms. The figure demonstrates that most employment changes occurred at low-TFP firms (blue diamonds). At the same time, the changes in employment at high-TFP firms (red squares) are very small and close to zero throughout the entire wage distribution. This partly reflects that there are fewer low-wage jobs at high-TFP firms (see Appendix Figure A1 on the density of jobs in each wage category). Nevertheless, even if we consider the wage category between 150% and 300% of the minimum wage, where there is a high density of jobs at both low- and high-TFP firms we find clear differences in the employment changes: while the change in employment is substantial and statistically significant at low-TFP firms, the change in employment is close to zero at high-TFP firms.

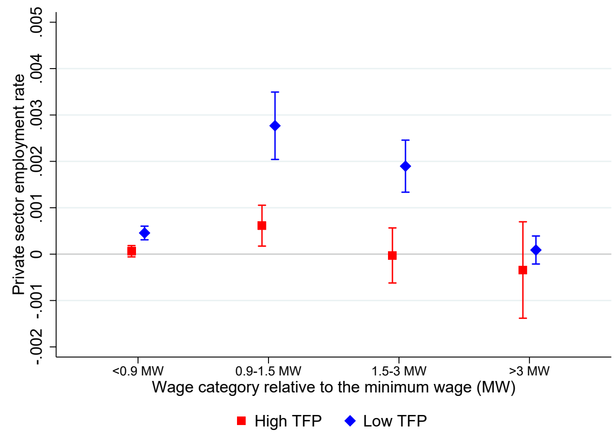
Placebo groups unaffected by the tax cut. As we mentioned in Section 3, the reform only affected private sector employees, while the self-employed and workers in the public sector were unaffected by the tax cut. Employment in these groups therefore should not be affected by the policy change. Furthermore, it is also possible that changes in private sector employment simply reflect switching from the public sector or from self-employment. Appendix Table A6 explores the source of the private sector employment increase by estimating our main regression equation (1) with mutually exclusive outcome variables: being employed in the private sector (including employment at single-entry bookkeeping firms and at firms with more than 10,000 workers, thus using a broader private sector employment definition than the definition used throughout the rest of the paper), being self-employed, working in the public sector, or being inactive/unemployed. Since these outcome variables are collectively exhaustive, the increase in one outcome must reflect a decline in other ones. Appendix Table A6 shows that the tax cut had a positive effect on employment at private sector firms

Figure 5: Impact of the Payroll Tax Cut Across the Wage Distribution

(a) Employment at all Private Sector Firms



(b) Employment by Productivity



Note: We report the change in employment across the wage distribution. The estimates are based on equation (1), where the outcome variable is being employed in a private sector company in a given wage bin (less than the 90% of the minimum wage; between 90% and 150% of the minimum wage; between 150% and 300% of the minimum wage; or above 300% of the minimum wage). 95% confidence intervals are reported with standard errors clustered at the age × period level.

– due to the inclusion of the smallest (single-entry bookkeeping) firms, the estimated effect is stronger than the baseline results (see Appendix Table A2 for a comparison of the definitions). Appendix Table A6 also shows that there is a slight reduction in the likelihood of being self-employed but the estimated change is an order of magnitude smaller than the employment changes we found for private sector employees. As a result, the switch from self-employment to private sector employment can explain at most 15% of the total increase in private sector employment. Furthermore, the slight negative impact on self-employment was fully offset by the slight increase in public sector jobs. As a result, the increase in the share of private sector employees mainly comes from a decline in unemployment and inactivity. Appendix Figure A2 corroborates these findings by replicating the descriptive evidence on changes in private sector jobs (Panel (b) of Figure 2) for public sector job (Panel (a)) and for the self-employed (Panel (b)). The change in employment in these two placebo groups is very small, suggesting that the increase in private sector employment in the treated age groups reflects the impact of the tax cut and not something else.

Effect by various firm quality measures. So far, we have focused on the heterogeneous effect of the policy along one dimension of firm quality: firms' total factor productivity. Nevertheless, there are other potential ways to measure firm quality. For instance, the search and matching model with sequential bargaining suggests that the heterogeneous incidence should also emerge if we consider high paying firms and firms characterized by high poaching index (share of new hires coming from other firms instead of unemployment). In Panel (a) of

Figure 6, we replicate the heterogeneity analysis in the employment effects with other firm quality measures (for short-run effects see Appendix Table A7).

Figure 6: Employment and Wage Changes in Private Sector Companies: Alternative Firm Quality Measures

Note: Panel (a) reports estimates of the impact of the payroll tax cut on private sector employment based on estimating equation (1). Panel (b) reports estimated pass-through rates based on equation (5). The red vertical line corresponds to the full pass-through of the tax cut into higher wages. 95% confidence intervals are reported with standard errors clustered at the age $\times$ period level.

Foreign-owned firms are the most productive firms that are usually well integrated into the world economy. Those firms are offering the highest paying, highest quality jobs in the Hungarian context. The estimated employment change at those firms is close to zero and statistically insignificant. At the same time, domestic firms, which are usually less efficient, responded to the policy by creating many new jobs. A similar pattern can be observed when we measure firm-quality using the poaching index, average wages or AKM firm effects. Low-paying firms create many new jobs, changing the composition of jobs in the economy.

Overall these estimates highlight that the composition of jobs changes in response to the tax cut, as low-quality firms will create more jobs than high-quality ones. To make sure that the results are not driven by the endogenous response of total factor productivity and other quality measures to the reform, we replicate the heterogeneous effects using only pre-reform years to define the firm quality indicators. Our results are almost the same using the pre-reform definitions of firm quality measures (Appendix Table A8).

Industry vs. firm type heterogeneity. We check whether the estimated heterogeneous effect of the tax cut on employment by firm productivity is driven by differences in the industry composition of high-productivity and low-productivity firms. To do so, we classify firms based on their within-industry relative productivity. We estimate a linear regression of the TFP indicator on level-1 Nomenclature of Economic Activities (NACE) industry codes, generate the residual and calculate its year-specific median. We then estimate the impact of the tax cut on employment at firms with above-median and below-median residualized TFP. The results reported in Panel A of Appendix Table A10 indicate that the employment effect of the tax cut is driven by low-quality firms, even conditional on industry composition.

Panel B shows the main estimates by worker heterogeneity when we proxy workers' skill with occupation. We calculate the change in employment separately for low-paid and high-paid occupations. Low-paid occupations are those that pay below the median on average and high-paid occupations are those that pay above the median on average. The table shows that employment increased by a similar amount in both low-paid (0.28 percentage points) and high-paid (0.24 percentage points) occupations. Furthermore, there is clear heterogeneity within both low-paid and high-paid occupations: virtually all the employment change comes from low-TFP firms. Columns (5) and (6) also highlight that the employment elasticity is similar in low-paid and high-paid occupations. At low-TFP firms it is close to -0.50, while at high-TFP firms it is close to zero within both occupation groups.

Worker type vs. firm type heterogeneity. So far, we have focused on the heterogeneous responses to the policy by firm type. Nevertheless, the differential responses by firm type might simply reflect that different types of workers sort to different types of firms. For instance, high-skilled workers might have more bargaining power and they also tend to work at high-TFP firms. To explore the empirical relevance of this interpretation of our main findings, we estimate the employment effects and firm heterogeneity for workers with similar skills.

In Table 4 we replicate the main analysis for various skill groups. Panel A shows the estimates when we examine the change in employment at jobs earning at most 1.5 times the minimum wage and for jobs earning above that. This is a similar exercise as in Figure 5 where we studied the employment effects throughout the wage distribution. The workers earning at most 1.5 times the minimum wage are predominantly low skilled ones and we see that their employment also increases slightly at high-TFP firms. When we focus on higher skilled workers with wages above 1.5 times above the minimum wage, we still see a clear heterogeneity in the data. Almost all the employment changes come from low-TFP firms, while high-TFP firms do not hire more even if they employ many workers in that wage category. These results suggest that the heterogeneous employment effect by firm quality is not driven by the different earnings composition of jobs by firm quality.

Table 4: Employment Effects of the Tax Cut by Subgroups

	(1)	(2)	(3)	(4)	(5)	(6)
		Employment			Elasticity	
	All firms	Low TFP	High TFP	All firms	Low TFP	High TFP
Panel A: By wage						
Jobs paying at most 1.5×minimum wage	0.0039***	0.0032***	0.0007***	-0.43	-0.48	-0.31
	[0.0005]	[0.0004]	[0.0002]	[0.06]	[0.06]	[0.09]
	{35%}	{27%}	{8%}			
	⟨0.1239⟩	⟨0.0922⟩	⟨0.0316⟩			
Jobs paying above 1.5×minimum wage	0.0016***	0.0020***	-0.0004	-0.17	-0.55	0.07
	[0.0005]	[0.0003]	[0.0005]	[0.05]	[0.08]	[0.09]
	{65%}	{24%}	{40%}			
	⟨0.2221⟩	⟨0.0748⟩	⟨0.1473⟩			
Panel B: By occupation						
Low-paid occupations	0.0028***	0.0030***	-0.0001	-0.29	-0.55	0.03
	[0.0004]	[0.0003]	[0.0002]	[0.04]	[0.05]	[0.05]
	{51%}	{28%}	{24%}			
	⟨0.1716⟩	⟨0.0956⟩	⟨0.0761⟩			
High-paid occupations	0.0024***	0.0023***	0.0001	-0.25	-0.47	-0.02
	[0.0006]	[0.0003]	[0.0005]	[0.06]	[0.06]	[0.11]
	{49%}	{19%}	{30%}			
	⟨0.1743⟩	⟨0.0716⟩	⟨0.1028⟩			
Panel C: By education						
Primary and lower-secondary education jobs	0.0038***	0.0037***	-0.0001	-0.29	-0.54	0.02
	[0.0005]	[0.0004]	[0.0003]	[0.04]	[0.06]	[0.05]
	{70%}	{37%}	{33%}			
	⟨0.2354⟩	⟨0.1140⟩	⟨0.1214⟩			
Upper-secondary education jobs	-0.0000	0.0004**	-0.0004	0.00	-0.22	0.34
	[0.0003]	[0.0002]	[0.0003]	[0.10]	[0.11]	[0.26]
	{16%}	{8%}	{8%}			
	⟨0.0547⟩	⟨0.0256⟩	⟨0.0291⟩			
Tertiary education jobs	0.0013***	0.0011***	0.0001	-0.54	-0.69	-0.15
	[0.0003]	[0.0002]	[0.0003]	[0.12]	[0.13]	[0.44]
	{14%}	{7%}	{7%}			
	⟨0.0528⟩	⟨0.0258⟩	⟨0.0270⟩			

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

Note: We report employment effect estimates separately for various subgroups. We estimate the regression equation (1) using employment in a given subgroup (job or occupation) and firm type (all firms in column 1, below-median TFP firms in column 2, and above-median TFP firms in column 3) as the outcome variable. In curly brackets we report the subgroup share within each panel. In angle brackets we report the mean of the outcome variable in May 2012 – the probability of being employed in a given subgroup and firm type. In Columns (4)-(6) we calculate the employment elasticity with respect to the wage. Standard errors are reported in brackets, clustered at the age × period level. ($N = 9,003,984$ individual-months)

Finally, in Panel C we study worker heterogeneity by education. Since we do not observe education directly, we again rely on occupation information in our data. First, we use the Hungarian Labor Force Survey[23] that has detailed information on education and occupation for the same individuals for a large sample of workers. We calculate the mode of the education level for each four-digit occupation. Then we assess the employment change by the modal education-level in each occupation.

[23]The Hungarian Labor Force Survey (Hungarian LFS) is very similar to the Current Population Survey in the United States.

The table shows that the employment increase mainly comes from the lowest-skilled workers with primary or lower-secondary education. There is also a slight increase in employment for workers with tertiary education and no change for workers with upper-secondary education. When we look at employment changes within an education group, we find clear indication for firm heterogeneity in all cases. Employment at low-TFP firms increased within every group and the elasticities vary between -0.22 and -0.69 (see column 5). These elasticities are statistically significant in all cases at the 5% level. At the same time, there is no evidence for significant employment change at high-TFP firms in any education group. The employment change is close to zero in all cases and the elasticities are statistically insignificant at the conventional levels. Overall, these findings highlight that the firm heterogeneity is present even if we focus on a group of workers with the same skill level and so our main results reflect firm heterogeneity and not only worker heterogeneity.

Effect on worker transitions and firm dynamics. Next, we decompose the effect of the tax cut on employment into the effect on new hires vs. separations. Then, we analyze whether the employment effects are driven by the entry of new firms as a consequence of the tax cut.

The estimated employment change can come from two sources: (1) workers who have been employed previously and stay employed at higher rates (incumbents) or (2) workers who were unemployed/inactive before and are hired (new entrants). Panel A of Appendix Table A12 decomposes our main employment effect into these two groups. We define incumbent workers as those who had a job in the previous 12 months (between $t-1$ and $t-13$) and new entrants as those who had at least one month without a job in that period. Then we estimate regression equation (1) using private sector employment as the outcome separately for incumbents and new entrants.

Panel A of Appendix Table A12 summarizes the key findings. Employment for new entrants increases by around 0.15 percentage point, which is around 28% of the overall 0.53 percentage point increase reported in Panel A of Table 3. This is nevertheless a quite substantial, 3.5% increase relative to baseline population share (4.3%) of new entrants. Employment for incumbents increases by 0.38 percentage point, which is 72% of the overall 0.53 percentage point increase in employment. This is a 1.3% increase relative to the baseline share (29%) of incumbents. These results highlight that the tax cut affected labor market transitions by inducing both higher labor market (re)entry rates and lower separation rates among workers in the treatment age group.

Besides labor market dynamics, we can also study the potential change in firm dynamics. A key prediction of models with perfectly competitive labor markets and firm heterogeneity à la Melitz (2003) is that employment creation should take place through firm entry. Panel B of

Appendix Table A12 shows the decomposition of the total change in employment into newly entering firms (firms that did not exist in the previous calendar year) and firms that existed before. Contrary to the prediction of models with perfectly competitive labor markets, we find that almost all the employment creation comes from firms that existed before, suggesting that no new firms were set up in response to the tax cut. Panel C corroborates these findings by showing that employment mainly increased at firms that existed before 2012, while the change in employment at newly created firms is negligible.

Labor market institutions and the minimum wage. As we noted before in Section 3.1, unions are weak in Hungary and central bargaining of wages is almost non-existent. As a result, larger firms do not usually face organized workforce with more institutional protections. Still to make sure that our results are not simply driven by large firms, we examine heterogeneity by firm size in Appendix Table A11. We divide firms into two size categories, using the definitions of OECD (2022*c*): micro and small firms (1 to 49 employees) and medium-sized and large firms (50 or more employees). More refined categorization is hindered by the fact that the vast majority of the smallest (micro) firms have below-median TFP and the vast majority of large firms have above-median TFP. We find that employment at low-productivity firms increases in both firm size categories, while among high-productivity firms there is no consistent employment effect in either firm size category.

We also discuss the potential impact of minimum wages on our results. In the presence of binding minimum wages, the tax cut could make some jobs viable, which could explain why job creation takes place disproportionately at low-productivity firms. That might play some role: as we saw on Figure 5, some jobs were created around the minimum wage in response to the tax cut. Nevertheless, there is also significant job creation substantially above the minimum wage at low-TFP firms, which means that our findings do not simply reflect the interaction of the minimum wage with the tax cut.

We also showed in Section 4.3 that firm dynamics and new firms entering after 2012 are not the major source of job creation (see Appendix Table A12) and around 78% of the jobs come from incumbent workers. This again suggests that the extra jobs are unlikely to simply reflect jobs that were not viable before.

The role of the economic environment. As we discussed in Section 3.1, the Hungarian labor market was booming in this period. To understand the importance of local economic conditions, we study the impact of the policy across local labor markets in Appendix Table A14. The country consists of 197 districts. We first divide districts by unemployment rate in 2012 and study the impact separately in districts with above- and below-median unemployment rates in Panel A. The effect of the tax cut on employment is somewhat larger in regions with above-median unemployment rate, where the average unemployment rate was around 18.3%, than in regions with below-median unemployment rate, where the average unemployment rate was around 8.6% (0.65 percentage points vs. 0.55 percentage points). Nevertheless, the heterogeneity is very similar across firms, as almost all the employment change comes from low-TFP firms.

In addition, we also divide districts by the change in private sector employment rate in Panel B. In stable labor markets the change in private sector employment is less than 2 percentage points (in absolute value), while in improving labor markets the change is more than 2 percentage points. The change in employment and the heterogeneity pattern is very similar in booming and stable environments.[24] Overall, these findings suggest that local economic conditions are unlikely to play a major role in explaining our main findings.

Substitution. A common concern about targeted tax cuts is that firms may substitute treated workers for untreated ones. This substitution could bias our main estimates, if it leads to substantial change in employment in the control group. Nevertheless, as we discussed in Section 4.1, there is no indication of any significant change in employment in the data among individuals in the control group. The lack of large employment responses in the control group is not surprising given that only a low share of the workers are treated and so the substitution effect on untreated workers should be limited.[25]

A different concern from the policy maker's perspective could be that firms that hire more treated workers might decide to hire fewer prime age or other untreated workers. We directly test the empirical relevance of this concern by studying the firm-level relationship between hiring treated and untreated workers before and after the policy change in Appendix Figure A3. The figure shows the non-parametric relationship between the two-year change in firm-level employment of treated workers (considering workers both below the age 25 and above the age 55 thresholds) and that of untreated ones (relative to the employment at baseline). We calculate the pre-policy relationship by studying the change between 2010 and 2012 (black dots and line) and the post-policy relationship between 2012 and 2014 (blue stars and line). We also calculate the no substitution counterfactual (red squares and line): how much the pre-policy relationship would change if firms increased their hiring of treated workers by the observed average firm-level employment change from 2012 to 2014, but kept the hiring rate of untreated workers at the 2010 to 2012 level. This no substitution counterfactual is closely aligned with the post reform relationship, indicating that substitution from untreated

[24] We do not have enough districts with substantial decline in labor market conditions and so we cannot study the impact of the tax cut in a recessionary environment.

[25] This argument is similar to the one made in Appendix Section B in Cengiz, Dube, Lindner and Zipperer (2019). Given that the share of treated workers in the aggregate production function is small, realistic values of labor-labor substitution put an upper bound on the size of employment changes of the untreated population.

workers is limited in our context.

5 Effect on Wages

5.1 Main Results

We study the impact of the tax cut on wages in this section. First, we study the impact on the wages of new entrants by estimating the following regression equation:

$$\ln w_{it} = \sum_{k=52}^{k=57} \alpha^k \mathbb{I}[age_{it} = k] + \theta \mathbb{I}[year_t \geq t_{reform}] + \beta \mathbb{I}[year_t \geq t_{reform}] \cdot \mathbb{I}[age_{it} \geq 55] + \varepsilon_{it}, \quad (3)$$

where w_{it} is the net wage of individual i in May at year t. Note that for wages, we use annual data throughout this section as this is the level of observation available.[26] In our case, t_{reform} is 2013.

A key limitation of the regression equation above is that it considers the same proportional wage changes across the entire wage distribution. Nevertheless, given the lump-sum nature of the tax cut, we expect that the proportional increase in wages will be quite small for high wage earners and could be much larger for low wage earners. To take this into account, we assess the impact of the policy by the tax cut rate – the size of the payroll tax cut relative to the wage in the previous year, formally $TCR_{it-1} = 14,500/w_{it-1}$, where HUF 14,500 is the tax cut amount. This variable goes from 14.5% for low wage earners to zero for very high wage earners, and reflects the percent change in wages that would occur if all of the tax cut were passed through to the worker. Notice that the tax cut rate is calculated for both treated and control workers. For the latter, the tax cut rate reflects the size of the tax cut (relative to their income) that would have been received if the workers were treated.

Then we estimate the following regression:

$$\begin{aligned}\ln w_{it} = \sum_{k=52}^{k=57} (\alpha_0^k + \alpha_1^k TCR_{it-1}) \mathbb{I}[age_{it} = k] + (\theta_0 + \theta_1 TCR_{it-1}) \mathbb{I}[year_t \geq t_{reform}] + \\ + (\beta_0 + \beta_1 TCR_{it-1}) \mathbb{I}[year_t \geq t_{reform}] \cdot \mathbb{I}[age_{it} \geq 55] + \varepsilon_{it}, \quad (4)\end{aligned}$$

where we interact each term in regression equation (3) with the tax cut rate, TCR_{it-1}. To calculate TCR_{it-1}, we need to rely on the previous year's wage and so we can only estimate this regression for workers who worked in the previous year (incumbent workers).

[26] We only see annual income for employment relationships spanning the entire year. This is a common feature of administrative social security data (see e.g. German IAB data).

Furthermore, to make sure that our exposure measure TCR_{it-1} is not contaminated by the policy itself, we only use one post-policy year 2013 and one pre-policy year 2012 in the benchmark regression. Later we perform a robustness check where we define the tax cut rate based on wages two years before, formally $TCR_{it-2} = 14,500/w_{it-2}$, and then we use data from 2014 and 2012. In the benchmark specification we also focus on full-time, full-month workers, to minimize measurement error in wages, and present robustness checks which include part-time workers.

The results of the wage regressions are reported in Table 5. Column (1) estimates wage effects for new entrants using equation (3). The change in the wages of new entrants is small and statistically insignificant. The average tax cut rate for new entrants was around 0.11, suggesting that the pass-through rate for new entrants is around 21% (s.e. 0.17).[27]

Table 5 also shows the estimates for the incumbent workers for whom we can calculate the tax cut rate. Column (2) suggests that the average impact of the tax cut on wages among incumbent workers is positive. The coefficient showing the treatment effect post policy in relation to the tax cut rate (β_1) is 0.22 (s.e. 0.09). This implies that a \$1 increase in the tax cut would result in a 22 cent increase in wages on average, or that average pass-through is 22% with firms capturing 78% of the tax cut on average. This estimate is similar to the one found for new entrants, though it is more precisely estimated here. We also examine heterogeneity in this treatment effect. We estimate the following equation, using the notation of equation (4):

$$
\begin{aligned}
\ln w_{it} = & \sum_{k=52}^{k=57} (\alpha_0^k + \alpha_1^k TCR_{it-1} + \alpha_2^k Q_{j(i,t)} + \alpha_3^k TCR_{it-1} Q_{j(i,t)}) \mathbb{I}[age_{it} = k] + \\
& + (\theta_0 + \theta_1 TCR_{it-1} + \theta_2 Q_{j(i,t)} + \theta_3 TCR_{it-1} Q_{j(i,t)}) \mathbb{I}[year_t \geq t_{reform}] + \\
& + (\beta_0 + \beta_1 TCR_{it-1} + \beta_2 Q_{j(i,t)} + \beta_3 TCR_{it-1} Q_{j(i,t)}) \mathbb{I}[year_t \geq t_{reform}] \cdot \mathbb{I}[age_{it} \geq 55] + \varepsilon_{it},
\end{aligned} \tag{5}
$$

where we interact all coefficients in equation (4) with $Q_{j(i,t)}$, the quality of firm j where individual i works at time t. To check that our estimates are not simply driven by transitioning to high-quality firms, in Appendix Table A15 we show that the estimated treatment effects are robust to using the firm quality in the previous year.

[27]Since past wages are not observed for new entrants, we cannot calculate TCR_{it-1}. Therefore, we approximate the tax cut rate using the current wages, formally $TCR_{it} = 14,500/w_{it}$. This is the exact tax cut rate TCR if there is no pass-through. If part of the tax cut is passed through then we should have (w_{it} − Pass-through) in the denominator. Assuming 100% pass-through the average tax cut rate would be 0.12.

Table 5: Wage Effects of the Tax Cut

	(1) log(wage)	(2) log(wage)	(3) log(wage)	(4) log(wage)	(5) log(wage)	(6) log(wage)	(7) log(wage)	(8) log(wage)
Post×Treat	0.022	-0.019*	0.008	0.007	-0.026	0.021**	-0.021**	0.011
	[0.018]	[0.010]	[0.007]	[0.006]	[0.113]	[0.009]	[0.009]	[0.016]
Post×Treat×TCR		0.221**	-0.077	-0.071	0.249	-0.191**	0.149*	-0.129
		[0.090]	[0.070]	[0.053]	[0.925]	[0.085]	[0.081]	[0.215]
HighTFP×Post×Treat			-0.046***	-0.041***	-0.068	-0.040***	-0.045***	-0.053**
			[0.013]	[0.011]	[0.118]	[0.006]	[0.014]	[0.021]
HighTFP×Post×Treat×TCR			0.678***	0.602***	0.905	0.600***	0.632***	0.780***
			[0.137]	[0.104]	[1.032]	[0.038]	[0.163]	[0.242]
Windfall×Post×Treated								0.546*
								[0.277]
Windfall×Post×Treat×TCR								-5.979**
								[2.588]
Pass-through rate								
All firms	0.208	0.221**						
	[0.168]	[0.090]						
Low TFP			-0.077	-0.071	0.249	-0.191**	0.149*	-0.129
			[0.070]	[0.053]	[0.925]	[0.085]	[0.081]	[0.215]
High TFP			0.602***	0.531***	1.154**	0.409***	0.781***	0.651***
			[0.131]	[0.110]	[0.425]	[0.107]	[0.121]	[0.097]
Observations	13,429	97,789	97,789	93,666	4,123	112,713	82,910	97,789
New entrants/incumbents	new	incumb	incumb	incumb	incumb	incumb	incumb	incumb
Workers	all	all	all	same firm	poached	all	all	all
Part-time included	no	no	no	no	no	yes	no	no
One vs. two year change	one	one	one	one	one	one	two	one
Windfall rate included	no	no	no	no	no	no	no	yes

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

Note: Column (1) estimates the effect on wages for new entrants who entered the labor market in the current year and so have less than 12 months employment using equation (3). Columns (2)-(8) estimate the wage change for incumbent workers (who have been continuously employed in the previous 12 months). Column (2) estimates wage change for all firms using equation (4), while columns (3)-(8) estimate heterogeneity by firm productivity using equation (5). Column (3) shows wage changes for all incumbent workers, while columns (4) and (5) show estimates for workers who stayed at the same firm and workers who were poached to another firm, respectively. In all columns except column (6) we focus on full-time workers. In column (6) we also include part-time workers in the analysis. In all columns except in column (7), we compare the wage changes between 2012 and 2013. In column (7) we study two-year wage changes and compare the wage change between 2012 and 2014. In column (8), we also interact the treatment, age, year, and tax cut rate indicators with the firm specific windfall rate, which reflects the size of the windfall received by the firm as a result of the tax cut. The pass-through rate at low-productivity firms is the β_1 coefficient in equation (5), while at high-productivity firms it is the sum of the β_1 and the β_3 coefficient in equation (5). Standard errors are reported in brackets, clustered at the age × period level.

Column (3) of Table 5 shows the main estimates of treatment effect heterogeneity. The estimates show that the wage effects are driven by high-productivity firms. In high-quality firms, the pass-through rate is 60% (the sum of β_1 and β_3, which is 68% plus -8%) and statistically significant. At the same time, the pass through rate is close to zero and statistically insignificant at low-quality firms. This is consistent with the predictions of labor market imperfections but not with the perfect competition (see Table 1). The pass-through heterogeneity holds both for workers who remain at the same firm and workers who transition to another firm (columns (4) and (5)), although the pass-through rate of the tax cut is higher for those who change employer. This latter is more in line with the search model with sequential bargaining predicting that switchers should experience a larger gain.

5.2 Robustness and Credibility Checks

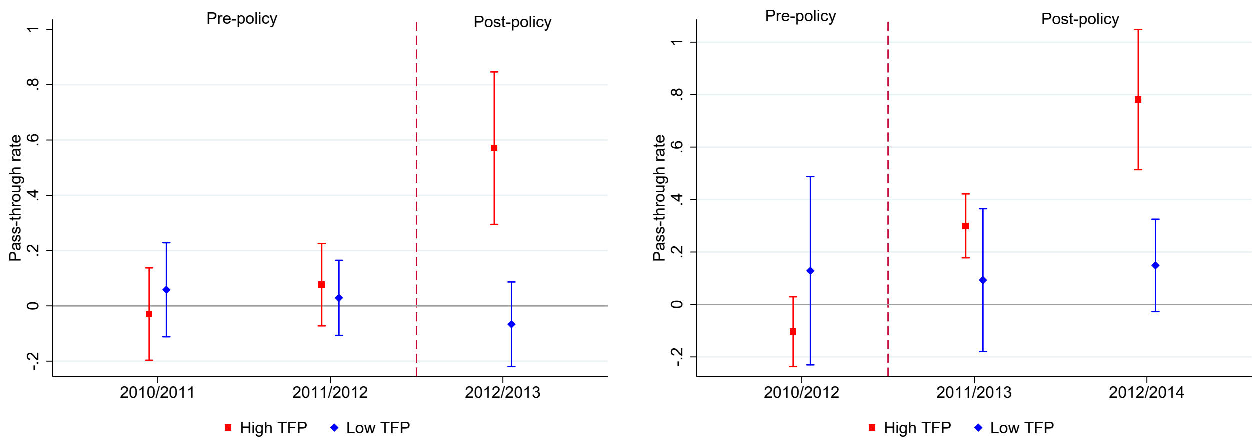
Parallel trends. Similarly to the employment estimates, the key identifying assumption in our difference-in-difference style regression is that wages in the treated age group would have evolved similarly to those in the control age group in the absence of the payroll tax cut. While this assumption cannot be tested directly, we can test whether the assumption holds in the pre-policy years. We estimate the same regression equation as for the main analysis, but we shift the time window to the pre-reform years and assume pre-reform (hypothetical) treatment years. Panel (a) of Figure 7 shows the estimated pass-through when we estimate regression equation (5) using years 2011-2012 (assuming $t_{reform} = 2012$) and 2010-2011 ($t_{reform} = 2011$). We report the estimated pass-through at low-productivity firms (β_1 from equation (5)) and high-productivity firms ($\beta_1 + \beta_3$ from equation (5)). In both pre-reform placebo analysis, we find no indication for any wage change at high- or low-productivity firms. The effects are therefore specific to the actual treatment year.

SUTVA and changing the treatment and control definitions. Similarly to the employment estimates we also study the sensitivity of our estimates to changing the treatment and control groups to alleviate the concerns related to spillovers to the control group and the potential violation of the SUTVA. Figure 8 shows the pass-through estimates for all firms (Panel (a)) and by firm quality (Panel (b)). The estimated patterns remain very similar if we define the control group farther away from the age 55 cut-off by using workers who are 52 and 53 years old or 52-year-olds only as the control group. We also explore how the estimates change if we define narrower treatment age groups. We show estimates when the treatment includes only those between 56 and 57 and when it includes only 57-year-olds. The estimated effects are similar in all these specifications suggesting that our estimates are not sensitive to changing the age window in the estimation.

Wage changes by tax cut rate. So far, we have assumed a linear relationship between the tax cut rate, TCR_{it-1} and wage changes. We also study the non-parametric relationship by estimating the change in wages for tax cut rate categories separately. In particular, we estimate regression equation (5) but replace the continuous tax cut rate variable with a set of dummy variables showing different levels of the tax cut rate. Figure 9 shows the main estimates separately for low- (blue diamonds) and high- (red squares) productivity firms. In the figure, past wages, w_{it-1}, increase from the left to the right and so the tax cut rate—the size of the (lump-sum) payroll tax cut relative to the wage—falls. The figure demonstrates that at high tax cut rates there is a clear change in wages at high-productivity firms, but not at the low-productivity ones. Furthermore, as the tax cut rate decreases (from left to right) we see a decrease in wage changes at high-productivity firms as we would expect if the

Figure 7: Evolution of Wage Changes in Private Sector Companies

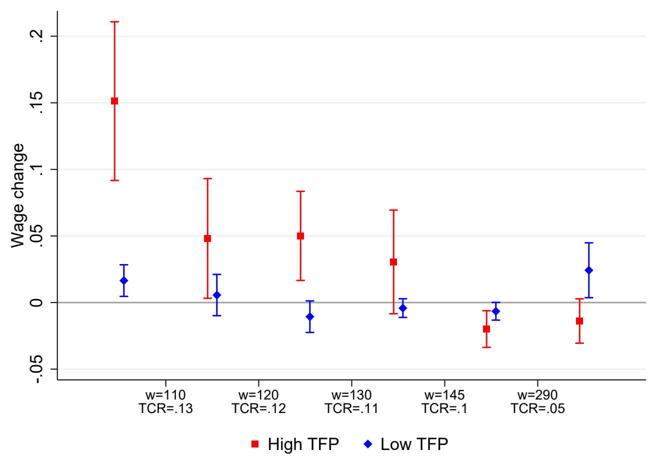
(a) One-Year Wage Changes (b) Two-Year Wage Changes



Note: Estimates of pass-through rates based on equation (5) are shown. Each result is based on the change in wages between the years indicated on the x-axis. Panel (a) shows changes over one-year intervals and Panel (b) over two-year intervals. 95% confidence intervals are reported with standard errors clustered at the age × period level.

wage changes were driven by the tax cut. At low tax cut rate levels the wage changes are small for both high- and low-productivity firms. The non-parametric relationship between tax cut rate and wage changes, therefore, corroborates that the estimated wage changes at high-TFP firms are driven by the tax cut and not something else.

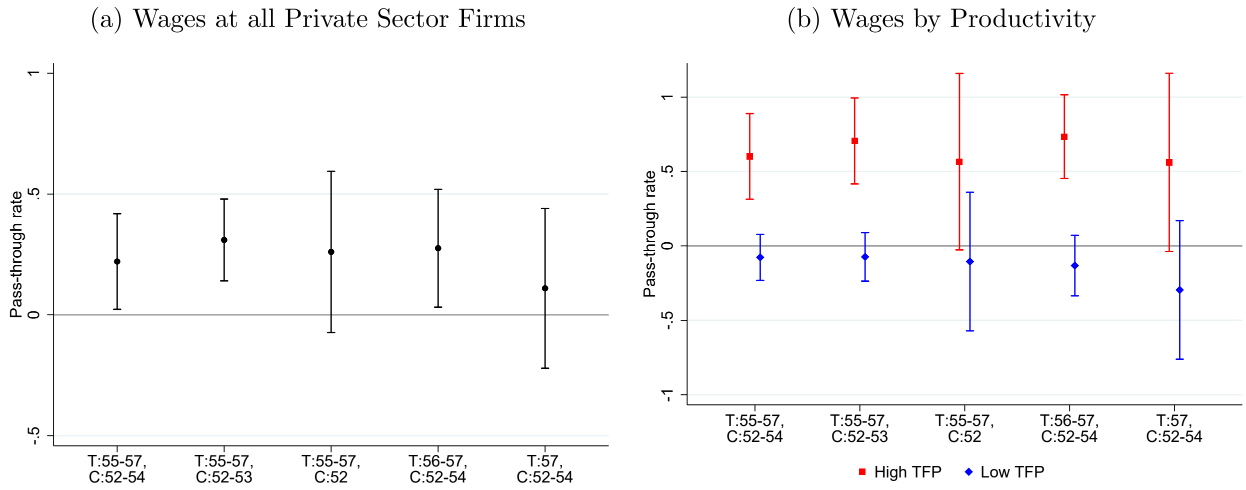
Figure 9: Wage Changes at Different Levels of Lagged Wages



Note: Estimates based on a modified version of equation (5) are shown, where the linear tax cut rate TCR_{it-1} is replaced with categories of the tax cut rate TCR_{it-1}. We report the cut-off values of lagged wages (in thousands of Hungarian forints) and the corresponding tax cut rates TCR_{it-1} on the x-axis of the figure. 95% confidence intervals are reported with standard errors clustered at the age × period level.

Robustness to including part-time workers. Since in our data we do not perfectly observe hours worked, so far, we have focused on full-time workers whose wage information

Figure 8: Wage Changes Using Alternative Control and Treatment Definitions



Note: Estimates of pass-through rates based on equation (5) are shown for alternative treatment and control definitions. In both panels, the first estimate replicates our baseline results and the subsequent estimates change the age cutoffs for the control ("C") or treatment ("T") groups. 95% confidence intervals are reported with standard errors clustered at the age × period level, except for the third and fifth estimate points (T:55-57, C:52 and T:57, C:52-54), where we do not cluster the standard errors as one cluster would capture the entire treatment or control age group.

is more precisely estimated. Column (6) of Table 5 shows the estimated change in wages when we include part time workers in the sample. The estimated pass-through at high-productivity firms declines when including part-time workers (from 60% to 41%) but it remains both economically and statistically significant.

Robustness to two-year change. So far, we have focused on one-year changes post policy. We made this restriction because we wanted to make sure that the policy change itself does not affect the measure of the tax cut rate, TCR_{it-1}, through changes in the previous year's wage. As a robustness check, we redefine the tax cut rate as $TCR_{it-2} = 14500/w_{it-2}$ and study two-year changes. Column (7) of Table 5 shows the estimates when we examine two-year changes. The estimated pass-through is somewhat higher (78% vs. 60% at high-productivity firms). In Panel (b) of Figure 7 we also report two-year wage changes. It suggests that between 2010-2012, the wages of control and treated workers evolved fairly similarly with the divergence happening only when the tax cut was introduced in 2013.

Effect by various firm quality measures. Similarly to the employment estimates, we replicate the heterogeneity in the wage effects analysis using other indicators of firm quality. We report the results in Panel (b) of Figure 6 and in Appendix Table A9. We see that a similar pattern of incidence emerges for a wide class of measures of "good" firms. Workers at foreign, high-poaching-index, high-wage, and high-wage-premium firms experienced substantial wage increases, ranging between around 50% to almost full pass through. At the same time, workers at domestic, low-poaching-index, low-wage and low-wage-premium firms did not experience any wage increases.

This suggests that the heterogeneity in incidence that we uncover is not tied to one specific quality measure and is a basic feature of the labor market. Comparing panels (a) and (b) of Figure 6 also demonstrates the heterogeneous incidence of the policy by firm type. While low-quality firms (blue diamonds) respond on the employment margin and not the wage margin, the opposite is true for high-quality firms (red squares).

Industry vs. firm heterogeneity. We also explore whether the differential pass-through rate is simply related to the industry composition of workers. We classify firms based on within-industry variation in TFP as discussed in Section 4.3. The results reported in Panel B of Appendix Table A10 indicate that the estimated heterogeneity in the incidence of the tax cut remains very similar to the benchmark classification. The pass-through rate is 46% for high-productivity firms based on the within-industry classification vs. 60% based on the overall classification.

Effect by education categories. We estimate wage effects by education categories and report the results in Appendix Table A17. Education is defined by the mode of the education level for each four-digit occupation (see Section 4.3 for details—here, to reduce the noise in the estimates, we consider two education categories: primary and lower-secondary on the one hand and upper-secondary and tertiary on the other hand). The table shows that for both education categories the pass-through rate of the tax cut is bigger at high-TFP and high wage premium firms. Also, the pass-through rate is higher and its heterogeneity is stronger at higher education category jobs, where the bargaining channel is likely to play a more important role (see e.g. Cahuc, Postel-Vinay and Robin, 2006, Hall and Krueger, 2012).

Effect by firm size. We also examine the heterogeneity of wage effects by two firm size categories, using the same categorization as for the employment effects. The results reported in Appendix Table A13 indicate that qualitatively the pattern of the wage effects is similar both at micro and small firms (size 1-49) and at medium-sized and large firms (size 50+), although the pass-through rate at high-quality firms is higher among medium-sized and large firms (65%) than among micro and small firms (45%).

5.3 Rent Sharing and Windfall Effects

Recent empirical work shows that firms that received larger rents or windfalls as a result of a tax cut for younger workers, grew more rapidly in the context of Sweden (Saez, Schoefer and Seim, 2019). We study the presence of such windfall effects in the context of the tax cut for older workers in Hungary. The main results are summarized in Appendix Figure A4.

We compare firms that have a high share of treated workers aged 55 and above with firms that have a medium share of such workers. Similarly to Saez, Schoefer and Seim (2019) we find mean reversion in the ratio of the windfall revenues to the total payroll (which we call exposure). Firm size, wages and sales revenue after the reform trend similarly for firms with high and medium shares of treated workers, and so we find no clear indication that windfall effects are important for this population. Interestingly, when we examine the impact of a tax cut on younger workers in Hungary in Section 7, we find remarkably similar findings as in Saez, Schoefer and Seim (2019).[28] This suggests that the lack of windfall effects for older workers is unlikely to reflect the different economic environment, and that the tax cut impacts younger and older workers differently.

Another important finding in Saez, Schoefer and Seim (2019) is that firms shared the rents coming from the tax cut equally between young treated and untreated workers. Such rent sharing would work against finding any wage effects in our empirical design that compares the wage change between treated and untreated workers. Still, as we demonstrated above, we find clear indication of wage changes between treated and untreated workers for high-productivity firms.

Nevertheless, we directly assess the implication of rent sharing in column (8) of Table 5. We calculate the firm-level rent as in Saez, Schoefer and Seim (2019) by taking the ratio of all the tax cuts instituted in 2013 (including those affecting younger workers and workers in elementary occupations) and the pre-reform total wage bill. We include this windfall measure in equation (5) and interact it with the age categories, the post reform dummy, and the post reform by treatment age dummy, and the interaction with the tax cut rate variable, TCR_{it-1} (including all other variables that are interacted with tax cut rate in equation (4)). The results show that including the windfall effects in the regression does not change the estimated pass-through at high- and low-productivity firms. If anything the estimated pass-through effects are slightly larger at high-productivity firms (65% instead of 60% in the benchmark estimate) and still close to zero at low-productivity firms once we take into account the windfall effects. Appendix Table A16 also shows that the windfall effects do not change the pass-through estimates when other firm quality measures are applied.

The treated post-reform windfall coefficient in column (8) of Table 5 suggests that firms hit by larger windfall increase the wages of treated workers slightly more than the wages of untreated workers. Nevertheless, these effects are less important at lower wages, where the tax cut played a more important role. Furthermore, the effect of the windfall shock on

[28] Appendix Figure D5 implements the same windfall analysis for younger workers. Similarly to Saez, Schoefer and Seim (2019), we find no pre-trends between high exposure and medium exposure firms among younger workers, but document an increase in revenues and employment at high exposure firms (relative to medium exposure firm) after the tax cut.

wages was limited given that the average windfall rate was 2.7% in our sample. Overall, these findings underscore the important role of firm heterogeneity, which is present even if we take into account the firm-level windfall shocks brought by the policy.

6 Welfare Analysis

In this section we evaluate the policy's welfare impact, taking into account its costs and fiscal externalities. 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 cut. We apply the following formula:

$$\text{MVPF} = \frac{\text{WTP}}{\text{Net Government Cost}}, \tag{6}$$

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.

The WTP consists of three parts. First, the part of the tax cut that is received by workers enters workers' WTP with a positive sign. To calculate this, we first calculate the per capita average amount of the tax cut (using the employment rate and average effective tax cut). Then, based on the estimated pass-through in Table 5, we determine the fraction of the tax cut that goes to workers. Second, workers who gain employment as a result of the tax cut lose their unemployment benefits which enters their WTP with a negative sign. Here, we rely on the estimated treatment effects on employment (Table 5) and the average unemployment benefit as observed in our data. Third, workers who gain employment are paid wages by their employers which enters their WTP with a positive sign—to calculate this part of the WTP, we estimate the employment effect by wage categories. The net cost is the sum of the tax cut minus the benefits a non-employed person receives minus the taxes paid after the additional wage due to increasing employment.

We calculate the MVPF two different ways. Under the first approach, we assume the policy maker only cares about workers' welfare and the social marginal utility of employers is zero. In this version, we do not incorporate the part of the tax cut that goes to employers into the WTP. In an alternative calculation, we assume that social marginal utility is the same on workers and employers and so we incorporate the part of the tax cut that goes to employers into the WTP.

We present the calculations in Table 6. When the policy maker only cares about workers' welfare, the overall MVPF is 0.27. The low MVPF reflects the fact that our estimates imply that most of the tax cut benefited employers. The MVPF is much larger at high-productivity

Table 6: Marginal Value of Public Funds

	(1) All firms	(2) Low TFP	(3) High TFP
(1) Direct cost	5116	2402	2774
(2) Tax cut going to workers	974	-159	1437
(3) Benefit receipt of non-employed who become employed	328	328	-6
(4) Additional net wages of non-employed who become employed	510	473	-10
(5) Additional tax revenue	438	401	-9
(1)-(3)-(5) Net cost	4349	1673	2789
(2)+(4)-(3) Willingness to pay (WTP), workers only	1155	-14	1433
(1)+(4)-(3) Willingness to pay (WTP), workers and firms	5297	2547	2770
Marginal value of public funds (MVPF), workers only	0.27	-0.01	0.51
Marginal value of public funds (MVPF), workers and firms	1.22	1.52	0.99

Note: We report per-worker average monthly amounts in HUF for workers aged 55 and above in each row. Row (1) reports the direct cost defined as the tax cut multiplied by the employment rate of the treatment group. Row (2) reports the tax cut received by workers based on the wage effect results reported in Table 5. Row (3) reports the benefits that non-employed individuals who become employed would have received based on the estimated employment effect of the reform and the average unemployment benefit amount. Row (4) reports the additional net wages received by non-employed individuals who become employed based on the estimated employment effect by wage categories. Row (5) reports the additional tax revenue defined as the total estimated income tax and social security contributions paid for workers who become employed. The marginal value of public fund (MVPF) is the ratio of willingness to pay and the net cost.

firms (0.51) than at low-productivity ones, where it is close to zero. The difference is mainly due to the higher pass-through rate of the tax cut to workers at high-quality firms. Our calculation, therefore, highlights that if policy makers mainly care about workers' welfare they should target high-quality firms with the tax cut.

Once we include the part of the tax cut going to employers into the WTP, the relationship between the MVPF and firm quality flips: payroll tax cuts targeting high-productivity firms have lower MVPF (0.99) than payroll tax cuts targeting low-productivity firms (1.52). This is because when the incidence of the tax cut between employers and employees does not matter, the employment creation effect will dominate the welfare calculations. Since employment creation mainly takes place at low-productivity firms, the MVPF will be larger for targeting these firms with the tax cut.

7 Effect on Younger Workers

Besides the payroll tax cut for older workers, a similar tax cut was also introduced for workers under age 25 in 2013. The tax cut led to a 6.6% reduction in the labor cost. We apply the same difference-in-differences model as for the older population to examine the impact of the policy on these workers. We summarize the basic results here and provide further details in Appendix Section D.

The overall impact of the tax cut on employment was larger for younger workers than for older workers (see Appendix Table D1). The estimated employment elasticity with respect to the cost of labor is -0.77 (or -0.52 based on the net present value of the tax cut). We find similar heterogeneity in the employment responses of younger workers, though the strength of heterogeneity depends on the firm quality measure applied (see Appendix Figure D3). We find that most jobs are created at firms with low AKM wage premia, low poaching rates, and at domestic firms, but contrary to the old, we find positive job creation even at better quality firms. Turning to wages, we find no indication of significant wage differences between treated and untreated younger workers (see Appendix Figure D4).

Two points should be noted. First, similarly to us, Saez, Schoefer and Seim (2019) find no differential change in wages in response to payroll tax cuts targeting young workers in Sweden.[29] Our findings highlight that wage pass-through differs among young and older workers. These differences could be explained by wage rigidity that constrains firms' pass-through differently for younger and older workers. For instance, passing through the tax cut to younger workers could mean a wage increase for a 22-24 years old and then a wage cut once workers reach age 25. At the same time, passing through the tax cut would simply mean that once age 55 is reached a pay raise is implemented. The latter might be more feasible than the former because workers dislike pay cuts (Bewley, 1998).

Second, the lack of wage responses for younger workers could be explained by that most young workers have little scope for wage negotiation in entry-level jobs (see Caldwell, Haegele and Heining, 2024). The large share of new entrants also implies that workers who are entering the labor market, or workers in probationary period, have no credible outside option and so firms can hire them and extract all the rents. If the share of these types of workers is large in a labor market, there will be smaller differences in the hiring incentives of low- and high-productivity firms. Thus, these differences between young and old workers are consistent with models of imperfect competition in the labor markets.

8 Conclusion

This paper studies the implications of payroll tax cuts in the presence of imperfect competition in labor markets. We highlight that tax policies can have heterogeneous impact across firm types. As a result, tax policies may change the composition of jobs in the economy. To empirically assess these heterogeneous effects, we exploit the introduction of age-dependent

[29] In Appendix Section D we also replicate their firm-level analysis and show that our findings for the young are broadly consistent with theirs.

payroll tax reductions in Hungary. Using rich administrative data, we show that in response to a large tax cut, both employment and wages increased among older workers affected by the policy. However, there is substantial heterogeneity across firm types. The positive effect of the payroll tax cut on employment is driven by low-quality firms, while the wage effect is mainly driven by high-quality firms. These estimated effects on employment and wages are in line with the predictions of the search model with sequential bargaining. While other imperfect competition models could potentially be enriched to explain the observed patterns, our findings are hard to reconcile with the neoclassical model of labor markets predominantly applied to evaluate the impact of payroll tax cuts.

Overall, our results highlight that at low-quality firms, the incidence of payroll tax cuts mainly falls on firms, while at high-quality firms, the incidence mainly falls on workers. Furthermore, universal tax cuts supporting all types of jobs and firms the same way could have some unintended consequences by creating bad jobs with little value for many workers. This aspect of payroll tax cuts should be considered in future evaluations of such policies.

References

Abowd, John M, Francis Kramarz, and David N Margolis. 1999. "High Wage Workers and High Wage Firms." *Econometrica*, 67(2): 251–333.

Anderson, Patricia M, and Bruce D Meyer. 2000. "The Effects of the Unemployment Insurance Payroll Tax on Wages, Employment, Claims and Denials." *Journal of Public Economics*, 78(1-2): 81–106.

Bagger, Jesper, and Rasmus Lentz. 2019. "An Empirical Model of Wage Dispersion With Sorting." *Review of Economic Studies*, 86(1): 153–190.

Benzarti, Youssef, and Jarkko Harju. 2021. "Using Payroll Tax Variation to Unpack the Black Box of Firm-Level Production." *Journal of the European Economic Association*, 19(5): 2737–2764.

Berger, David, Kyle Herkenhoff, and Simon Mongey. 2022. "Labor Market Power." *American Economic Review*, 112(4): 1147–93.

Bewley, Truman F. 1998. "Why Not Cut Pay?" *European Economic Review*, 42(3-5): 459–490.

Bilbiie, Florin O, Fabio Ghironi, and Marc J Melitz. 2012. "Endogenous Entry, Product Variety, and Business Cycles." *Journal of Political Economy*, 120(2): 304–345.

Blanchflower, David G. 2021. *Not Working: Where Have All the Good Jobs Gone?* Princeton University Press.

Bontemps, Christian, Jean-Marc Robin, and Gerard J Van den Berg. 1999. "An Empirical Equilibrium Job Search Model with Search on the Job and Heterogeneous Workers and Firms." *International Economic Review*, 40(4): 1039–1074.

Bontemps, Christian, Jean-Marc Robin, and Gerard J Van den Berg. 2000. "Equilibrium Search with Continuous Productivity Dispersion: Theory and Nonparametric Estimation." *International Economic Review*, 41(2): 305–358.

Boockmann, Bernhard, Thomas Zwick, Andreas Ammermüller, and Michael Maier. 2012. "Do Hiring Subsidies Reduce Unemployment Among Older Workers? Evidence from Natural Experiments." *Journal of the European Economic Association*, 10(4): 735–764.

Bozio, Antoine, Thomas Breda, and Julien Grenet. 2019. "Does Tax-Benefit Linkage Matter for the Incidence of Social Security Contributions?" IZA Discussion Paper 12502.

Burdett, Kenneth, and Dale T Mortensen. 1989. "Equilibrium Wage Differentials and Employer Size." Northwestern University Center for Mathematical Studies in Economics and Management Science Discussion Paper 860.

Burdett, Kenneth, and Dale T Mortensen. 1998. "Wage Differentials, Employer Size, and Unemployment." *International Economic Review*, 257–273.

Cahuc, Pierre, Fabien Postel-Vinay, and Jean-Marc Robin. 2006. "Wage Bargaining with On-the-Job Search: Theory and Evidence." *Econometrica*, 74(2): 323–364.

Caldwell, Sydnee, and Emily Oehlsen. 2018. "Monopsony and the Gender Wage Gap: Experimental Evidence from the Gig Economy." *Mimeo.*

Caldwell, Sydnee, Ingrid Haegele, and Jörg Heining. 2024. "Bargaining and Inequality in the Labor Market." *Mimeo.*

Carbonnier, Clément, Clément Malgouyres, Loriane Py, and Camille Urvoy. 2022. "Who Benefits from Tax Incentives? The Heterogeneous Wage Incidence of a Tax Credit." *Journal of Public Economics*, 206(1): 104577.

Card, David, Ana Rute Cardoso, Joerg Heining, and Patrick Kline. 2018. "Firms and Labor Market Inequality: Evidence and Some Theory." *Journal of Labor Economics*, 36(S1): S13–S70.

Card, David, Jörg Heining, and Patrick Kline. 2013. "Workplace Heterogeneity and the Rise of West German Wage Inequality." *Quarterly Journal of Economics*, 128(3): 967–1015.

Cengiz, Doruk, Arindrajit Dube, Attila Lindner, and Ben Zipperer. 2019. "The Effect of Minimum Wages on Low-Wage Jobs." *Quarterly Journal of Economics*, 134(3): 1405–1454.

Chandola, Tarani, and Nan Zhang. 2018. "Re-employment, Job Quality, Health and Allostatic Load Biomarkers: Prospective Evidence From the UK Household Longitudinal Study." *International Journal of Epidemiology*, 47: 47–57.

Cseres-Gergely, Zsombor, and György Molnár. 2015. "Public Works Programmes in the Public Employment System, 2011-2013–Basic Facts." In *The Hungarian Labour Market 2015*. 148–159. Centre for Economic and Regional Studies Institute of Economics.

Di Addario, Sabrina, Patrick Kline, Raffaele Saggio, and Mikkel Sølvsten. 2023. "It Ain't Where You're From, It's Where You're At: Hiring Origins, Firm Heterogeneity, and Wages." *Journal of Econometrics*, 233(2): 340–374.

Egebark, Johan, and Niklas Kaunitz. 2018. "Payroll Taxes and Youth Labor Demand." *Labour Economics*, 55(1): 163–177.

Fuest, Clemens, Andreas Peichl, and Sebastian Siegloch. 2018. "Do Higher Corporate Taxes Reduce Wages? Micro Evidence from Germany." *American Economic Review*, 108(2): 393–418.

Garin, Andrew, and Filipe Silvério. 2023. "How Responsive Are Wages to Firm-Specific Changes in Labour Demand? Evidence from Idiosyncratic Export Demand Shocks." *Review of Economic Studies*, Forthcoming.

Gruber, Jonathan. 1997. "The Incidence of Payroll Taxation: Evidence from Chile." *Journal of Labor Economics*, 15(3): S72–S101.

Hall, Robert E, and Alan B Krueger. 2012. "Evidence on the Incidence of Wage Posting, Wage Bargaining, and On-the-Job Search." *American Economic Journal: Macroeconomics*, 4(4): 56–67.

Hendren, Nathaniel, and Ben Sprung-Keyser. 2020. "A Unified Welfare Analysis of Government Policies." *Quarterly Journal of Economics*, 135(3): 1209–1318.

Hicks, John. 1932. *The Theory of Wages.* London: Macmillan.

Hungarian Central Statistical Office. 2022. "Real Earnings (1992-)." `https://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_qli042.html`.

Huttunen, Kristiina, Jukka Pirttilä, and Roope Uusitalo. 2013. "The Employment Effects of Low-Wage Subsidies." *Journal of Public Economics*, 97(1): 49–60.

Jäger, Simon, Benjamin Schoefer, Samuel Young, and Josef Zweimüller. 2020. "Wages and the Value of Nonemployment." *Quarterly Journal of Economics*, 135(4): 1905–1963.

Kaminski, Bartlomiej. 1999. "Hungary's Integration into European Union Markets: Production and Trade Restructuring." World Bank Policy Research Working Paper 2135.

Katz, Lawrence F, and Lawrence H Summers. 1989. "Industry Rents: Evidence and Implications." *Brookings Papers on Economic Activity: Microeconomics*, 1989: 209–290.

Kline, Patrick, Neviana Petkova, Heidi Williams, and Owen Zidar. 2019. "Who Profits from Patents? Rent-Sharing at Innovative Firms." *Quarterly Journal of Economics*, 134(3): 1343–1404.

Kramarz, Francis, and Thomas Philippon. 2001. "The Impact of Differential Payroll Tax Subsidies on Minimum Wage Employment." *Journal of Public Economics*, 82(1): 115–146.

Kugler, Adriana, and Maurice Kugler. 2009. "Labor Market Effects of Payroll Taxes in Developing Countries: Evidence from Colombia." *Economic Development and Cultural Change*, 57(2): 335–358.

Ku, Hyejin, Uta Schönberg, and Ragnhild C Schreiner. 2020. "Do Place-Based Tax Incentives Create Jobs?" *Journal of Public Economics*, 191(1): 104105.

Kushnir, Alexey, Alexander Tarasov, and Robertas Zubrickas. 2021. "On Equilibrium in Monopolistic Competition with Endogenous Labor." *Economics Letters*, 201: 109774.

Lamadon, Thibaut, Magne Mogstad, and Bradley Setzler. 2022. "Imperfect Competition, Compensating Differentials, and Rent Sharing in the US Labor Market." *American Economic Review*, 112(1): 169–212.

Laun, Lisa. 2017. "The Effect of Age-Targeted Tax Credits on Labor Force Participation of Older Workers." *Journal of Public Economics*, 152(1): 102–118.

Melitz, Marc J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica*, 71(6): 1695–1725.

Moscarini, Giuseppe, and Fabien Postel-Vinay. 2018. "On the Job Search and Business Cycles." IZA Discussion Paper 11853.

OECD. 2022*a*. "Taxing Wages 2022." https://www.oecd.org/tax/taxing-wages-20725124.htm.

OECD. 2022*b*. "Employment and Labour Market Statistics." https://www.oecd-ilibrary.org/employment/data/oecd-employment-and-labour-market-statistics_lfs-data-en.

OECD. 2022*c*. "Enterprises by Business Size." https://data.oecd.org/entrepreneur/enterprises-by-business-size.htm.

Postel-Vinay, Fabien, and Jean-Marc Robin. 2002. "Equilibrium Wage Dispersion With Worker and Employer Heterogeneity." *Econometrica*, 70(6): 2295–2350.

Rodrik, Dani, and Charles F Sabel. 2022. "Building a Good Jobs Economy." In *A Political Economy of Justice.* , ed. Danielle Allen, Yochai Benkler, Leah Downey, Rebecca Henderson and Josh Simons, 61–95. Chicago:University of Chicago Press.

Rodrik, Dani, and Stefanie Stantcheva. 2021. "Fixing Capitalism's Good Jobs Problem." *Oxford Review of Economic Policy*, 37(4): 824–837.

Rothstein, Jesse. 2010. "Is the EITC as Good as an NIT? Conditional Cash Transfers and Tax Incidence." *American Economic Journal: Economic Policy*, 2(1): 177–208.

Rovigatti, Gabriele, and Vincenzo Mollisi. 2020. "PRODEST: Stata Module for Production Function Estimation Based on the Control Function Approach." Boston College Department of Economics Statistical Software Components S458239.

Saez, Emmanuel, Benjamin Schoefer, and David Seim. 2019. "Payroll Taxes, Firm Behavior, and Rent Sharing: Evidence from a Young Workers' Tax Cut in Sweden." *American Economic Review*, 109(5): 1717–63.

Saez, Emmanuel, Manos Matsaganis, and Panos Tsakloglou. 2012. "Earnings Determination and Taxes: Evidence from a Cohort-Based Payroll Tax Reform in Greece." *Quarterly Journal of Economics*, 127(1): 493–533.

Saygin, Perihan Ozge, Andrea Weber, and Michèle A Weynandt. 2021. "Coworkers, Networks, and Job-Search Outcomes Among Displaced Workers." *ILR Review*, 74(1): 95–130.

Svraka, András. 2019. "The Effect of Labour Cost Reduction on Employment of Vulnerable Groups." *Public Finance Quarterly*, 64(1): 72–92.

Tonin, Mirco. 2009. "Employment Protection Legislation in Central and East European Countries." *SEER-South-East Europe Review for Labour and Social Affairs*, 12(4): 477–491.

US Bureau of Labor Statistics. 2022. "Usual Weekly Earnings of Wage and Salary Workers, Second Quarter 2022." https://www.bls.gov/news.release/wkyeng.nr0.htm.

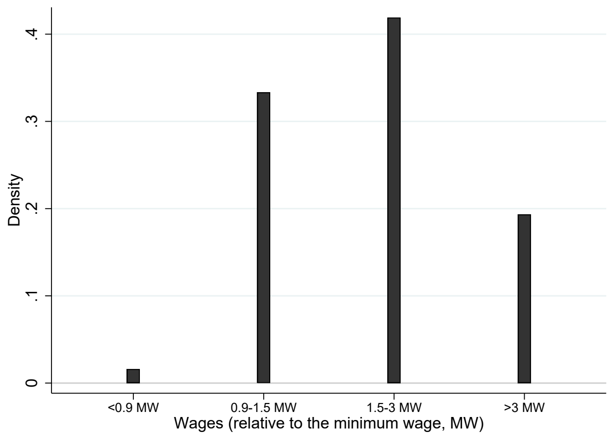
Wooldridge, Jeffrey M. 2009. "On Estimating Firm-Level Production Functions Using Proxy Variables to Control for Unobservables." *Economics Letters*, 104(3): 112–114.

Online Appendix

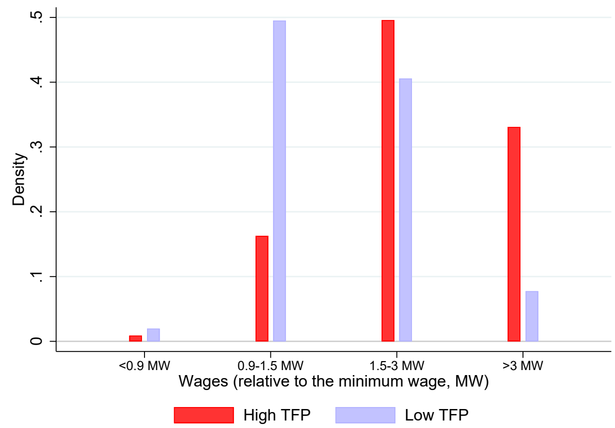
A Additional Figures and Tables

Appendix Figure A1: The Wage Distribution of Private Sector Workers

(a) All



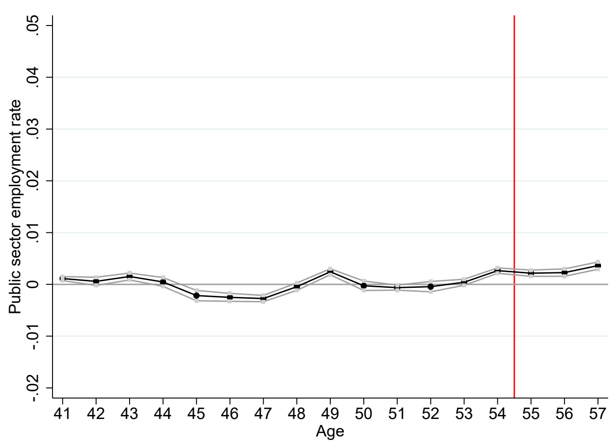
(b) By TFP



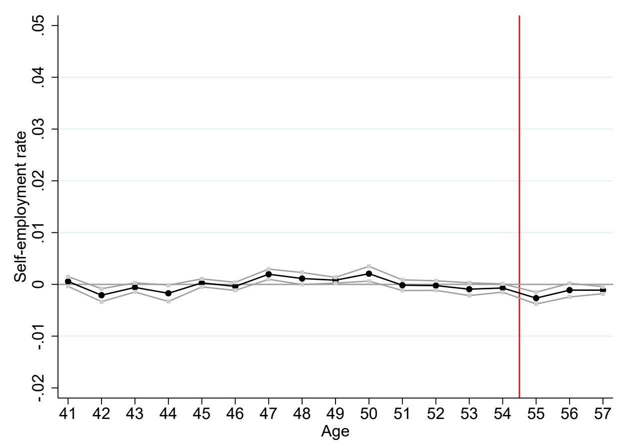
Note: Figure shows the density of workers aged 52-57 working at private sector companies (our main sample). We plot wage categories relative to the minimum wage. Panel (a) shows the distribution at all private sector firms. Panel (b) shows the distribution separately for workers at high-productivity (above-median TFP) firms (in red) and at low-productivity (below-median TFP) firms (in blue).

Appendix Figure A2: Change in Employment in Sectors Unaffected by the Tax Cut

(a) Public Sector Employment Rate

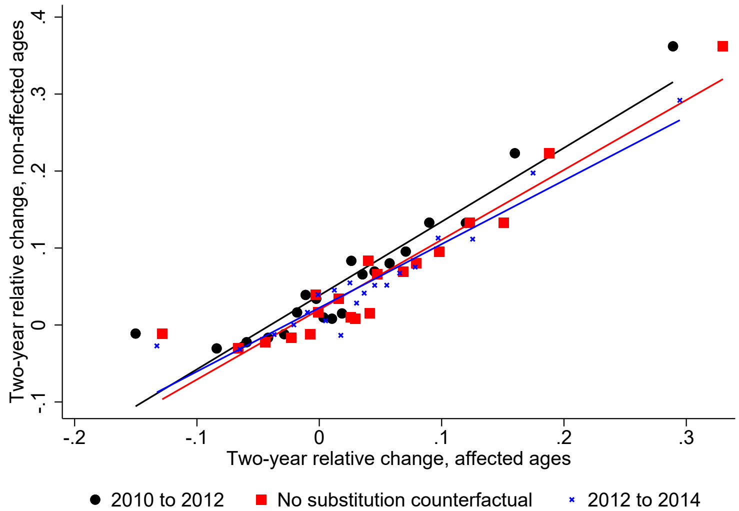


(b) Self-Employment Rate



Note: Figure shows the public sector employment rate in Panel (a) and the self-employment rate in Panel (b) by age before and after the introduction of the age-specific payroll tax cut affecting only private sector firms. The figure shows the difference in employment rates between years 2012 and 2013-2015 relative to the average change between ages 41 and 54, with the 95% confidence interval (standard errors clustered at the age × period level). The vertical red line shows the age threshold where the tax cut was effective for private sector workers. At the same time, nothing was changed at that age threshold for public sector workers or the self-employed.

Appendix Figure A3: Relationship between Firm-Level Employment Change in Affected Age Groups and Non-affected Age Groups



Note: Figure shows the relationship between firm-level two-year employment change in affected age groups and non-affected age groups before the introduction of the payroll tax cut (2010 to 2012, in black) and after the introduction of the payroll tax cut (2012 to 2014, in blue). 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 (affected 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 (unaffacted ages). We exclude firms with less than 10 workers and firms that are not in the sample throughout years 2010-2014. We show a binned scatterplot 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 cut). The blue dots and line refer to relative change from 2012 to 2014 (with the tax cut being introduced in 2013). The red squares and line correspond to a counterfactual scenario where we increase the 2012 employment in the affected age groups by 14.7%, which is the average firm-level employment change from 2012 to 2014, while employment changes in the unaffected ages are left at their 2010 to 2012 values. This later estimate, therefore, shows the relationship that would emerge if the 2010-2012 employment in the affected age groups increased as estimated, and firms did not substitute unaffected workers with affected workers by cutting their employment.

Appendix Figure A4: Firm-level Effects of Payroll Tax Cuts

Note: Figure replicates the basic results of Saez, Schoefer and Seim (2019). Using 2012 data, we calculate the firm-level exposure to the tax cut defined as the total tax cut based on workers aged 55 and above at the firm relative to the total payroll of the firm. We calculate the quartiles of the exposure, excluding firms with zero exposure, and group firms into three categories. "Low exposure" firms have either zero tax cut or belong to the bottom quartile. "Medium exposure" firms belong to the middle two quartiles. "High exposure" firms belong to the the top quartile. We compare the evolution of various outcomes of the firms in these groups, focusing on the medium and high exposure groups. Panel (a) shows the average exposure to the tax cut. Panel (b) shows firm size. Panel (c) shows average net wage. Panel (d) shows sales revenue.

Appendix Table A1: Employment Rate in the Administrative Data and in the Labor Force Survey

	(1) Administrative data	(2) Labor Force Survey
Panel A: Private and public sector		
Including self-employment	60.1%	61.6%
Excluding self-employment	49.4%	51.8%
Panel B: Private sector (excluding self-employment)		
All private sector firms	41.9%	
Double-entry bookkeeping firms	36.2%	
Double-entry bookkeeping firms with at most 10,000 employees	33.0%	

Note: Table reports employment rates in the non-retired population of men aged 52-57 in 2012. Column (1) reports employment rates based on the linked employer-employee administrative data used in this paper. Column (2) reports employment rates based on the Labor Force Survey (LFS) of the Hungarian Central Statistical Office, which is the European equivalent of the Current Population Survey (CPS). Panel A shows employment rates in the private and public sectors with and without the self-employed. Panel B shows private sector employment in all firms, double-entry bookkeeping firms, and double-entry bookkeeping firms with at most 10,000 employees. It displays statistics only based on the administrative data because civil servants and the type of the firm cannot be identified in the LFS. The employment category in the last row corresponds to the employment definition we use in this paper.

Appendix Table A2: Employment Effects of the Tax Cut for All Private Sector Firms and for Firms with Double-entry Bookkeeping

	(1)	(2)	(3)
		Employment	
	All firms	Low TFP	High TFP
Panel A: Double-entry bookkeeping firms, excluding firms with more than 10,000 workers	0.0053***	0.0053***	-0.0001
	[0.0005]	[0.0005]	[0.0004]
	⟨0.330⟩	⟨0.167⟩	⟨0.163⟩
Panel B: All firms, including single-entry bookkeping firms and firms with more than 10,000 workers	0.0096***	0.0094***	0.0003
	[0.0006]	[0.0006]	[0.0004]
	⟨0.409⟩	⟨0.227⟩	⟨0.181⟩

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on private sector employment for all firms (column 1) and separately for below-median (column 2) and above-median (column 3) TFP firms. We report the β coefficient from regression equation (1). In angle brackets we report the mean of these outcome variables in May 2012—the probability of being employed in a given subgroup and type of firm. The β coefficient compares the change in employment among the 55 to 57 age group that was affected by the payroll tax cut relative to the change in employment among the 52 to 54 age group that was not affected by the tax cut. In Panel A, we report the results for the baseline category of private sector employment (excluding firms with more than 10,000 workers). In Panel B, we report the results for all firms, assuming that all single-entry bookkeping firms (for which firms the TFP is not observed) are below-median TFP firms. Standard errors are reported in brackets, clustered at the age × period level. ($N = 9,003,984$ individual-months)

Appendix Table A3: Employment Effects of the Tax Cut: Extensive Margin Employment Decisions

	(1)	(2)	(3)
	All firms	Low TFP	High TFP
Panel A: Change in the probability of employment			
— $After \times Treated$	0.0054***	0.0053***	0.0001
	[0.0005]	[0.0005]	[0.0004]
Panel B: Percent change in employment			
—Employment without tax cut	0.342	0.176	0.176
—Employment with tax cut	0.347	0.182	0.182
—Percent change in employment	1.58%	3.00%	0.05%
Panel C: Percent change in labor cost $(1 + \tau_{ss})$			
—Labor cost without tax cut	1.27	1.26	1.28
—Labor cost with tax cut	1.20	1.18	1.22
—Percent change in labor cost	-5.27%	-6.02%	-4.45%
Panel D: Implied elasticity (Panel B/Panel C)			
—Elasticity based on percent change in labor cost	-0.30	-0.50	-0.01
	[0.03]	[0.05]	[0.06]
Panel E: Elasticity based on net present value			
—Percent change in net present value of labor cost	-7.49%	-8.82%	-5.98%
—Implied elasticity	-0.21	-0.34	-0.01
	[0.02]	[0.03]	[0.04]

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

Note: Table shows the employment effect of the tax cut as in Table 3 with the difference that we focus on extensive margin employment decisions (whether to work or not) without taking into account working hours. ($N = 9,003,984$ individual-months)

Appendix Table A4: Employment Effects of the Tax Cut: Excluding Elementary Occupations From Employment Definition

	(1) All firms	(2) Low TFP	(3) High TFP
Panel A: Baseline employment definition			
Employment effect	0.0053***	0.0053***	-0.0001
	[0.0005]	[0.0005]	[0.0004]
Implied elasticity	-0.30	-0.53	0.01
	[0.03]	[0.05]	[0.06]
Panel B: Employment excluding elementary occupations			
Employment effect	0.0063***	0.0063***	-0.0000
	[0.0006]	[0.0005]	[0.0005]
Implied elasticity	-0.41	-0.73	0.00
	[0.04]	[0.06]	[0.07]

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on employment. Panel A shows the baseline results. In Panel B only employment in non-elementary occupations is considered. This is motivated by the fact that workers in elementary occupations were eligible for the tax cut independently of their age. We estimate the impact of the reform using regression (1). In particular, we report the β coefficient and estimate the regression with the outcome variable being employed at a private sector firm (column 1), at a private sector firm with below-median TFP (column 2), and at a private sector firm with above-median TFP (column 3). The β coefficient estimates the change in employment among the 55 to 57 age group that was affected by the payroll tax cut relative to the change in employment among the 52 to 54 age group that was not affected by the tax cut. Standard errors are reported in brackets, clustered at the age $\times$ period level. ($N = 9,003,984$ individual-months in both panels)

Appendix Table A5: Employment Effects of the Tax Cut: Alternative Sample Definitions

	(1) All firms	(2) Low TFP	(3) High TFP
Panel A: Baseline sample			
Employment effect	0.0053***	0.0053***	-0.0001
	[0.0005]	[0.0005]	[0.0004]
Implied elasticity	-0.30	-0.53	0.01
	[0.03]	[0.05]	[0.06]
Panel B: Sample with retirees			
Employment effect	0.0065***	0.0062***	-0.0001
	[0.0005]	[0.0004]	[0.0004]
Implied elasticity	-0.37	-0.64	0.01
	[0.03]	[0.05]	[0.06]

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on employment under different sample definitions. Panel A replicates the baseline results reported in Panel A of Table 3. Panel B shows the same estimates with retirees included in the sample. In both panels we estimate the impact of the reform using regression (1). In particular, we report the β coefficient and estimate the regression with the outcome variable being employed at a private sector firm (column 1), at a private sector firm with below-median TFP (column 2), and at a private sector firm with above-median TFP (column 3). The β coefficient estimates the change in employment among the 55 to 57 age group that was affected by the payroll tax cut relative to the change in employment among the 52 to 54 age group that was not affected by the tax cut. Standard errors are reported in brackets, clustered at the age $\times$ period level. ($N = 9,003,984$ individual-months in Panel A, $N = 9,482,667$ individual-months in Panel B)

Appendix Table A6: The Effect of the Tax Cut on Labor Market Status

	(1)
Private sector employment (41%)	0.0096***
	[0.0006]
Public sector employment (6.2%)	0.0016***
	[0.0003]
Self-employment (9.7%)	-0.0014***
	[0.0003]
Inactive/unemployed (42%)	-0.0101***
	[0.0007]

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

Note: Table shows the impact of the payroll tax cut on labor market status. Labor market status is determined based on four mutually exclusive categories: all type of private sector employment (41% of the 52-57 years old), public sector employment (6.2% of the 52-57 years old), self-employment (9.7% of the 52-57 years old) and inactivity/unemployment (42% of the 52-57 years old). To make sure that these categories are mutually exclusive, private sector employment (contrary to the benchmark analysis) also includes single-entry bookkeeping firms and firms with more than 10,000 workers (see Section 3.2 and for separate estimates for these firm categories see Table A2). The population share of each labor market status category is reported in parentheses. We report the difference-in-difference estimates from equation (1) using being employed in the private sector (row 1), being employed in the public sector (row 2), being self-employed (row 3) and being inactive or unemployed (row 4) as the outcome variable. The difference-in-differences estimate compares the change in the outcome variable among the 55 to 57 age group that was affected by the payroll tax cut relative to the change in the outcome variable among the 52 to 54 age group that was not affected by the tax cut. Standard errors are reported in brackets, clustered at the age × period level. ($N = 9,003,984$ individual-months)

Appendix Table A7: Employment Effects of the Tax Cut: Short-run Estimates

	(1) Employment, baseline	(2) Employment, TFP	(3) Employment, PI	(4) Employment, foreign ownership	(5) Employment, firm-level wage	(6) Employment, AKM FE
All firms	0.0029***					
	[0.0005]					
Low-quality firms		0.0045***	0.0024***	0.0035***	0.0032***	0.0036***
		[0.0004]	[0.0005]	[0.0004]	[0.0003]	[0.0004]
High-quality firms		-0.0016***	0.0005	-0.0006	-0.0003	-0.0007
		[0.0005]	[0.0007]	[0.0003]	[0.0005]	[0.0006]

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

Note: Table shows difference-in-differences estimates of the short-run impact of the payroll tax cut on private sector employment. Column (1) and (2) replicate the analysis in Panel A of Table 3, but restrict the sample to the period between 2012 (the year before the policy change) and 2013 (the year after the policy change) instead of focusing on the period between 2012 and 2015 as in Table 3). We estimate the impact of the reform using regression (1). In particular, we report the β coefficient and estimate the regression with the outcome variable being employed at a private sector firm (row 1), at a low-quality private sector firm (row 2) and at a high-quality private sector firm (row 3). Columns (3)-(6) report robustness to using different quality measures. In column (3) we measure firm quality based on the poaching index (PI), reflecting the fraction of new hires poached from other firms instead of coming from unemployment. Column (4) reports estimates by ownership. In Hungary foreign-owned firms offer the highest-paying, highest-quality jobs. In column (5) we measure firm quality by the average wage the firms pays. Finally, in column (6) we measure firm quality based on the firm-level wage premium estimated using an Abowd, Kramarz, Margolis (AKM) style decomposition. Standard errors are reported in brackets, clustered at the age × period level. ($N = 4,711,215$ individual-months)

Appendix Table A8: Employment and Wage Effects of the Tax Cut: Robustness to Using Measures of Firm-Quality Based on Pre-Reform Years

Panel A: Employment	(1)	(2)	(3)	(4)	(5)
Firm quality uses pre-reform years only	TFP	PI	Foreign ownership	Firm-level wage	AKM FE
Low-quality firms	0.0059***	0.0060***	0.0062***	0.0040***	0.0032***
	[0.0005]	[0.0005]	[0.0004]	[0.0003]	[0.0004]
High-quality firms	-0.0006	-0.0009	-0.0008**	0.0013***	0.0010**
	[0.0005]	[0.0006]	[0.0003]	[0.0004]	[0.0004]
Panel B: Log(wage), pass-through rate					
Firm quality uses pre-reform years only	TFP	PI	Foreign ownership	Firm-level wage	AKM FE
Low-quality firms	-0.094	0.053	-0.105	0.219*	-0.113
	[0.119]	[0.085]	[0.139]	[0.113]	[0.078]
High-quality firms	0.547***	0.610***	1.236***	1.103***	1.019***
	[0.108]	[0.123]	[0.180]	[0.200]	[0.224]

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on employment and wages, assessing robustness to defining firm quality using only pre-reform years (instead of all years). Panel A shows the effect of tax cut on employment and Panel B on wages. TFP, firm-level wage and foreign ownership are defined based on year 2012. The poaching index (PI) and AKM firm fixed effects are estimated using all pre-policy years (2003 and 2012). In Panel A we report the β coefficient from regression equation (1). In Panel B we report the pass-through rate. The pass-through rate at low-productivity firms is the β_1 coefficient on the Post × Treated × TCR term in equation (5), while at the high-productivity firms it is the sum of that coefficient and the β_3 coefficient on High-quality × Post × Treated × TCR in equation (5). Standard errors are reported in brackets, clustered at the age × period level.

Appendix Table A9: Wage Effects of the Tax Cut by Various Firm Quality Indicators

	(1) log(wage)	(2) log(wage)	(3) log(wage)	(4) log(wage)	(5) log(wage)
Post × Treated	0.008	-0.005	0.003	-0.004	0.010
	[0.007]	[0.012]	[0.011]	[0.016]	[0.020]
Post × Treated × TCR	-0.077	0.058	-0.042	0.030	-0.115
	[0.070]	[0.108]	[0.101]	[0.139]	[0.167]
High-quality × Post × Treated	-0.046***	-0.032***	-0.068***	-0.054***	-0.072***
	[0.013]	[0.004]	[0.014]	[0.008]	[0.014]
High-quality × Post × Treated × TCR	0.678***	0.464***	1.179***	0.963***	1.235***
	[0.137]	[0.056]	[0.211]	[0.051]	[0.160]
Pass-through rate					
Low-quality	-0.077	0.058	-0.042	0.030	-0.115
	[0.070]	[0.108]	[0.101]	[0.139]	[0.167]
High-quality	0.602***	0.521***	1.137***	0.993***	1.119***
	[0.131]	[0.113]	[0.211]	[0.167]	[0.233]
Observations	97,789	97,789	97,789	97,789	97,789
Quality measure	TFP	PI	foreign-owned	firm-level wage	AKM FE

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on private sector wages based on estimating equation (5). In each column, we interact all coefficients with an indicator for whether the firm is high quality (above-median with respect to the given quality measure or foreign-owned). In all columns we show the wage changes for all incumbent workers and we focus on full-time workers. In all columns we compare the wage changes between 2012 and 2013 to the wage changes between 2011 and 2012. In column (1) we repeat the results using TFP as a measure of quality reported in column (3) of Table 5. In column (2) we measure quality based on the poaching index (PI), reflecting the fraction of new hires poached from other firms instead of coming from unemployment. In column (3) we measure quality based on ownership. In Hungary foreign-owned firms are the most productive firms offering the highest-paying, highest-quality jobs. In column (4) we measure firm quality by the average wage the firms pays. Finally, in column (5) we measure firm quality based on the firm-level wage premium estimated using an Abowd, Kramarz, Margolis (AKM) style decomposition. The pass-through rate is calculated as in Table 5. Standard errors are reported in brackets, clustered at the age × period level.

Appendix Table A10: Employment and Wage Effects of the Tax Cut: Robustness to Classification of Firms Based on Within-Industry TFP Variation

	(1)	(2)	(3)	(4)
	Baseline		Net of industry composition	
	Low TFP	High TFP	Low TFP	High TFP
Panel A: Employment				
Employment effect	0.0053***	-0.0001	0.0041***	-0.0002
	[0.0005]	[0.0004]	[0.0005]	[0.0006]
Implied elasticity	-0.53	0.01	-0.40	0.03
	[0.05]	[0.06]	[0.05]	[0.10]
Observations	9,003,984	9,003,984	9,003,984	9,003,984
Panel B: Log(wage)				
Pass-through rate	-0.077	0.602***	-0.011	0.457***
	[0.070]	[0.131]	[0.074]	[0.140]
Observations	97,789	97,789	97,789	97,789

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on employment and wages, assessing the effect of using only within industry total factor productivity variations when we classify firms to low and high TFP. Panel A shows the effect of tax cut on employment and Panel B on wages. In Panel A we report the β coefficient from regression equation (1). In Panel B we report the pass-through rate. The pass-through rate at low-productivity firms is the β_1 coefficient on the Post $\times$ Treated $\times$ TCR term in equation (5), while at the high-productivity firms it is the sum of that coefficient and the β_3 coefficient on High-quality $\times$ Post $\times$ Treated $\times$ TCR in equation (5). Columns (1) and (2) repeat the baseline results from Tables 3 and 5. In columns (3) and (4), the median TFP is based on the residualized TFP from a linear regression of TFP on level 1 industry codes. As a result, the industry composition among low and high TFP firms will be similar. Standard errors are reported in brackets, clustered at the age $\times$ period level.

Appendix Table A11: Employment Effects of the Tax Cut: Heterogeneity by Firm Size

	(1)	(2)	(3)
		Employment	
	All firms	Low TFP	High TFP
Firms with 1-49 workers	0.0015***	0.0015***	0.0001
	[0.0004]	[0.0003]	[0.0002]
	{39%}	{33%}	{6%}
	⟨0.1272⟩	⟨0.1074⟩	⟨0.0198⟩
Firms with 50+ workers	0.0036***	0.0035***	0.0001
	[0.0005]	[0.0003]	[0.0005]
	{61%}	{18%}	{43%}
	⟨0.2021⟩	⟨0.0608⟩	⟨0.1413⟩

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on employment separately for micro and small-sized firms (1-49 workers) and medium and large firms (50+ workers). In the top row we report the β coefficient from regression equation (1) with the outcome variable being whether someone is employed at a micro/small sized firm, at a micro/small sized firm with below-median (column 2) or above-median (column 3) TFP. In the bottom row we report the β coefficient from regression equation (1) with the outcome variable being whether someone is employed at a medium/large sized firm, at a medium/large sized firm with below-median (column 2) or above-median (column 3) TFP. In curly brackets, we show the share of individuals working at different sized (and different productivity) firms, while in angle brackets we show the mean of the outcome variable in May 2012. Standard errors are reported in brackets, clustered at the age $\times$ period level. ($N = 9,003,984$ individual-months)

Appendix Table A12: Employment Effects of the Tax Cut for New Entrant and Incumbent Workers and Firms

	(1)	(2)	(3)
		Employment	
	All firms	Low TFP	High TFP
Panel A: New entrant or incumbent workers			
New entrant workers	0.0015***	0.0014***	0.0001
	[0.0002]	[0.0002]	[0.0001]
	⟨0.0425⟩	⟨0.0267⟩	⟨0.0159⟩
Incumbent workers	0.0038***	0.0039***	-0.0001
	[0.0005]	[0.0004]	[0.0004]
	⟨0.2873⟩	⟨0.1409⟩	⟨0.1464⟩
Panel B: New entrant or incumbent firms			
New entrant firms	0.0001	0.0002*	-0.0001***
	[0.0001]	[0.0001]	[0.00004]
	⟨0.0054⟩	⟨0.0045⟩	⟨0.0008⟩
Incumbent firms	0.0052***	0.0051***	0.0001
	[0.0005]	[0.0005]	[0.0004]
	⟨0.3247⟩	⟨0.1625⟩	⟨0.1622⟩
Panel C: Firms established before or after 2012			
Firms established after 2012	-0.0001	0.0002*	-0.0003***
	[0.0001]	[0.0001]	[0.0001]
	⟨0⟩	⟨0⟩	⟨0⟩
Firms existed in 2012	0.0053***	0.0051***	0.0002
	[0.0004]	[0.0004]	[0.0004]
	⟨0.3301⟩	⟨0.1670⟩	⟨0.1631⟩

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

Note: Table shows difference-in-differences based on equation (1). In Panel A we study the change in employment for new entrants, who entered the labor market in the current year and so have less than 12 months employment, and for incumbent workers who have been continuously employed in the previous 12 months. In panel B we study the impact separately for new entrant firms, which were established in the current year and incumbent firms, which already existed in the previous year. In panel C we study separately the employment change at firms that existed before the payroll tax cut and at firms that were established after the payroll tax cut. In each panel the sum of new entrants and incumbents adds up to total employment and the employment rate in each of these categories (relative to the total population) in May 2012 is shown in angle brackets. In panel C the employment rate is zero because there is no employment in May 2012 at firms established after 2012. Standard errors are reported in brackets, clustered at the age × period level. ($N = 9,003,984$ individual-months)

Appendix Table A13: Wage Effects of the Tax Cut: Heterogeneity by Firm Size

	(1)	(2)
	log(wage)	log(wage)
Post × Treated	-0.002	0.020
	[0.016]	[0.016]
Post × Treated × TCR	0.028	-0.234
	[0.136]	[0.174]
High TFP × Post × Treated	-0.027	-0.061***
	[0.034]	[0.017]
High TFP × Post × Treated × TCR	0.422	0.889***
	[0.285]	[0.167]
Pass-through rate		
Low TFP	0.028	-0.234
	[0.136]	[0.174]
High TFP	0.450	0.653***
	[0.290]	[0.128]
Observations	35,862	61,861
Firm size	1-49 workers,	50+ workers

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

Note: Table shows difference-in-differences estimates based on equation (5). In column (1), the sample is restricted to workers employed at micro and small-sized firms (1-49 workers). In column (2), the sample is restricted to workers employed at medium and large firms (50+ workers). In both columns we show the wage changes for all incumbent workers and we focus on full-time workers. In both columns we compare the wage changes between 2012 and 2013 to the wage changes between 2011 and 2012. The pass-through rate is calculated as in Table 5

Appendix Table A14: Employment Effects of the Tax Cut: Heterogeneity by Local Labor Market Conditions

	(1)	(2)
	Employment	
	Low TFP	High TFP
Panel A: By unemployment rate		
Districts with below-median unemployment rate in 2012	0.0055***	-0.0014**
	[0.0008]	[0.0007]
	⟨0.1807⟩	⟨ 0.2040⟩
Observations	3,603,336	3,603,336
Districts with above-median unemployment rate in 2012	0.0065***	-0.0003
	[0.0008]	[0.0008]
	⟨0.1706⟩	⟨0.1315⟩
Observations	3,938,028	3,938,028
Panel B: By change in labor market conditions		
Districts with stable labor market conditions	0.0050***	-0.0005
	[0.0005]	[0.0005]
	⟨0.1650⟩	⟨0.1585⟩
Observations	5,278,340	5,278,340
Districts with improving labor market conditions	0.0051***	0.0011
	[0.0007]	[0.0008]
	⟨0.1718⟩	⟨ 0.1601⟩
Observations	4,400,856	3,421,239
Panel C: By share of older workers		
Districts with below-median ratio of aged 55-57	0.0054***	-0.0007
	[0.0006]	[0.0006]
	⟨0.1538⟩	⟨0.1662⟩
Observations	4,287,445	4,287,445
Districts with above-median ratio of aged 55-57	0.0050***	0.0009*
	[0.0007]	[0.0004]
	⟨0.1808⟩	⟨0.1583⟩
Observations	4,716,539	4,716,539

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

Note: Table explores the heterogeneity in the employment effects of the tax cut by local labor market characteristics. In Panel A, the employment changes are studied separately for districts with below- and above-median unemployment rates in 2012. The mean unemployment rate was 8.6% in districts with below-median unemployment rate and 18.3% in districts with above-median unemployment rate. In Panel B, we study the employment effects of the tax cut separately in stable and in improving labor markets. In districts with stable labor market conditions, the change in private sector employment rate between 2012 and 2015 was between -2 and +2 percentage points, with a mean of 0.1 percentage point. In districts with improving labor market conditions, the change in private sector employment rate between 2012 and 2015 was above +2 percentage points, with a mean of 3 percentage points. We exclude here the few deteriorating labor markets with more than -2 percentage points decline in private sector employment rate. In Panel C, we show employment effects separately for districts with below- and above-median shares of men aged 55 and 57 within the male population in 2012. The mean share was 0.074 in districts with a below-median share and 0.085 in districts with an above-median share. In each panel, and for each region, we apply the same difference-in-differences estimate as in Panel A of Table 3. In particular, we report the β coefficient from regression equation (1) with the outcome variable being employed at a private sector firm with below-median productivity (column 1) and at a private sector firm with above-median productivity (column 2). In angle brackets, we show the mean of the outcome variable in May 2012. Standard errors are reported in brackets, clustered at the age $\times$ period level.

Appendix Table A15: Wage Effects of the Tax Cut, Using Lagged Firm Quality Measures

	(1) log(wage)	(2) log(wage)	(3) log(wage)	(4) log(wage)
Post × Treated	0.008	0.022***	-0.026***	0.011
	[0.005]	[0.007]	[0.006]	[0.013]
Post × Treated × TCR	-0.062	-0.174**	0.210***	-0.097
	[0.053]	[0.068]	[0.046]	[0.181]
High TFP × Post × Treated	-0.044***	-0.036***	-0.038***	-0.051**
	[0.023]	[0.008]	[0.017]	[0.018]
High TFP × Post × Treated × TCR	0.587***	0.484***	0.540***	0.687***
	[0.122]	[0.064]	[0.076]	[0.201]
Windfall rate × Post × Treated				0.561*
				[0.309]
Windfall rate × Post × Treated × TCR				-6.324**
				[2.601]
Pass-through rate				
Low TFP	-0.062	-0.174**	0.210***	-0.097
	[0.053]	[0.068]	[0.046]	[0.181]
High TFP	0.525***	0.310***	0.750***	0.590***
	[0.124]	[0.095]	[0.067]	[0.092]
Observations	97,789	112,713	82,910	97,789
New entrants vs. incumbents	incumbents	incumbents	incumbents	incumbents
Part-time included	no	yes	no	no
One vs. two year change	one	one	two	one
Windfall rate included	no	no	no	yes

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on wages when we use lagged firm quality ($Q_{j(it-1)}$) in the regression equation (5) instead of current firm quality $Q_{j(it)}$. Columns (1)-(4) estimate heterogeneity by firm productivity using equation (5) (but with lagged firm quality measure). In all columns except column (2) we focus on full-time workers. In column (2) we also include part-time workers in the analysis. In all columns except in column (3), we compare the wage changes between 2012 and 2013. In column (3) we study two-year wage changes and compare the wage change between 2012 and 2014. In column (4), we also interact the treatment, age, year, and tax cut rate indicators with the firm specific windfall rate, which reflects the size of the windfall received by the firm as a result of the tax cut. Following (Saez, Schoefer and Seim, 2019) we calculate this as the (lagged) ratio of age- and occupation specific payroll tax cuts payable after the reform and the total payroll. The difference-in-differences estimate compares the change in wages among the 55 to 57 age group that was affected by the payroll tax cut with the change in employment among the 52 to 54 age group that was not affected by the tax cut. The pass-through rate at low-productivity firms is the β_1 coefficient on the Post × Treated × TCR term in equation (5), while at high-productivity firms it is the sum of the β_1 coefficient and the β_3 coefficient on the High TFP × Post × Treated × TCR term in equation (5). Standard errors are reported in brackets, clustered at the age × period level.

Appendix Table A16: Wage Effects of the Tax Cut by Various Firm Quality Indicators, Wage Model Extended with Windfall Indicator

	(1) log(wage)	(2) log(wage)	(3) log(wage)	(4) log(wage)	(5) log(wage)	(6) log(wage)	(7) log(wage)	(8) log(wage)	(9) log(wage)	(10) log(wage)
Post × Treated	0.008	0.011	-0.005	-0.001	0.003	0.006	-0.0004	0.011	0.010	0.025
	[0.007]	[0.016]	[0.012]	[0.011]	[0.011]	[0.008]	[0.016]	[0.019]	[0.020]	[0.024]
Post × Treated × TCR	-0.077	-0.129	0.058	-0.035	-0.042	-0.101	0.030	-0.094	-0.115	-0.272
	[0.070]	[0.215]	[0.108]	[0.104]	[0.101]	[0.129]	[0.139]	[0.189]	[0.167]	[0.237]
High-quality × Post × Treated	-0.046***	-0.053**	-0.032***	-0.036***	-0.068***	-0.070***	-0.054***	-0.065***	-0.072***	-0.082***
	[0.032]	[0.021]	[0.004]	[0.003]	[0.014]	[0.013]	[0.008]	[0.012]	[0.014]	[0.021]
High-quality × Post × Treated × TCR	0.678***	0.780***	0.464***	0.536***	1.179***	1.222***	0.963***	1.073***	1.235***	1.345***
	[0.137]	[0.242]	[0.056]	[0.064]	[0.211]	[0.235]	[0.051]	[0.109]	[0.160]	[0.255]
Windfall rate × Post × Treated		0.546*		0.772*		0.391		-0.111		-0.150
		[0.277]		[0.382]		[0.286]		[0.257]		[0.268]
Windfall rate × Post × Treated × TCR		-5.979**		-6.943***		-4.141**		-0.412		0.588
		[2.588]		[1.810]		[1.716]		[1.208]		[2.247]
Pass-through rate										
Low-quality	-0.077	-0.129	0.058	-0.035	-0.042	-0.101	0.030	-0.094	-0.115	-0.272
	[0.070]	[0.215]	[0.108]	[0.109]	[0.101]	[0.129]	[0.139]	[0.189]	[0.167]	[0.237]
High-quality	0.602***	0.651***	0.521***	0.501***	1.137***	1.121***	0.993***	0.979***	1.119***	1.074***
	[0.131]	[0.097]	[0.113]	[0.103]	[0.211]	[0.176]	[0.167]	[0.164]	[0.233]	[0.199]
Observations	97,789	97,789	97,789	97,789	97,789	97,789	97,789	97,789	97,789	97,789
Quality measure	TFP	TFP	PI	PI	foreign-owned	foreign-owned	firm-level wage	firm-level wage	AKM FE	AKM FE
New entrants vs. incumbents	incumbents	incumbents	incumbents	incumbents	incumbents	incumbents	incumbents	incumbents	incumbents	incumbents
Part-time included	no	no	no	no	no	no	no	no	no	no
One vs. two year change	one	one	one	one	one	one	one	one	one	one
Windall rate included	no	yes	no	yes	no	yes	no	yes	no	yes

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

Note: Table shows the wage effects of the tax cut by various firm quality indicators. The odd columns in the table repeat the estimates of Table A9 showing the difference-in-differences estimates of the impact of the payroll tax cut on private sector wages based on estimating equation (5). In all even columns, we also interact the treatment, age, year, and tax cut rate indicators with the firm-specific windfall rate, which reflects the size of the windfall received by the firm as a result of the tax cut. Following (Saez, Schoefer and Seim, 2019) we calculate this as the (lagged) ratio of age- and occupation specific payroll tax cuts payable after the reform and the total payroll. In columns (1) and (2) we use TFP as the firm quality indicator. In columns (3) and (4) we measure quality based on the poaching index (PI), reflecting the fraction of new hires poached from other firms instead of coming from unemployment. In columns (5) and (6) we measure quality based on ownership. In Hungary foreign-owned firms are the most productive firms offering the highest-paying, highest-quality jobs. In columns (7) and (8) we measure firm quality by the average wage the firms pays. Finally, in columns (9) and (10) we measure firm quality based on the firm-level wage premium estimated using an Abowd, Kramarz, Margolis (AKM) style decomposition. The difference-in-differences estimate compares the change in wages among the 55 to 57 age group that was affected by the payroll tax cut with the change in employment among the 52 to 54 age group that was not affected by the tax cut. Standard errors are reported in brackets, clustered at the age × period level.

Appendix Table A17: Wage Effects of the Tax Cut: Heterogeneity by Education

	(1) Primary and lower-secondary jobs, log(wage)	(2) Upper-secondary and tertiary jobs, log(wage)	(3) Primary and lower-secondary jobs, log(wage)	(4) Upper-secondary and tertiary jobs, log(wage)
Post × Treated	0.032***	-0.014	0.005	-0.001
	[0.010]	[0.011]	[0.078]	[0.208]
Post × Treated × TCR	-0.285***	0.209	-0.060	0.038
	[0.084]	[0.135]	[0.009]	[0.026]
High-quality × Post × Treated	-0.053***	-0.037	-0.042*	-0.081***
	[0.013]	[0.021]	[0.021]	[0.022]
High-quality × Post × Treated × TCR	0.643***	0.792**	0.731**	1.990***
	[0.130]	[0.308]	[0.276]	[0.458]
Pass-through rate				
Low-quality	-0.285***	0.209	-0.060	0.038
	[0.084]	[0.135]	[0.078]	[0.208]
High-quality	0.358*	1.001***	0.671**	2.028***
	[0.164]	[0.193]	[0.292]	[0.525]
Observations	66,180	30,794	66,180	30,794
Quality measure	TFP	TFP	AKM FE	AKM FE

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

Note: Table shows difference-in-differences estimates of the impact of the payroll tax cut on private sector wages based on estimating equation (5). The sample is split by education categories of jobs (measured at the previous year), which are defined by imputing the modal education level of employees of the same four-digit occupation code in the 2013 Labor Force Survey of the Central Statistical Office of Hungary. In all columns we show the wage changes for all incumbent workers and we focus on full-time workers. In all columns we compare the wage changes between 2012 and 2013 to the wage changes between 2011 and 2012. In columns (1) and (2), we use TFP as firm quality indicator, in columns (3) and (4) we use the firm-level wage premium estimated using an Abowd, Kramarz, Margolis (AKM) style decomposition. The pass-through rate is calculated as in Table 5. Standard errors are reported in brackets, clustered at the age × period level.

B Elasticity Calculations Based on Change in Net Present Value of Labor Cost

Forward-looking firms consider not only tax cuts they realize today, but also the net present value of all the future streams of tax cuts. In this section, we calculate the employment elasticity based on the net present value of the tax cut. Even workers in our control group are affected by the tax cut as they might reach age 55 and so firms employing them can benefit from the tax cut in the future. The present value of tax cuts realized in the future depends on several factors—the discount rate, the expected retirement age, and the typical separation rate of workers at the firm (before reaching the retirement age).

We calculate the percent change in net present value of labor cost along the following steps. We use the percent change in labor cost as reported in Table 3, which is the percent difference in the labor cost of workers in the treatment and control group. This value varies with firm quality: -5.27% for all firms, -6.02% for low-TFP firms, and -4.45% for high-TFP firms. We discount the future savings with a rate of 7% as the Central Bank Base Rate was 7% as of January 1, 2012. We take into account workers' separation rate, and the fact that this separation rate varies by firm-quality. We use the 12-months separation rate of men aged 52-57 in 2011 as observed in our data. This rate is 17.9% for all firms, 22.3% for low-TFP firms, and 13.6% for high-TFP firms. We assume that all worker-firm relationships end at age 62 when workers retire.

We calculate the elasticity of employment as the ratio of the percent change in employment as reported in Panel B of Table 3 (1.59% for all firms, 3.18% for low-TFP firms, and -0.03% for high-TFP firms) and the percent change in net present value of labor cost. The results under the baseline parameters are reported in Panel A of Table B1. These elasticity estimates are also reported in Panel E of Table 3.

Appendix Table B1: Elasticity of Employment Based on Net Present Value of Labor Cost

	(1)	(2)	(3)	(4)	(5)	(6)
	Percent change in net present value of labor cost			Elasticity		
	All	Low TFP	High TFP	All	Low TFP	High TFP
Panel A: Benchmark						
	-7.49	-8.82	-5.98	-0.21	-0.36	0.01
				[0.02]	[0.03]	[0.04]
Panel B: Discount rate (benchmark: 0.07)						
0.1	-7.65	-8.90	-6.22	-0.21	-0.36	0.00
				[0.02]	[0.03]	[0.04]
0.13	-7.75	-8.94	-6.39	-0.21	-0.36	0.00
				[0.02]	[0.03]	[0.04]
Panel C: Retirement age (benchmark: 62)						
60	-5.69	-7.21	-4.08	-0.28	-0.44	0.01
				[0.03]	[0.04]	[0.06]
64	-8.11	-9.37	-6.62	-0.20	-0.34	0.00
				[0.02]	[0.03]	[0.04]
Panel D: Separation rate						
Common job finding rate (0.348)	-7.76	-8.86	-6.55	-0.20	-0.36	0.00
				[0.02]	[0.03]	[0.04]
Common separation probability (0.179)	-7.49	-8.55	-6.32	-0.21	-0.37	0.00
				[0.02]	[0.04]	[0.04]

Note: Columns (1)-(3) report percent change in net present value of labor cost under various scenarios. Firms' labor cost is net wage times $(1 + \tau_{ss})$, where τ_{ss} is the employer social security contribution. The reform cut τ_{ss} for workers in the treatment group. Panel A calculates the percent change in net present value of labor cost under the benchmark parameters with discount rate 0.07, retirement age 62, and TFP-specific separation rate as observed in our data (0.18 for all firms, 0.22 for low-TFP firms, 0.14 for high-TFP firms). Panels B, C and D modify the discount rate, retirement age, and separation rate, respectively. Columns (4)-(6) calculate the implied employment elasticity with respect to the wage change by taking the ratio of the percent change in employment (as reported in Table 3) and labor cost (columns (1)-(3)). Standard errors are reported in brackets, clustered at the age $\times$ period level. (N = 9,003,984 individual-months)

In Panel B of Table B1, we repeat the calculation of the percent change in net present value of labor cost and the elasticity of employment with two alternative discount rate values: 0.1 and 0.13. In Panel C, we use the benchmark discount rate (0.07) but consider a lower and a higher retirement age: 60 and 64. Finally, in Panel D, we use the benchmark discount rate and retirement age, but instead of using the separation rate we apply the job finding rates of the simulation exercise of Section E.1.6 (0.348). The rationale for applying the job finding rate is that firms in our model can only enjoy the benefit of the tax cut as long as workers do not find any other job offers that could be used in bargaining. Finally, the last row applies the same separation rate for high- and low-TFP firms.

Panels B, C, and D of Table B1 demonstrate that the elasticities vary little across the different specifications. This highlights that the estimates are not sensitive to the modeling assumptions made in the benchmark case. The employment elasticity is always between -0.36 and -0.44 at low-TFP firms, while it is close to zero for high-TFP firms. In all specifications, the difference in responses to the tax cut between the two firm types is both statistically and economically significant.

C Effect on Women

Women were eligible for the payroll tax cut but they were also targeted by a pension policy introduced in 2011. The so-called "Women 40" policy grants an early retirement option for women with 40 years of work credits, regardless of age. Years spent on maternity benefits also count towards the work credits, with the restriction that a woman must have been employed for 32 years (or at least 25 years if she has 5 or more children). Unfortunately, our data do not allow us to determine eligibility as we do not observe the full employment history of older people in our sample.

Even though this reform is unlikely to have a major effect on the employment of the treated population (age 55-57), we exclude women from the main analysis to ensure that our results are not driven by the pension policy. In this section, we estimate the employment and wage effects of the payroll tax cut among older women.

Appendix Table C1: Elasticity of Employment: Women

	(1) All firms	(2) Low TFP	(3) High TFP
Panel A: Change in the probability of employment			
— $After \times Treated$	0.0051***	0.0037***	0.0014***
	[0.0007]	[0.0005]	[0.0005]
Panel B: Percent change in employment			
—Employment without tax cut	0.236	0.130	0.106
—Employment with tax cut	0.241	0.134	0.107
—Percent change in employment	2.16%	2.85%	1.32%
Panel C: Percent change in labor cost $(1+\tau_{ss})$			
—Labor cost without tax cut	1.26	1.25	1.27
—Labor cost with tax cut	1.19	1.17	1.21
—Percent change in labor cost	-5.35%	-5.88%	-4.60%
Panel D: Implied elasticity (Panel B/Panel C)			
— Elasticity based on percent change in labor cost	-0.40	-0.48	-0.29
	[0.06]	[0.07]	[0.10]
Panel E: Elasticity based on net present value			
—Percent change in net present value of labor cost	-7.46%	-8.51%	-6.03%
—Implied elasticity	-0.29	-0.33	-0.22
	[0.04]	[0.05]	[0.08]

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

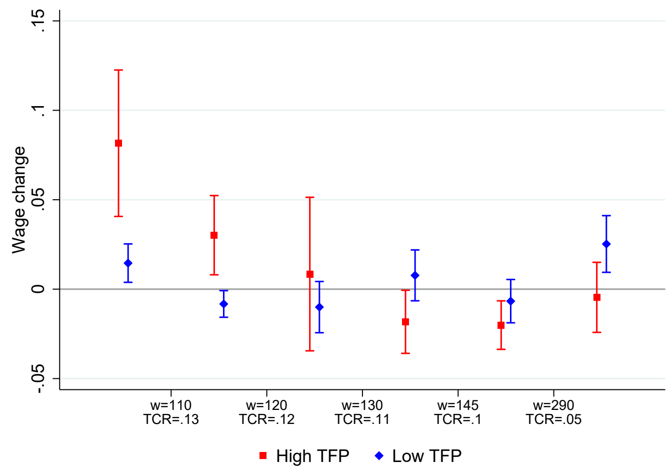
Note: Table applies the same analysis for women as Table 3 for men. ($N = 9,529,124$ individual-months)

Employment effects. We estimate the same difference-in-differences model for women as for men, specified in equation (1). Among older women private sector employment increased by 0.51 percentage points (2.16%) as a result of the tax cut (see Table C1). The overall employment effect was almost identical among men (0.53 percentage points, 1.59%). Table C1 also shows the implied labor demand elasticity. The 5.35% decrease in labor costs and the resulting 2.16% increase in employment of women aged 55-57 over 2013-2015 imply a labor demand elasticity of -0.40. Overall, the employment effect and the implied labor demand elasticity are similar among older women and men, though somewhat larger among women.

Heterogeneity by firm quality. To investigate whether the employment effect for women differs by firm quality, we estimate the difference-in-differences model, specified in equation (1) with the outcome variable being employment either at a low-TFP or at a high-TFP firm. We apply exactly the same definition for low- and high-TFP firms as for men. Table C1 shows that private sector employment of older women increases more at low-quality firms, the increase is 0.37 vs. 0.14 percentage points at low- vs. high-TFP firms. This translates into a -0.48 (s.e. 0.07) employment elasticity at low-TFP firms and a -0.29 (s.e. 0.10) employment elasticity at high-TFP ones. Therefore there is a clear and statistically significant difference in the employment responses at high- and low-quality firms albeit those differences are less stark for women than for men.

Wage effects by firm quality. We also estimate the wage effects of the tax cut among older women. Figure C1 shows the wage effects from 2012 to 2013 for women by firm quality at different levels of the effective tax cut. The patterns of wage effects are similar for women and men (see Figure 9 for men). Wages increase only at high-TFP firms and only at lower wage levels with a higher corresponding effective tax cut rate. However, the wage increase we see at high-productivity firms is somewhat smaller for women than for men.

Appendix Figure C1: Wage Changes at Different Levels of Lagged Wages: Women



Note: Figure applies the same analysis for women as Figure 9 for men.

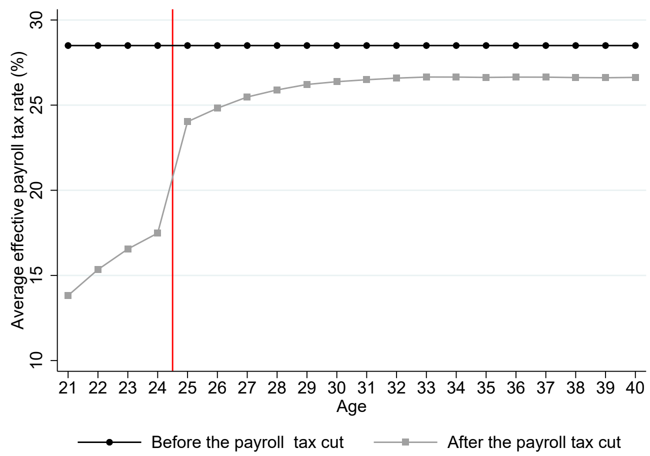
D Effect on Younger Workers

Parallel to the introduction of the payroll tax cut for older workers, a similar tax cut was applied for under-25 workers. We briefly summarize the main results we find for younger workers in Section 7 and we provide further details below.

We estimate the impact of the payroll tax cut in a difference-in-differences framework, comparing younger workers below the age 25 cutoff to workers just above (ages 22-24 vs. 25-27) during 2012-2015 (before and after the introduction of the tax cut in 2013). In 2015, the government introduced the Youth Guarantee Program recommended by the European Council, which targeted workers younger than age 25, however 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.

Employment effects. Figure D1 shows the effective average payroll tax rate for ages 20-40 before and after the implementation of the tax cut. We see a discontinuity at age 25 after the policy was implemented (in gray) compared to the constant rate of 28.5% before (in black). There is a jump from 17% to 24% from age 24 to 25, which is a slightly larger average effective tax cut than for workers above 55 (a cut of 7 vs. 6 percentage points for the younger and older age groups, respectively). At younger ages the effective tax cut decreases with age, which reflects the gradual increase in wages and thus the lower proportional tax cut. Furthermore, career starters received some extra tax cuts and the share of those workers steadily declines with age.

Appendix Figure D1: Employers' Social Security Contribution Rate by Workers' Age: Younger Workers

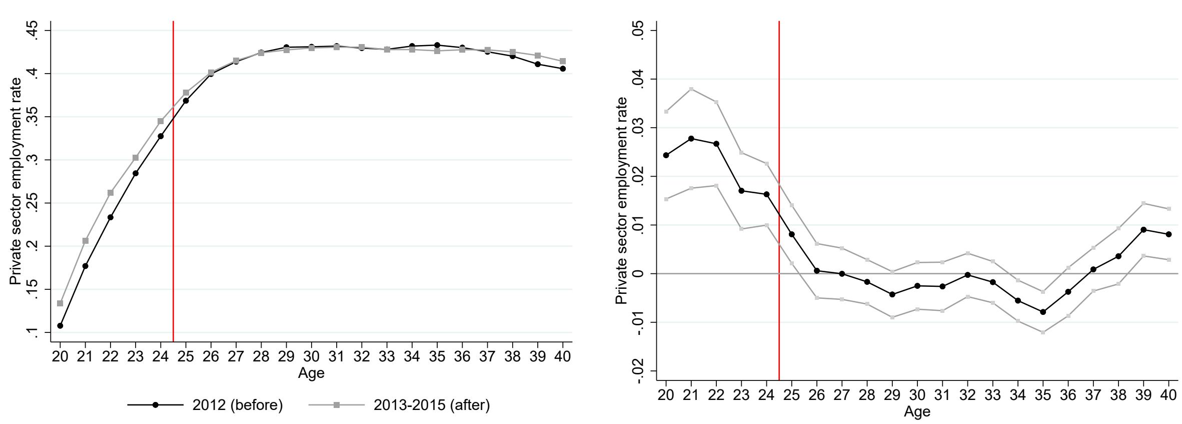


Note: Figure applies the same analysis for younger workers as Figure 1 for older workers. In particular, figure shows the average employer social security contribution rate by worker age for male workers in the private sector. Before the implementation of the payroll tax cut, the payroll tax rate was a flat 28.5%. Between 2013-2015 (after the implementation of the cut) all individuals over up to age 24 experienced a lump-sum tax cut of HUF 14,500 per month (around 6% of the average salary). Certain individuals were also eligible for the tax cut independently of their age (see Section 3.1 for the details).

Figure D2 depicts employment in private sector companies for men by age before and after the payroll tax cut was introduced in 2013. Panel (a) shows raw employment rates by age before (year 2012, in black) and after the policy (years 2013-2015, in gray). 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 declining slowly. 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 a clear divergence below 26.

Appendix Figure D2: Employment in Private Sector Companies by Age: Younger Workers

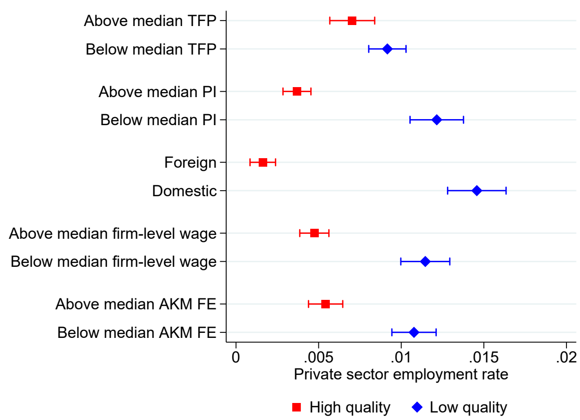
(a) Private Sector Employment Rate (b) Change in Private Sector Employment Rate



Note: Figure applies the same analysis for younger workers as Figure 2 for older workers.

Panel (b) shows estimates of the age-specific differences in employment at private sector companies for men before vs. after the payroll tax cut was introduced. It suggests that for ages above 25 changes in employment rates were close to zero (somewhat below zero at age 35 and at ages 39-40) but age-specific employment levels strongly diverge between the pre- and the post-reform periods among younger workers below 25. 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, which likely reflects the fact that in employment relationships formed at younger ages there is more time left until the tax cut phases out at age 25. Overall, this figure suggests that the payroll tax cut had a positive employment effect among younger workers. This effect is larger than for older employees above 55 (2 vs. 1 percentage point).

Appendix Figure D3: Employment in Private Sector Companies: Alternative Firm Quality Measures, Younger Workers



Note: Figure applies the same analysis for younger workers as Panel (a) of Figure 6 for older workers.

We estimate the same difference-in-differences regression for younger workers as for older workers (specified in equation (1)), where employees aged 22-24 are in the treatment group and the 25-27 age group acts as control group. Table D1 shows the baseline results for younger workers. Among younger workers private sector employment increased by 1.6 percentage points (5.1%) as a result of the payroll tax cut, compared to the 0.53 percentage points (1.6%) increase among older workers. We also show the elasticity of employment in Table D1. The 1.6 percentage points (5.1%) increase in employment and the 6.6% decrease in labor costs for the 22-24 age group over years 2013-2015 imply a labor demand elasticity of -0.77. Overall, the employment effect is larger and labor demand is more elastic for younger workers.

Heterogeneity by firm quality. Figure D3 shows the heterogeneity in the employment responses by various firm quality measures. We discuss these results in the main text.

Wage effects. We assess the impact on wages among younger workers in a similar fashion as for older workers, using a modified version of equation (5) (replacing the linear tax cut rate in the last interaction term with categories of the tax cut rate). Figure D4 shows the wage effects for younger workers from 2012 to 2013 at different levels of the effective tax cut rate. We find no significant change in wages at any level of the tax cut rate.

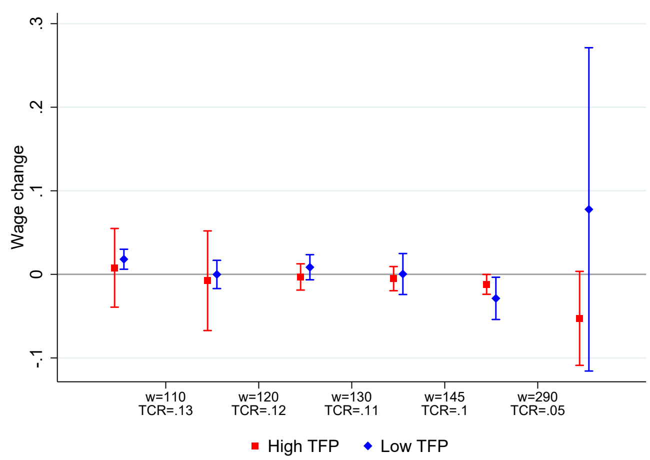
Appendix Table D1: Elasticity of Employment: Younger Workers

	(1) All firms	(2) Low TFP	(3) High TFP
Panel A: Change in the probability of employment			
— $After \times Treated$	0.0162***	0.0092***	0.0070***
	[0.0011]	[0.0006]	[0.0007]
Panel B: Percent change in employment			
—Employment without tax cut	0.317	0.142	0.175
—Employment with tax cut	0.333	0.151	0.182
—Percent change in employment	5.11%	6.45%	4.02%
Panel C: Percent change in labor cost $(1 + \tau_{ss})$			
—Labor cost without tax cut	1.25	1.23	1.26
—Labor cost with tax cut	1.17	1.15	1.18
—Percent change in labor cost	-6.61%	-7.03%	-5.96%
Panel D: Implied elasticity (Panel B/Panel C)			
— Elasticity based on percent change in labor cost	-0.77	-0.92	-0.67
	[0.05]	[0.06]	[0.07]
Panel E: Elasticity based on net present value			
—Percent change in net present value of labor cost	-9.81%	-10.02%	-9.21%
—Implied elasticity	-0.52	-0.64	-0.44
	[0.03]	[0.04]	[0.04]

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

Note: Table applies the same analysis for younger workers as Table 3 for older workers. ($N = 8,611,542$ individual-months)

Appendix Figure D4: Wage Changes at Different Levels of Lagged Wages: Younger Workers



Note: Figure applies the same analysis for younger workers as Figure 9 for older workers.

Why do we see some discrepancy between young and old workers' employment and wage responses? The differences could reflect that young and old workers are operating in different types of labor markets. Young inexperienced workers are more likely to get uniform wages à la perfect competition. Bargaining options are often limited as most workers are new entrants, with temporary contracts, or on probation. This implies that the young inexperienced workers often lack outside options that could be used in negotiations. The search model with sequential bargaining predicts that employment should be less heterogeneous in that environment, and wages are also less affected. Constraints on wage setting could be also different for young and old. For instance, passing through the effect of the policy on young workers would mean paying more at age 24 and then less at age 25. This wage cut is probably less feasible than the wage increase once someone reached age 55.

Interestingly, when we focus on young but experienced workers we find more similarities to the observed pattern for old workers. Table D2 shows that there is large heterogeneity in employment responses among experienced younger workers (those who enter the labor market around age 18), while we find limited heterogeneity among non-experienced younger workers who are entering the labor market at later ages.

Appendix Table D2: Impact on Employment by Experience: Younger Workers

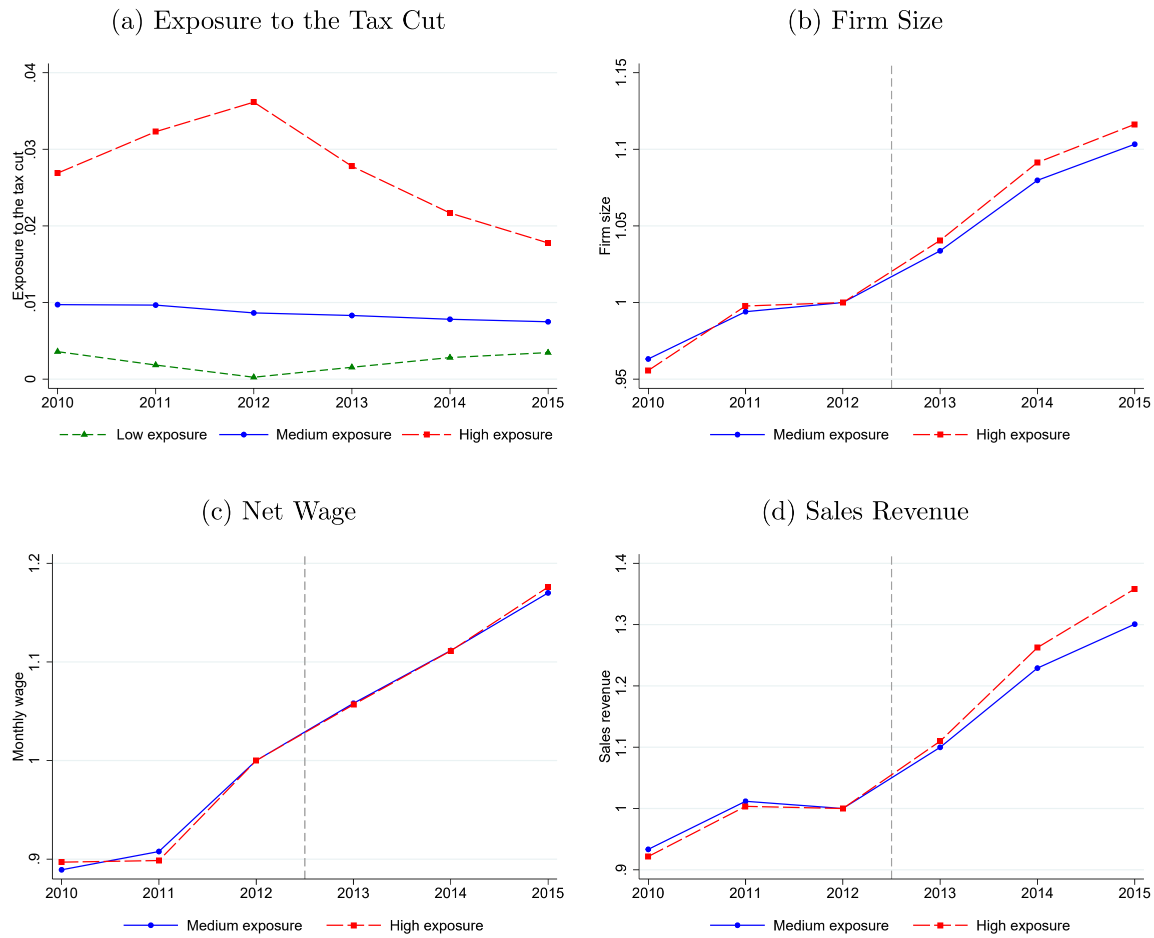
	(1)	(2)	(3)
		Employment	
	All Firms	Low TFP	High TFP
All workers	0.0162***	0.0092***	0.0070***
	[0.0011]	[0.0006]	[0.0007]
	⟨0.3171⟩	⟨0.1421⟩	⟨0.1750⟩
Experienced workers	0.0110***	0.0164***	-0.0054***
	[0.0020]	[0.0011]	[0.0018]
	⟨0.4821⟩	⟨0.2311⟩	⟨0.2510⟩
Non-experienced workers	0.0221***	0.0111***	0.0111***
	[0.0012]	[0.0007]	[0.0007]
	⟨0.3002⟩	⟨0.1330⟩	⟨0.1672⟩

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

Note: Table shows difference-in-differences estimates based on equation (1). We compare the change in employment among the 22 to 24 age group that was affected by the payroll tax cut with the change in employment among the 25 to 27 age group that was not affected by the tax cut. The sample is further split by working at least 6 months at ages 18-19 ("experienced" vs. "non-experienced"). The employment rate in each of these categories (relative to the total population) in May 2012 is shown in angle brackets. Standard errors are reported in brackets, clustered at the age × period level. ($N = 8,611,542$ individual-months; experienced young: $N = 707,259$ individual-months; non-experienced young: $N = 8,004,351$ individual-months.)

Windfall effects. We also assess potential windfall effects at firms that already employed many younger workers from the treatment age group (below age 25) before the tax cut was implemented, following the strategy of Saez, Schoefer and Seim (2019). We compare firms that have a high share of treated workers below age 25 with firms that have a medium share in 2012 (last pre-reform year), the same exercise as for older workers in Appendix Figure A4. Again, Panel (a) of Figure D5 indicates mean reversion in the exposure to the tax cut (ratio of the windfall revenues to the total payroll) and net wages trend similarly for firms with high and medium shares of younger treated workers (Panel (c)). However, we see some divergence in the evolution of firm size and sales revenue (Panel (b) and (d) of Figure D5); both of them grew faster at firms with high exposure, suggesting a small positive impact of a larger tax windfall on growth. These figures are similar to the findings of Saez, Schoefer and Seim (2019) on the young workers' tax cut in Sweden, suggesting that responses to a tax cut have many similar features in the two countries and economic environments. At the same time, the figures differ from what we found for older workers. This suggests that the windfall effects documented by Saez, Schoefer and Seim (2019) might be less relevant for firms employing older workers.

Appendix Figure D5: Firm-level Effects of Payroll Tax Cuts of Younger Workers



Note: Figure applies the same analysis for younger workers as Appendix Figure A4 for older workers.

E The Effect of Tax Cuts in Different Labor Market Models

We present the basic setup and main results of the models summarized in Section 2. We provide detailed derivations in the Supplementary Material.

E.1 Search and Matching with Zero Bargaining Power of Workers

First, we illustrate the impact of payroll taxes in the presence of search frictions. We introduce a tax cut in a framework with random search, heterogeneous firms, and sequential bargaining on wages (Postel-Vinay and Robin, 2002).

E.1.1 Setup

Firms are heterogeneous and characterized by productivity $y \in [y_{min}, y_{max}]$, with continuous cumulative distribution function $\Psi(\cdot)$. Workers are homogeneous. Workers are either unemployed or employed. If unemployed, they receive leisure of value b (with $b < y_{min}$) 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 exogenously with probability

$\delta \in [0,1]$.[30]

Firms advertise vacancies at an increasing and convex cost $\kappa(\cdot)$. Job market tightness is the ratio between total vacancies (v) and total search effort by the unemployed (u) and employed ($(1-\delta)(1-u)$). A searching worker locates an open vacancy with probability $\phi(\theta)$, increasing in θ. The probability for an open vacancy to meet a worker who is searching for jobs is $\phi(\theta)/\theta$, decreasing in θ.

Wage setting is based on sequential auction as in 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. First, we discuss the case when all the bargaining power is at the firms and so they are able to extract all rents from the workers (see e.g. Postel-Vinay and Robin, 2002 and Moscarini and Postel-Vinay, 2018).

E.1.2 Value of Vacancy Posting

Firms need to post vacancies to find workers. The value of posting vacancies will be the following:

$$V_v(y,\tau) = \max_{\nu} \Bigg\{ \underbrace{-\kappa(\nu)}_{\text{Cost of vacancy}} + \underbrace{\nu \frac{\phi(\theta)}{\theta} P(u)}_{\text{Probability of meeting unemployed}} \times \underbrace{\beta \left[\frac{y+\tau}{1-\beta+\delta\beta} - \frac{1-\delta\beta}{1-\beta+\delta\beta} \frac{b}{1-\beta} \right]}_{\text{Benefit of meeting with unemployed}} + \\ + \underbrace{\nu \frac{\phi(\theta)}{\theta}(1-P(u))}_{\text{Probability of meeting employed}} \times \underbrace{\beta \int_{y_{min}}^{y} \frac{y-y'}{1-\beta+\delta\beta} \Gamma(y')}_{\text{Benefit of meeting employed}} \Bigg\}. \tag{E.1}$$

This equation highlights the key trade-offs firms face when they decide about posting a vacancy. The first part reflects the cost of posting. The second part reflects the (expected) benefit of meeting an applicant who is unemployed, while the third part reflects the (expected) benefit of meeting with an applicant who is employed. The equation also highlights the key channels through which payroll taxes affect vacancy posting and employment. In particular, the tax cut only appears in the second part of this equation, which reflects the benefits of hiring from unemployment. At the same time, the tax cut has no impact on the third part of the value of vacancy posting, hiring from employment, as all firms receive the tax cut and the competition for workers will shift the surplus from the firms to the worker. Note that this shift in incidence of the policy will take place even if firms have all the bargaining power.

The equation, therefore, highlights that the tax cut increases the benefit of hiring from unemployment, while it has no effect on hiring from employment. It is worth noting that the model predicts a difference between hiring from employment and unemployment. In the Supplementary Material we provide an indicative test of this prediction, which is a replication

[30] 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.

of Figure 1 of Di Addario, Kline, Saggio and Sølvsten (2023). Our results indicate that non-employment implies an average penalty of 12% on subsequent hiring wages. This is twice the penalty estimated by Di Addario, Kline, Saggio and Sølvsten (2023).

E.1.3 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 (E.1). Furthermore, market tightness, θ, and the distribution of vacancies, $\Gamma(y)$, are consistent with firms' vacancy posting decisions.

E.1.4 Wage

The derivation of equilibrium wage levels 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 a firm that can deliver greater value than the current contract, but is less productive than the current firm, the contract is renegotiated and the worker stays.

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

The value of employment at firm of type y and at wage w is $V_e(w, y)$. A worker moves to a potentially better match with a firm type-y' if it offers at least the wage $\omega(y, y', \tau)$ defined by:

$$V_e(\omega(y, y', \tau), y) = V_e(y + \tau, y). \tag{E.2}$$

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

The Bellman equation for the value of employment is the following (corresponding to equation (16) of Postel-Vinay and Robin, 2002):

$$\begin{aligned} &\underbrace{\left(\delta + \frac{1-\beta}{\beta} + s\phi(\theta)(1 - \Gamma(q(w, y, \tau)))\right)}_{\text{Separation rate + discount rate + prob. of renegotiation or poaching}} \cdot \underbrace{V_e(w, y)}_{\text{Value of employment}} = \\ &= \underbrace{U(w)}_{\text{Flow utility from wage}} + \underbrace{s\phi(\theta) \int_{q(w,y,\tau)}^{y} V_e(x + \tau, x) d\Gamma(x)}_{\text{Expected value from renegotiation}} + \\ &+ \underbrace{s\phi(\theta)(1 - \Gamma(y))V_e(y + \tau, y)}_{\text{Expected value from poaching}} + \underbrace{\delta V_u}_{\text{Expected value from job loss}}, \end{aligned} \tag{E.3}$$

where $q(w, y, \tau)$ is the threshold productivity, defined by $\omega(q(w, y, \tau), y, \tau) = w$. In other words, $q(w, y, \tau)$ is the lowest productivity level y' such that competition between a type-y and a type-y' firm raises the wage above w (which equals y_{min} if $w = b$). $U(w)$ is the instantaneous utility flow from wage w. The second term on the right hand side of equation (E.3) captures the employment value after a wage increase at the current firm (reflecting that the incumbent firm needs to match the offer of the competitor), whereas the third term captures the value of employment at a higher productivity firm (after being poached, using equation (E.2)).

Assuming CRRA utility function with rate of relative risk aversion ζ ($U(x) = x^{1-\zeta}$), where $0 \leq \zeta < 1$, we can derive an expression for wages, following Appendix A.1. of Postel-Vinay and Robin (2002) and incorporating the tax cut (τ) into their model:

$$\ln \omega(y, y', \tau) = \frac{1}{1-\zeta} \ln \left[(y+\tau)^{1-\zeta} - \frac{(1-\zeta)s\phi(\theta)}{\frac{1-\beta}{\beta} + \delta} \int_{y}^{y'} (1-\Gamma(x))(x+\tau)^{-\zeta} dx \right]. \qquad \text{(E.4)}$$

The wage of workers who have not been subject to wage bargaining yet is:

$$\ln \omega_u(y, \tau) = \frac{1}{1-\zeta} \ln \left[b^{1-\zeta} - \frac{(1-\zeta)s\phi(\theta)}{\frac{1-\beta}{\beta} + \delta} \int_{y_{min}}^{y} (1-\Gamma(x))(x+\tau)^{-\zeta} dx \right]. \qquad \text{(E.5)}$$

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).

E.1.5 Effects of the Tax Cut

We now study the effect of changing the tax cut. We describe what happens to the steady-state equilibrium when we raise the tax cut amount. Here we state the results only, we provide proofs in the Supplementary Material.

Result 1 *Hiring intensity is increasing in firm productivity.*

Result 2 *The partial effect of the tax cut leads to more vacancy posting at all firms.*

Result 3 *The equilibrium unemployment rate (u) and the probability that a randomly drawn applicant is unemployed decrease in τ.*

Result 4 *The partial effect of the tax cut on vacancy posting decreases with firm productivity.*

Result 5 *Ignoring the impact of the tax cut on the composition of incumbents at a firm, the effect of the tax cut on wages is on average positive for workers who already had a wage bargaining or have been poached. This effect increases with firm productivity.*

Result 6 *The partial effect of the tax cut on wages of workers arriving from unemployment (who have not had a wage bargaining) is zero at the lowest productivity firms and positive at higher productivity levels.*

Note, that younger 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 an 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. Also, the firm heterogeneity in the employment effects of the tax cut is smaller if all workers are new entrants since then low- and high-productivity firms hire from unemployment to the same extent, thus low-productivity firms no longer benefit disproportionately more from the tax cut.

E.1.6 Simulation

In the search and matching framework with sequential bargaining, we quantify the impact of a tax cut that is 6% of the average wage in the economy. We assume that all bargaining power is at firms. The functional forms used in the simulations are the following. The cost function, based on Bagger and Lentz (2019) is:

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

where $c_v > 0$ determines curvature. 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:

- The tax cut is 6% of the average wage without tax: $\tau = \bar{w}_0 \times 0.06$.
- y has $Pareto(\lambda, y_{min})$ distribution, where λ is the scaling parameter and y_{min} is a drift that shifts the original Pareto distribution, such that the lower bound is equal to y_{min}. During the simulations $\lambda = 1.25$ and $y_{min} = 1000$.
- $\zeta = 0.95$, which is the exponent in the CRRA utility function, implying close to log-utility. The simulation results are robust to different ζ values. It primarily has an effect on the wage change.
- $A = 1/4$, to calibrate an unemployment rate of around 20%.
- $\alpha = 1/2$, similar to Moscarini and Postel-Vinay (2018).
- The employment-to-employment transition rate (EE) is 0.041, which is in line with the empirical data for Hungary (12-month transition rate between employers among the continuously working older workers). The searching intensity (s) is a direct mapping of this parameter, see the derivations in Moscarini and Postel-Vinay (2018). To obtain s, we solve for:
$$\phi(\theta)(1-\delta)\delta s \int_0^1 \frac{1-x}{\delta + (1-\delta)s\phi(\theta)x} dx = EE. \tag{E.6}$$
- $\beta = 0.95$, which matches the monthly value of $0.95^{1/12}$ by Moscarini and Postel-Vinay (2018).
- $b = y_{min} = 1000$, 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 $\delta = 0.1$, corresponding to the 12-month separation rate observed in the data for Hungary.

Table E1 displays the simulated impact of the tax cut on unemployment, job market tightness and job finding rate. The rate of unemployment decreases by 1.7 percentage points from its baseline rate of 22.3%. At the same time, both job market tightness and job finding rate increase as a consequence of the tax cut.

Appendix Table E1: Steady-State Parameters

Tax cut	0%	6%	Δ (15%)
Unemployment	0.223	0.206	-0.017
Job market tightness (θ)	1.935	2.380	0.445
Job finding rate	0.348	0.386	0.038

The tax cut increases the vacancy posting activities of firms. In line with our theoretical considerations, the impact is bigger at low-productivity firms. At low-productivity firms, the vacancies posted increase by 12%, whereas at more productive firms only by 8.3%. These simulated impacts are slightly higher if we ignore the equilibrium effects in the model. As a consequence of the increased vacancy posting activities, employment at less productive firms increases by 3.7%, while employment at more productive firms increase by 0.8%.

Turning to wages, the wage impact of the tax cut for workers who were not employed the previous period is essentially zero, while it is 2.3% for the rest of the workers ("incumbents"). Finally, among incumbent workers, the wage effect is small (0.8%) at low-productivity firms, whereas it is larger (2.9%) at high-productivity firms.

E.2 Search and Matching with Non-zero Bargaining Power of Workers

So far we assumed that all the bargaining power is at firms, therefore they are able to extract all rents from the workers. Now, following Cahuc, Postel-Vinay and Robin (2006), we allow workers to have bargaining power. Also, as in Cahuc, Postel-Vinay and Robin (2006), we assume linear utility function ($U(x) = x$).

We follow the notation of our baseline model and denote by λ the bargaining power of workers. The value of posting vacancies is the same as before (equation (E.1)), except for the benefit from posting a vacancy is now multiplied by $(1 - \lambda)$:

$$V_v(y,\tau) = \max_{\nu} \left\{ -\kappa(\nu) + \beta\nu\frac{\phi(\theta)}{\theta}(1-\lambda)\left[P(u)\Big(V(y,\tau)-V_u(\tau)\Big) + (1-P(u))\int_{y_{min}}^{y}\Big(V(y,\tau)-V(x,\tau)\Big)d\Gamma(x)\right]\right\}. \tag{E.7}$$

As before, the tax cut has no impact on the last part of the value of vacancy posting, hiring from employment, as all firms receive the tax cut and the competition for workers will shift the surplus from the firms to the worker. The tax cut affects the benefits of hiring from unemployment. However, since τ increases $V_u(\tau)$, this benefit is smaller than when workers have no bargaining power.

Based on equation (A.15) in Cahuc, Postel-Vinay and Robin (2006), the equilibrium wage of worker at type-y' firm previously employed at type-y firm is:

$$\omega(y,y',\tau) = \lambda(y'+\tau) + (1-\lambda)(y+\tau) - (1-\lambda)^2 s\phi(\theta)\int_{y}^{y'}\frac{(1-\Gamma(x))}{\frac{1-\beta}{\beta}+\delta+s\phi(\theta)\lambda(1-\Gamma(x))}dx. \tag{E.8}$$

Therefore, without considering the equilibrium effects, there is a full pass-through of the tax cut to the wage of poached workers. The equilibrium wage of a worker arriving from unemployment is (based on equation (A.17) of Cahuc, Postel-Vinay and Robin, 2006):

$$\omega_u(y,\tau) = \lambda(y+\tau)+(1-\lambda)y_{min}-(1-\lambda)^2 s\phi(\theta)\int_{y_{min}}^{y}\frac{(1-\Gamma(x))}{\frac{1-\beta}{\beta}+\delta+s\phi(\theta)\lambda(1-\Gamma(x))}dx. \quad \text{(E.9)}$$

Since workers have some bargaining power, the tax cut also increases the wage of workers arriving from unemployment, even without considering the general equilibrium effects.

To summarize, in a model à la Cahuc, Postel-Vinay and Robin (2006), firms still get surplus from the tax cut if they hire from unemployment, but less than if all bargaining power were at firms. As in our baseline model, since low-productivity firms tend to hire from unemployment, they will benefit disproportionately more from the tax cut. Competition between firms implies that the tax cut will benefit the workers more if they are poached or if they received an offer from another firm. However, the relative benefit compared to being hired from unemployment is smaller if workers have some bargaining power.

E.3 Search and Matching with Wage Posting

We build on the wage posting model of Burdett and Mortensen (1989) and Burdett and Mortensen (1998), and follow specifically the framework of Bontemps, Robin and Van den Berg (1999) and Bontemps, Robin and Van den Berg (2000). This is an equilibrium search model, in which each firm selects a specific wage and offers that wage to any worker it meets. Importantly, in this model, firms do not re-negotiate with workers who find a better-paying job – this is a key difference from our baseline model.

There are L identical workers and N heterogeneous firms. The exogenous match destruction rate is δ. The arrival rate of job offers is ϕ_0 for the unemployed and ϕ_1 for the employed. The distribution of wage offers is $\Gamma(\cdot)$, and the reservation wage is ω_r. The discount rate is ρ. Firms are heterogeneous and characterized by productivity $y \in [y_{min}, y_{max}]$, with continuous cumulative distribution function $\Psi(\cdot)$.

In this setting, firms offer $\omega(y)$ to maximize profits, where τ is the tax cut and $l(\omega)$ is the number of workers:

$$(y+\tau-\omega)l(\omega). \quad \text{(E.10)}$$

The least productive firm (y_{min}) offers ω_r: $w(y_{min}) = \omega_r$.

Following the derivations of Bontemps, Robin and Van den Berg (1999) and Bontemps, Robin and Van den Berg (2000), the reservation wage is

$$\omega_r = b + (\phi_1-\phi_0)\int_{\omega_r}^{\infty}\frac{1-\Gamma(\omega)}{\rho+\delta+\phi_1(1-\Gamma(\omega))}d\omega, \quad \text{(E.11)}$$

where b is the unemployment benefit. The equilibrium wage is

$$\omega(y) = y+\tau-\left(1+\frac{\phi_1}{\delta}(1-\Psi(y))\right)^2\left(\int_{y_{min}}^{y}\frac{1}{(1+\frac{\phi_1}{\delta}(1-\Psi(x))^2}dx+\frac{y_{min}+\tau-\omega_r}{(1+\frac{\phi_1}{\delta})^2}\right), \quad \text{(E.12)}$$

with $\Gamma(\omega(y)) = \Psi(y)$.

It follows from the wage equation that the effect of τ on $\omega(y)$ at the least productive firm is 0 (using that $\Psi(y_{min}) = 0$), and at the most productive firm is $1-\dfrac{1}{(1+\frac{\phi_1}{\delta})^2}$.

In this model, the wage offer distribution remains unchanged even if τ changes, because of the monotonicity of its effect on wage. It follows not only that the reservation wage remains unchanged, but employment is also unaffected by the tax cut.

E.4 Monopsonistic Competition

We follow Card, Cardoso, Heining and Kline (2018) in presenting a model with monopsonistic competition, with the difference that we assume homogeneous workers. This is a model with differentiated products, which endows firms with power to set wages. Importantly, unlike in our baseline model, firms do not observe workers' outside options. As in Card, Cardoso, Heining and Kline (2018), workers are fully informed about job opportunities and firms hire any worker who is willing to accept a job at the posted wage.

The utility of worker i from working at firm j is

$$U_{ij} = \lambda \ln(\omega_j - b) + \epsilon_{ij}, \tag{E.13}$$

where b is a reference wage level, and the ϵ_{ij} are independent draws from a type-I extreme value distribution. Workers then have logit choice probabilities of working at firm j:

$$p_j = \frac{(\omega_j - b)^\lambda}{\sum_{k=1}^{J}(w_k - b)^\lambda}, \tag{E.14}$$

with J denoting the number of firms in the market. Assuming that the number of firms is large, the firm-specific labor supply function is

$$\ln l(\omega_j) = \ln(p_j \cdot L) = \ln(C) + \lambda \ln(\omega_j - b), \tag{E.15}$$

where C is common to all firms in the market. Note, that aggregate labor supply is inelastic, and the elasticity of firm-level labor supply is

$$e_j = \frac{\lambda \omega_j}{\omega_j - b}, \tag{E.16}$$

which is decreasing in w_j (higher paying firms face a more inelastic labor supply).

Firms' production function is $Y_j = y_j f(l(\omega_j))$, where y_j is productivity. Firms solve the cost minimization problem, where τ is the tax cut:

$$\min_{\omega_j} (\omega_j - \tau) l(\omega_j) \text{ such that } y_j f(l(\omega_j)) \geq Y. \tag{E.17}$$

We make two assumptions. First, we assume that the production function is linear in $l(\omega_j)$, therefore $f_l = 1$. Second, we assume that the marginal revenue is a fixed constant (i.e., there is a fixed output price), normalized to one. Using these simplifying assumptions, we can derive that the impact of the tax cut on the wage is positive and the pass-through rate is between 0 and 1 (see the Supplementary Material for details). Also, the pass-through rate of τ increases in firm productivity y_j if $y_j\lambda + b > \tau(1 + \lambda)$, which holds if τ is relatively small.

Turning to the impact of the tax cut on employment, we use the labor supply result that $l(\omega_j) = C(\omega_j - b)^\lambda$, and plug in the above solution for the wage. We assume that the number of firms (J) is large and the impact of y_j on C is (approximately) zero. With this assumption,

$$\frac{\partial^2 l(\omega_j)}{\partial\tau\partial y_j} = C\lambda(\omega_j - b)^{\lambda-1}\frac{\partial^2\omega_j}{\partial\tau\partial y_j} + C\lambda(\lambda-1)(\omega_j - b)^{\lambda-2}\frac{\partial\omega_j}{\partial y_j}\frac{\partial\omega_j}{\partial\tau} + \frac{\partial C}{\partial\tau}\lambda(\omega_j - b)^{\lambda-1}\frac{\partial\omega_j}{\partial y_j}. \quad \text{(E.18)}$$

Card, Cardoso, Heining and Kline (2018) argue that a labor supply elasticity of 4 is in line with a supply-side parameter of $\lambda \approx 0.08$, thus the $\lambda < 1$ assumption is reasonable. Under this assumption, if the wage effect of the tax cut increases in firm productivity, the second and the last terms in equation (E.18) are negative (also using that C decreases in the tax cut), the first term is positive.

We do not have an analytic solution for the sign of $\frac{\partial^2 l(\omega_j)}{\partial\tau\partial y_j}$ if $b > 0$. We look at the effect of the tax cut on employment at the extreme cases. It follows that (see the Supplementary Material for details), under reasonable assumptions, the positive impact of the tax cut on wages increases with firm productivity. Intuitively, as more productive firms face a less elastic part of the labor supply curve, they need to increase wages more to attract more workers. At the same time, the share of workers employed at the most productive firms decreases. Note, that if aggregate labor supply is allowed to be elastic then employment may increase at all firms as a consequence of the tax cut, similar to what we find under the search and matching model with sequential bargaining.

When $b = 0$, we have a special case where the elasticity of labor supply is constant. In that case, there is full pass-through of the tax cut to wages without heterogeneity in the pass-through across firms. Under this specific case, the employment effect of the tax cut decreases with firm productivity.

E.5 Firm Heterogeneity with Perfectly Competitive Labor Market

We build on the seminal model of Melitz (2003) to analyze the impact of the tax cut in a model with monopolistically competitive firms. Production requires labor only. As standard in this literature, we assume that labor is inelastically supplied at its aggregate level L. Later we will relax this assumption. Each worker earns a common wage ω.[31] Consumers have constant elasticity of substitution (CES) preferences with elasticity of substitution $\sigma > 1$. There are M firms on the market, with M endogenously determined. Firms draw their random productivity y from cumulative distribution function $\Psi(\cdot)$. Entry and exit from the market is free and firms know their productivity before entry. The distribution of the productivity of firms operating in the market is given by $\mu(.)$.

Consumers' utility is

$$U = \left[\int_{j\in\Omega} x(j)^{\frac{\sigma-1}{\sigma}} dj\right]^{\frac{\sigma}{\sigma-1}}, \quad \text{(E.19)}$$

where Ω is the set of available goods, $x(j)$ is the consumption of good j, and $\sigma > 1$. Consumers' budget constraint is

$$\int_{j\in\Omega} p(j)x(j)dj = I, \quad \text{(E.20)}$$

[31] Following Melitz (2003), we normalize the nominal wage to 1 and, therefore, focus on the real wage.

where $p(j)$ is the price of good j, and I is total income. In this setting, the demand function is

$$x(j) = \frac{1}{p(j)} \left(\frac{P}{p(j)} \right)^{\sigma-1} I, \tag{E.21}$$

where P is the aggregate price.

To produce $x(y)$ unit of goods, firms must hire $\frac{1}{y}x(y)$ workers, plus need to pay f fixed labor cost (to which the tax cut does not apply).[32] Assuming monopolistic competition, firms do not consider their influence on aggregate price.

There is a productivity cut-off y^* with $\pi(y^*) = 0$, below which productivity firms do not operate. Since the tax cut decreases the cost of production, a larger tax cut implies that the productivity cut-off y^* decreases, i.e., less productive firms enter the market. The impact of the tax cut on the common real wage is positive. Neglecting the effect on the productivity cut-off, there is full pass-through of the tax cut to the real wage. The pass-through is further amplified by the effect on the productivity cut-off.[33]

Looking at the employment effects of the tax cut, low-productivity firms enter the market, consequently, employment increases at low-productivity firms. Due to inelastic labor supply, aggregate employment remains unchanged, implying that employment has to decrease at least at some firms that were producing even before the tax cut (incumbent firms). The effect of the tax cut on employment is:

$$\frac{\partial l(y,\tau)}{\partial \tau} = \frac{\partial \left(\frac{1}{y}x(y) + f \right)}{\partial \tau} = y^{\sigma-1} \frac{\sigma - 1}{\sigma} \frac{\partial \left(\left(L + \frac{\sigma}{\sigma-1} M \bar{\pi} \right) \left[\int_{y^*}^{y_{max}} y^{\sigma-1} M \mu(y) dy \right]^{-1} \right)}{\partial \tau}. \tag{E.22}$$

Since the partial derivative in the last expression is the same for each firm, it follows that if the effect of the tax cut is negative on the employment at an incumbent firm then it has to be negative for all incumbent firms. Using that $\sigma > 1$, it also follows that the effect of the tax cut on employment decreases with firm productivity:

$$\frac{\partial^2 l(y,\tau)}{\partial \tau \partial y} = (\sigma - 1) y^{\sigma-2} \frac{\sigma - 1}{\sigma} \frac{\partial \left(\left(L + \frac{\sigma}{\sigma-1} M \bar{\pi} \right) \left[\int_{y^*}^{y_{max}} y^{\sigma-1} M \mu(y) dy \right]^{-1} \right)}{\partial \tau} = \frac{\sigma - 1}{y} \frac{\partial l(y,\tau)}{\partial \tau} < 0. \tag{E.23}$$

If we relax the assumption of inelastic labor supply, the positive effect of the tax cut on real wage still holds. Aggregate employment may then increase as a consequence of the tax cut, but the heterogeneity of the effect is ambiguous. Moreover, Kushnir, Tarasov and Zubrickas (2021) show that the existence of the equilibrium is not guaranteed for higher values of the labor supply elasticity.

[32] We follow the standard approach in the literature and use $x(j)$ and $x(y)$ interchangeably as each variety j is produced by one firm characterized by productivity y, thus the output can be written as a function of y.

[33] This finding is similar to the results of Bilbiie, Ghironi and Melitz (2012), who show that deregulation and higher productivity cause steady-state marginal cost to increase. Bilbiie, Ghironi and Melitz (2012) argue that this result is due to the endogenous number of firms—higher productivity (or in our case, the tax cut) results in a more attractive business environment, which leads to more entry and a larger number of firms. This puts pressure on labor demand which leads to higher long-run marginal cost.

Supplementary Material

We provide detailed derivations on the effect of tax cuts in different labor market models.

S.1 Search and Matching with Zero Bargaining Power of Workers

First, we illustrate the impact of payroll taxes in the presence of search frictions. We introduce a tax cut in a framework with random search, heterogeneous firms, and sequential bargaining on wages (Postel-Vinay and Robin, 2002).

S.1.1 Setup

Firms are heterogeneous and characterized by productivity $y \in [y_{min}, y_{max}]$, with continuous cumulative distribution function $\Psi(\cdot)$. Workers are homogeneous. Workers are either unemployed or employed. If unemployed, they receive leisure of value b (with $b < y_{min}$) 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 exogenously with probability $\delta \in [0, 1]$.

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

$$\theta = \frac{v}{u + s(1-\delta)(1-u)}. \tag{S.24}$$

A searching worker locates an open vacancy with probability $\phi(\theta)$, increasing in θ. The probability for an open vacancy to meet a worker who is searching for jobs is $\phi(\theta)/\theta$, decreasing in θ.

Wage setting is based on sequential auction as in 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. First, we discuss the case when all the bargaining power is at the firms and so they are able to extract all rents from the workers (see e.g. Postel-Vinay and Robin, 2002 and Moscarini and Postel-Vinay, 2018).

S.1.2 Bellman Equations

The value of unemployment is the following:

$$V_u = b + \beta V_u, \tag{S.25}$$

where β is the discount factor. Thus,

$$V_u = \frac{b}{1-\beta}. \tag{S.26}$$

Notice that the probability of finding a job does not show up in the value of unemployment, which comes from the assumption that firms have all the bargaining power. We will relax that assumption later. Note also that employed workers will benefit from job offers as the competition between firms will drive up their wages.

Now we turn to specify the joint value to the firm and the worker from a match:

$$V(y,\tau) = y + \tau + \delta\beta V_u + (1-\delta)\beta V(y,\tau), \tag{S.27}$$

where τ is the lump-sum tax cut (we assume that $b+\tau < y_{min}$). Note, that since we assume that all the bargaining power is at the firms, the joint value of the match goes to the firm.

Firms need to post vacancies to find workers. The value of posting vacancies will be the following:

$$V_v(y,\tau) = \max_{\nu} \Bigg\{ -\kappa(\nu) + \beta\nu\frac{\phi(\theta)}{\theta}\Bigg(P(u)\Big[V(y,\tau) - V_u\Big] + \\ + (1-P(u))\int_{y_{min}}^{y}\Big[V(y,\tau) - V(y',\tau)\Big]d\Gamma(y')\Bigg)\Bigg\} \tag{S.28}$$

where $-\kappa(\nu)$ is the cost of posting ν vacancies, which leads to $\nu\phi(\theta)/\theta$ chance to be matched to an applicant. In the value function above,

$$P(u) = \frac{u}{(u + (1-\delta)s(1-u))} \tag{S.29}$$

reflects the probability that a randomly drawn applicant is unemployed, which leads to the $V(y,\tau) - V_u$ profits, given that firms can extract all the surplus from the match. The chance that a randomly drawn applicant is employed is $1 - P(u)$ and the benefit of this from the firm's perspective depends on the previous employer of the applicant. If the applicant works at a more productive firm, then the firm cannot attract that worker and so there is no benefit from being matched to that applicant. That is why the integral goes only to y in the above formula. Nevertheless, if the firm meets with an applicant employed at a firm with lower productivity y', then the firm can poach that worker and acquire the difference between the new surplus ($V(y,\tau)$) and the surplus at the previous firm ($V(y',\tau)$). The chance that the firm meets with an employed worker at firm y' depends on the vacancy distribution function

$$\Gamma(y) = \frac{\int_{y_{min}}^{y}\nu(y',\tau)d\Psi(y')}{\int_{y_{min}}^{y_{max}}\nu(y',\tau)d\Psi(y')}, \tag{S.30}$$

where $\nu(y,\tau)$ is the optimal choice of vacancy of a firm y at tax cut level τ.

Plugging in $V(y,\tau)$ (equation (S.27)) and V_u (equation (S.25)) into equation (S.28), leads to:

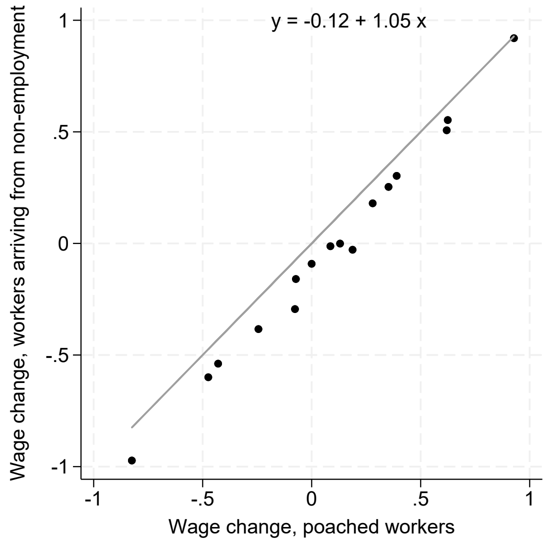
$$V_v(y,\tau) = \max_{\nu} \Bigg\{ \underbrace{-\kappa(\nu)}_{\text{Cost of vacancy}} + \underbrace{\nu\frac{\phi(\theta)}{\theta}P(u)}_{\text{Probability of meeting unemployed}} \times \underbrace{\beta\left[\frac{y+\tau}{1-\beta+\delta\beta} - \frac{1-\delta\beta}{1-\beta+\delta\beta}\frac{b}{1-\beta}\right]}_{\text{Benefit of meeting with unemployed}} + \\ + \underbrace{\nu\frac{\phi(\theta)}{\theta}(1-P(u))}_{\text{Probability of meeting employed}} \times \underbrace{\beta\int_{y_{min}}^{y}\frac{y-y'}{1-\beta+\delta\beta}\Gamma(y')}_{\text{Benefit of meeting employed}} \Bigg\}. \tag{S.31}$$

This equation highlights the key trade-offs firms face when they decide about posting a vacancy. The first part reflects the cost of posting. The second part reflects the (expected) benefit of meeting an applicant who is unemployed, while the third part reflects the (expected) benefit of meeting with an applicant who is employed. The equation also highlights the key channels through which payroll taxes affect vacancy posting and employment. In particular, the tax cut only appears in the second part of this equation, which reflects the benefits of hiring from unemployment. At the same time, the tax cut has no impact on the third part of the value of vacancy posting, hiring from employment, as all firms receive the tax cut and the competition for workers will shift the surplus from the firms to the worker. Note that this shift in incidence of the policy will take place even if firms have all the bargaining power.

The equation, therefore, highlights that the tax cut increases the benefit of hiring from unemployment, while it has no effect on hiring from employment. It is worth noting that the model predicts a difference between hiring from employment and unemployment. In Appendix Figure S1 we provide an indicative test of this prediction, which is a replication of Figure 1 of Di Addario, Kline, Saggio and Sølvsten (2023). We use the same data as in our main analysis and restrict the sample to men aged 52-57 when entering their second job (corresponding to the age group which is the focus of our analysis). Following Di Addario, Kline, Saggio and Sølvsten (2023), we plot the mean residualized change in log hiring wages between the first and second job of workers who arrived from non-employment to the second job against the mean residualized change of those who arrive from employment to the second job (i.e., poached workers).

The figure indicates that non-employment implies an average penalty of 12% on subsequent hiring wages. This is twice the penalty estimated by Di Addario, Kline, Saggio and Sølvsten (2023). The slope of the fitted line is 1.05, which indicates that the non-employment penalty is similar across the wage distribution of firms.

Appendix Figure S1: Hiring Wage Penalty for Non-employment



Note: This figure replicates Figure 1 of Di Addario, Kline, Saggio and Sølvsten (2023). The figure shows the mean change of residualized log hiring wage changes of workers arriving from non-employment (y-axis), as function of the mean change of residualized log hiring wage changes of workers poached from other firms (x-axis). Each point corresponds to a different pair of quartile of coworker wages at the first and second job. The continuous gray line is a 45-degree line. To create the figure, we use observations from 2009-2015 and restrict the sample to men. We consider wages earned in the private sector, deflated by aggregate real wage growth. We calculate the change in log hiring wages between the first and second job of workers. Here the first job is a job to which a worker entered from non-employment, and the second job is the next employment at a different firm. We consider job entries which were at most 5 years apart. We further restrict the sample to men aged 52-57 when entering the second job (corresponding to the age group which is in the focus of our analysis). Hiring wage is the average wage over the first 12 months of employment at the new job (or of fewer months if the employment lasted for less than 12 months). We perform a 90% winsorization on log hiring wages, and with an OLS regression, we net out the effect of age at entry at the first and second job, and monthly calendar date effects from the change in log hiring wages, and calculate the residuals.

S.1.3 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 (S.31). Furthermore, market tightness, θ, and the distribution of vacancies, $\Gamma(y)$, are consistent with firms' vacancy posting decisions.

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

$$L(y) = (1-\delta)\Big[1 - s\phi(\theta)(1-\Gamma(y))\Big]L(y) + \phi(\theta)\Gamma(y)u, \tag{S.32}$$

where the first term on the right-hand side captures that part of employment that survives the exogeneous separation $(1-\delta)$ and is not poached by higher productivity firms $(1 - s\phi(\theta)(1-\Gamma(y)))$, whereas the second term $(\phi(\theta)\Gamma(y)u)$ captures the employment arriving from unemployment. Employment at firms with productivity y is the derivative of $L(y)$ with respect to y:

$$l(y) = (1-\delta)\left[\Big[1 - s\phi(\theta)(1-\Gamma(y))\Big]l(y) + s\phi(\theta)\gamma(y)\int_{y_{min}}^{y} l(y')dy'\right] + \phi(\theta)\gamma(y)u. \tag{S.33}$$

The steady-state rate of unemployment is:

$$u = (1 - \phi(\theta))u + \delta(1 - u). \tag{S.34}$$

Thus,

$$u = \frac{\delta}{\delta + \phi(\theta)}. \tag{S.35}$$

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

$$\kappa'(\nu(y,\tau)) = \beta\frac{\phi(\theta)}{\theta}\left(P(u)\left[\frac{y+\tau}{1-\beta+\delta\beta} - \frac{1-\delta\beta}{1-\beta+\delta\beta}\frac{b}{1-\beta}\right] + \right.$$
$$\left. + (1-P(u))\int_{y_{min}}^{y}\left[\frac{y-y'}{1-\beta+\delta\beta}\right]d\Gamma(y')\right). \tag{S.36}$$

The equilibrium solution of θ and $\Gamma(y)$ satisfies equations (S.24), (S.29), (S.30), (S.32), (S.35) and (S.36).

S.1.4 Wage

The derivation of equilibrium wage levels 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 a firm that can deliver greater value than the current contract, but is less productive than the current firm, the contract is renegotiated and the worker stays.
3. *No change:* If neither of the above two conditions is met, the worker stays at the current firm and the wage remains unchanged.

The value of employment at firm of type y and at wage w is $V_e(w, y)$. A worker moves to a potentially better match with a firm type-y' if it offers at least the wage $\omega(y, y', \tau)$ defined by:

$$V_e(\omega(y, y', \tau), y) = V_e(y + \tau, y). \tag{S.37}$$

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

The Bellman equation for the value of employment is the following (corresponding to equation (16) of Postel-Vinay and Robin, 2002):

$$\underbrace{\left(\delta+\frac{1-\beta}{\beta}+s\phi(\theta)(1-\Gamma(q(w,y,\tau)))\right)}_{\text{Separation rate + discount rate + prob. of renegotiation or poaching}} \cdot \underbrace{V_e(w,y)}_{\text{Value of employment}} =$$

$$= \underbrace{U(w)}_{\text{Flow utility from wage}} + \underbrace{s\phi(\theta)\int_{q(w,y,\tau)}^{y} V_e(x+\tau,x)d\Gamma(x)}_{\text{Expected value from renegotiation}} +$$

$$+ \underbrace{s\phi(\theta)(1-\Gamma(y))V_e(y+\tau,y)}_{\text{Expected value from poaching}} + \underbrace{\delta V_u}_{\text{Expected value from job loss}}, \tag{S.38}$$

where $q(w,y,\tau)$ is the threshold productivity, defined by $\omega(q(w,y,\tau),y,\tau)=w$. In other words, $q(w,y,\tau)$ is the lowest productivity level y' such that competition between a type-y and a type-y' firm raises the wage above w (which equals y_{min} if $w=b$). $U(w)$ is the instantaneous utility flow from wage w. The second term on the right hand side of equation (S.38) captures the employment value after a wage increase at the current firm (reflecting that the incumbent firm needs to match the offer of the competitor), whereas the third term captures the value of employment at a higher productivity firm (after being poached, using equation (S.37)).

Assuming CRRA utility function with rate of relative risk aversion ζ ($U(x)=x^{1-\zeta}$), where $0\leq\zeta<1$, we can derive an expression for wages, following Appendix A.1. of Postel-Vinay and Robin (2002) and incorporating the tax cut (τ) into their model:

$$\ln\omega(y,y',\tau)=\frac{1}{1-\zeta}\ln\Big[(y+\tau)^{1-\zeta}-\frac{(1-\zeta)s\phi(\theta)}{\frac{1-\beta}{\beta}+\delta}\int_{y}^{y'}(1-\Gamma(x))(x+\tau)^{-\zeta}dx\Big]. \tag{S.39}$$

The wage of workers who have not been subject to wage bargaining yet is:

$$\ln\omega_u(y,\tau)=\frac{1}{1-\zeta}\ln\Big[b^{1-\zeta}-\frac{(1-\zeta)s\phi(\theta)}{\frac{1-\beta}{\beta}+\delta}\int_{y_{min}}^{y}(1-\Gamma(x))(x+\tau)^{-\zeta}dx\Big]. \tag{S.40}$$

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 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 by $\tilde{G}(q|y)$ the cumulative distribution function of the conditional distribution of bargaining position within the pool of workers within type-y firms.

$$G(w|y)=\tilde{G}(q|y)=\frac{(1+\Upsilon(1-\Gamma(y)))^2}{(1+\Upsilon(1-\Gamma(q)))^2} \tag{S.41}$$

for all $q\in\{b\}\cup[y_{min},y]$, where $\Upsilon=\phi(\theta)s/\delta$. Equation (S.41) is derived following the derivation on page 2341 of Postel-Vinay and Robin (2002).

S.1.5 Effects of the Tax Cut

We now study the effect of changing the tax cut. We describe what happens to the steady-state equilibrium when we raise the tax cut amount.

First, let us point out that hiring intensity increases in firm productivity y because both the output and the acceptance rate increase with y in the right hand side of equation (S.36). Using that $\kappa(\cdot)$ is increasing in ν leads us to Result 1.

Result 1 *Hiring intensity is increasing in firm productivity:* $\dfrac{\partial \nu(y,\tau)}{\partial y} > 0$.

Our next result follows directly from equation (S.36), using that $\kappa(\cdot)$ is increasing and convex in the amount of vacancies.

Result 2 *The partial effect of the tax cut (an increase in τ holding u constant) leads to more vacancy posting at all firms, formally* $\dfrac{\partial \nu(y,\tau)}{\partial \tau} > 0$.

An immediate consequence of Result 2 is that increased vacancy posting leads to tighter labor market. This itself lowers the equilibrium unemployment rate as it is shown in equation (S.35) (remember, $\phi(\theta)$ increases in θ).

Furthermore, equation (S.29) can be rewritten as:

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

and so $P(u)$ will decrease as a consequence of the tax cut.

Note that the decrease in $P(u)$ has a feedback equilibrium effect on vacancy posting as it affects the right hand side of (S.36). Since the maximum value firms are willing to offer, $V(y',\tau)$, must be at least as high as the value of unemployment V_u, we have $V(y',\tau) \geq V_u$ for all y'. Notice that this implies that the left hand side of (S.36) will decrease, and so will vacancy posting, since $\kappa(\cdot)$ is increasing in ν. Therefore, the equilibrium effect will dampen to some extent the immediate effect of the tax cut on vacancy posting. Nevertheless, we can rule out that the feedback effect is large enough to fully offset the initial increase in vacancy posting. To see that, assume the opposite is true and the feedback effect fully offsets the initial increase in vacancy posting. In such a situation there would be no feedback effect to begin with, leading to a contradiction.

As a consequence, the following result will be true:

Result 3 *The equilibrium unemployment rate (u) and the probability that a randomly drawn applicant is unemployed ($P(u)$) decrease in τ.*

Now we turn to discussing the heterogeneity in response to the tax cut. Firms' optimality condition – equation (S.36) – implies that the change in the right hand side is the same for all types of firms in the absence of any equilibrium effects (i.e., unemployment rate is constant). Based on the convexity of the vacancy cost function $\kappa(\cdot)$ 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.

To derive this result formally, we introduce the notation for the inverse of the first derivative of the cost function $\chi(\cdot) := (\kappa')^{-1}(\cdot)$. Using this notation, we can rewrite equation (S.36) as:

$$\nu(y,\tau) = \chi\Bigg(\beta\frac{\phi(\theta)}{\theta}\Bigg(P(u)\Bigg[\frac{y+\tau}{1-\beta+\delta\beta} - \frac{1-\delta\beta}{1-\beta+\delta\beta}\frac{b}{1-\beta}\Bigg]+ \\ + (1-P(u))\int_{y_{min}}^{y}\Bigg[\frac{y-y'}{1-\beta+\delta\beta}\Bigg]d\Gamma(y')\Bigg)\Bigg). \tag{S.43}$$

It follows that

$$\frac{\partial^2\nu(y,\tau)}{\partial\tau\partial y} = \chi''\Bigg(\beta\frac{\phi(\theta)}{\theta}\Bigg(P(u)\Bigg[\frac{y+\tau}{1-\beta+\delta\beta} - \frac{1-\delta\beta}{1-\beta+\delta\beta}\frac{b}{1-\beta}\Bigg]+ \\ + (1-P(u))\int_{y_{min}}^{y}\Bigg[\frac{y-y'}{1-\beta+\delta\beta}\Bigg]d\Gamma(y')\Bigg)\Bigg)\cdot\beta\frac{\phi(\theta)}{\theta}P(u)\frac{1}{1-\beta+\delta\beta}. \tag{S.44}$$

In this formula the terms after the $\chi''(\cdot)$ expression are positive. Thus the sign of $\chi''(\cdot)$ needs to be determined:

$$\chi''(x) = \big((\kappa')^{-1}\big)''(x) = \left(\frac{1}{\kappa'(z)}\right)' = -\kappa''(z) < 0, \tag{S.45}$$

where $z = (\kappa')^{-1}(x)$ and in the last step we used the convexity of the $\kappa(\cdot)$ function. This leads us to Result 4.

Result 4 *The partial effect of the tax cut on vacancy posting decreases with firm productivity, formally* $\frac{\partial^2\nu(y,\tau)}{\partial\tau\partial y} < 0$.

Result 4 implies that the partial effect of the policy is that employment increases more at low-quality firms than at high-quality firms. However, some of these effects will be offset by the decrease in the unemployment rate. The lower unemployment rate affects more negatively the low-quality firms than the high-quality ones (this can be seen from equation (S.28)). Unfortunately, it is not possible to derive analytically the equilibrium effect of the tax cut on the employment rate. In Section E.1.6, we provide simulation-based evidence that the equilibrium effects are small in practice and the derived partial effects dominate.

Turning to the impact of the tax cut on wages, we use equation (S.39) to derive the partial effect of the tax cut on the wage of workers who have been poached or had a wage bargaining. To simplify notation, let's use the shorthand notation $\Omega = \Big[(y+\tau)^{1-\zeta} - \frac{(1-\zeta)s\phi(\theta)}{\frac{1-\beta}{\beta}+\delta}\int_y^{y'}(1-$

$\Gamma(x))(x+\tau)^{-\zeta}dx\Big]$.

$$\frac{\partial \ln \omega(y, y', \tau)}{\partial y'} = \frac{1}{1-\zeta}\frac{1}{\Omega}\left[- \frac{(1-\zeta)s\phi(\theta)}{\frac{1-\beta}{\beta}+\delta}(1-\Gamma(y'))(y'+\tau)^{-\zeta}\right]. \tag{S.46}$$

From this, we derive how the partial effect of the tax cut varies with firm productivity:

$$\frac{\partial^2 \ln \omega(y, y', \tau)}{\partial \tau \partial y'} = \frac{1}{1-\zeta}\frac{1}{\Omega^2}\frac{(1-\zeta)s\phi(\theta)}{\frac{1-\beta}{\beta}+\delta}\left[\Omega\zeta(1-\Gamma(y'))(y'+\tau)^{-\zeta-1} + (1-\Gamma(y'))(y'+\tau)^{-\zeta}\frac{\partial \Omega}{\partial \tau}\right], \tag{S.47}$$

which is clearly non-negative (positive except for at $y' = y_{max}$, where it reaches zero), using that $0 \leq \zeta < 1$. Note also that based on (S.39), the partial effect of the tax cut on the logarithmic wage and wage level of incumbents is positive at all levels of y and y'. We focus on the effect of the tax cut on the level of the wage, because in the empirical application, we estimate the effect of the tax cut *rate* on the log wage, which corresponds to the effect of the tax cut on the wage level. Let's denote by $\tilde{\omega}(y', \tau)$ the average wage at a firm with productivity y'. Equation (S.47) shows that the impact of the tax cut on log wages, given y, increases with firm productivity. Ignoring the impact of the tax cut on the composition of incumbents, it follows that the impact of the tax cut on $\tilde{\omega}(y', \tau)$ also increases with firm productivity. Therefore,

$$0 \leq \frac{\partial^2 \ln \tilde{\omega}(y', \tau)}{\partial \tau \partial y'} = \frac{1}{\tilde{\omega}}\frac{\partial^2 \tilde{\omega}(y', \tau)}{\partial \tau \partial y'} - \frac{1}{\tilde{\omega}^2}\frac{\partial \tilde{\omega}(y', \tau)}{\partial \tau}\frac{\partial \tilde{\omega}(y', \tau)}{\partial y'}. \tag{S.48}$$

Based on (S.39), $\frac{\partial \omega(y, y'\tau)}{\partial \tau} > 0$, therefore, ignoring composition effects, $\frac{\partial \tilde{\omega}(y'\tau)}{\partial \tau} > 0$. It follows that the non-negativity of $\frac{\partial \tilde{\omega}(y', \tau)}{\partial y'}$ is sufficient for $\frac{\partial^2 \tilde{\omega}(y', \tau)}{\partial \tau \partial y'}$ being also non-negative. Under standard assumptions (see pages 2317-2318 of Postel-Vinay and Robin, 2002), the non-negativity of $\frac{\partial \tilde{\omega}(y', \tau)}{\partial y'}$ holds. This leads us to Result 5.

Result 5 *Ignoring the impact of the tax cut on the composition of incumbents at a firm, the effect of the tax cut on wages is on average positive for workers who already had a wage bargaining or have been poached. This effect increases with firm productivity* $\Big(\frac{\partial^2 \tilde{\omega}(y', \tau)}{\partial \tau \partial y'} \geq 0\Big)$.

The wages at the lowest productivity firm are determined by equation (S.40), because once an employer receives an alternative offer she is poached by the competing (more productive) firm. As the option value is zero at the lowest productivity firms, the partial effect of the tax cut on wages is also zero for workers at the lowest productivity firms.

At firms above the lowest productivity, the partial effect of the tax cut on the wage of workers who had not had a wage bargaining is positive (the same reasoning applies as for the wage of the incumbents). Whether this positive effect increases with firm productivity depends on the relative role of the option value, since due to the option value, $\frac{\partial \omega_u(y, \tau)}{\partial y} < 0$.

Therefore, even though $\frac{\partial \ln \omega_u(y,\tau)}{\partial\tau\partial y} \geq 0$ holds, it does not necessarily follow that $\frac{\partial \omega_u(y,\tau)}{\partial\tau\partial y} \geq 0$ is also satisfied.

Result 6 *The partial effect of the tax cut on wages of workers arriving from unemployment (who have not had a wage bargaining) is zero at the lowest productivity firms and positive at higher productivity levels:* $\dfrac{\partial \omega_u(y,\tau)}{\partial \tau} = 0$ *if* $y = y_{min}$ *and* $\dfrac{\partial \omega_u(y,\tau)}{\partial \tau} > 0$ *if* $y > y_{min}$.

The equilibrium effect of the tax cut on wages cannot be derived analytically. First, its positive effect on $\phi(\theta)$ increases the negative wage implications of the option value in equations (S.39) and (S.40). On the other hand, we know from from Result 4 that the tax cut shifts the distribution of vacancies towards less productive firms, thus $(1-\Gamma)$ decreases as a consequence of the tax cut but this decreasing effect varies with firm productivity.

Note also that the wages of new entrants are driven by equation (S.40). Intuitively, younger 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 an 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. Also, the firm heterogeneity in the employment effects of the tax cut is smaller if all workers are new entrants since then low- and high-productivity firms hire from unemployment to the same extent, thus low-productivity firms no longer benefit disproportionately more from the tax cut.

S.2 Search and Matching with Non-zero Bargaining Power of Workers

In our baseline model presented in section S.1, we assumed that all the bargaining power is at firms, therefore they are able to extract all rents from the workers. Now, following Cahuc, Postel-Vinay and Robin (2006), we allow workers to have bargaining power. Also, as in Cahuc, Postel-Vinay and Robin (2006), we assume linear utility function ($U(x) = x$).

We follow the notation of our baseline model and denote by λ the bargaining power of workers.

The value of unemployment is the following:

$$V_u(\tau) = b + \beta\phi(\theta)\lambda \int_{y_{min}}^{y_{max}} V(x,\tau)d\Gamma(x) + \beta\phi(\theta)(1-\lambda)V_u(\tau) + \beta(1-\phi(\theta))V_u(\tau) =$$

$$= b + \beta\phi(\theta)\lambda \int_{y_{min}}^{y_{max}} V(x,\tau)d\Gamma(x) + \beta(1-\lambda)V_u(\tau), \quad \text{(S.49)}$$

where b is the value of leisure received when unemployed, β is the discount factor, $\phi(\theta)$ is the probability of locating an open vacancy, $y \in [y_{min}, y_{max}]$ is firm productivity, $\Gamma(\cdot)$ is vacancy distribution, and τ is the lump-sum tax cut. This expression differs from the value of unemployment in our baseline model (equation (S.25)) in that now, due to the presence of bargaining power, the value from a match is included in the value of unemployment. Since the value of the match increases in the tax cut, it also implies that the value of unemployment is positively related to the tax cut.

The joint value to the firm and the worker from a match is:

$$V(y,\tau) = y + \tau + \delta\beta V_u + (1-\delta)\beta V(y,\tau) + \lambda(1-\delta)\beta s\phi(\theta)\int_y^{y_{max}} (V(x,\tau) - V(y,\tau))d\Gamma(x), \tag{S.50}$$

where δ is the separation probability, s is the probability of job search if employed. The last term on the right hand side is new compared to the no-bargaining-power value function (equation (S.27)), reflecting the value workers derive from job offers.

The value of posting vacancies is the same as before (equation (S.28)), except for the benefit from posting a vacancy is now multiplied by $(1-\lambda)$:

$$V_v(y,\tau) = \max_{\nu}\Bigg\{ -\kappa(\nu) + \beta\nu\frac{\phi(\theta)}{\theta}(1-\lambda)\Bigg[P(u)\Big(V(y,\tau) - V_u(\tau)\Big) + + (1-P(u))\int_{y_{min}}^{y}\Big(V(y,\tau) - V(x,\tau)\Big)d\Gamma(x)\Bigg]\Bigg\}. \tag{S.51}$$

As before, the tax cut has no impact on the last part of the value of vacancy posting, hiring from employment, as all firms receive the tax cut and the competition for workers will shift the surplus from the firms to the worker. The tax cut affects the benefits of hiring from unemployment. However, since τ increases $V_u(\tau)$, this benefit is smaller than when workers have no bargaining power.

Based on equation (A.15) in Cahuc, Postel-Vinay and Robin (2006), the equilibrium wage of worker at type-y' firm previously employed at type-y firm is:

$$\omega(y,y',\tau) = \lambda(y'+\tau) + (1-\lambda)(y+\tau) - (1-\lambda)^2 s\phi(\theta)\int_y^{y'}\frac{(1-\Gamma(x))}{\frac{1-\beta}{\beta} + \delta + s\phi(\theta)\lambda(1-\Gamma(x))}dx. \tag{S.52}$$

Therefore, without considering the equilibrium effects, there is a full pass-through of the tax cut to the wage of poached workers. The equilibrium wage of a worker arriving from unemployment is (based on equation (A.17) of Cahuc, Postel-Vinay and Robin, 2006):

$$\omega_u(y,\tau) = \lambda(y+\tau) + (1-\lambda)y_{min} - (1-\lambda)^2 s\phi(\theta)\int_{y_{min}}^{y}\frac{(1-\Gamma(x))}{\frac{1-\beta}{\beta} + \delta + s\phi(\theta)\lambda(1-\Gamma(x))}dx. \tag{S.53}$$

Since workers have some bargaining power, the tax cut also increases the wage of workers arriving from unemployment, even without considering the general equilibrium effects.

To summarize, in a model à la Cahuc, Postel-Vinay and Robin (2006), firms still get surplus from the tax cut if they hire from unemployment, but less than if all bargaining power were at firms. As in our baseline model, since low-productivity firms tend to hire from unemployment, they will benefit disproportionately more from the tax cut. Competition between firms implies that the tax cut will benefit the workers more if they are poached or if they received an offer from another firm. However, the relative benefit compared to being hired from unemployment is smaller if workers have some bargaining power.

S.3 Search and Matching with Wage Posting

We build on the wage posting model of Burdett and Mortensen (1989) and Burdett and Mortensen (1998), and follow specifically the framework of Bontemps, Robin and Van den Berg (1999) and Bontemps, Robin and Van den Berg (2000). This is an equilibrium search model, in which each firm selects a specific wage and offers that wage to any worker it meets. Importantly, in this model, firms do not re-negotiate with workers who find a better-paying job – this is a key difference from our baseline model.

There are L identical workers and N heterogeneous firms. The exogenous match destruction rate is δ. The arrival rate of job offers is ϕ_0 for the unemployed and ϕ_1 for the employed. The distribution of wage offers is $\Gamma(\cdot)$, and the reservation wage is ω_r. The discount rate is ρ. Firms are heterogeneous and characterized by productivity $y \in [y_{min}, y_{max}]$, with continuous cumulative distribution function $\Psi(\cdot)$.

In this setting, firms offer $\omega(y)$ to maximize profits, where τ is the tax cut and $l(\omega)$ is the number of workers:

$$(y + \tau - \omega)l(\omega). \tag{S.54}$$

The least productive firm (y_{min}) offers ω_r: $w(y_{min}) = \omega_r$.

Following the derivations of Bontemps, Robin and Van den Berg (1999) and Bontemps, Robin and Van den Berg (2000), equilibrium outcomes of this model are the following. Employment is

$$l(\omega) = \frac{L}{N} \frac{1 + \frac{\phi_1}{\delta}}{(1 + \frac{\phi_1}{\delta}(1 - \Gamma(\omega))^2}. \tag{S.55}$$

The reservation wage is

$$\omega_r = b + (\phi_1 - \phi_0) \int_{\omega_r}^{\infty} \frac{1 - \Gamma(\omega)}{\rho + \delta + \phi_1(1 - \Gamma(\omega))} d\omega, \tag{S.56}$$

where b is the unemployment benefit. The equilibrium wage is

$$\omega(y) = y + \tau - \left(1 + \frac{\phi_1}{\delta}(1 - \Psi(y))\right)^2 \left(\int_{y_{min}}^{y} \frac{1}{(1 + \frac{\phi_1}{\delta}(1 - \Psi(x))^2} dx + \frac{y_{min} + \tau - \omega_r}{(1 + \frac{\phi_1}{\delta})^2} \right), \tag{S.57}$$

with $\Gamma(\omega(y)) = \Psi(y)$.

It follows from the wage equation that the effect of τ on $\omega(y)$ at the least productive firm is 0 (using that $\Psi(y_{min}) = 0$), and at the most productive firm is $1 - \frac{1}{(1 + \frac{\phi_1}{\delta})^2}$.

In this model, the wage offer distribution remains unchanged even if τ changes, because of the monotonicity of its effect on wage. It follows not only that the reservation wage remains unchanged, but employment is also unaffected by the tax cut.

S.4 Monopsonistic Competition

We follow Card, Cardoso, Heining and Kline (2018) in presenting a model with monopsonistic competition, with the difference that we assume homogeneous workers. This is a model with differentiated products, which endows firms with power to set wages. Importantly, unlike in our baseline model, firms do not observe workers' outside options. As in Card, Cardoso, Heining and Kline (2018), workers are fully informed about job opportunities and firms hire any worker who is willing to accept a job at the posted wage.

The utility of worker i from working at firm j is

$$U_{ij} = \lambda \ln(\omega_j - b) + \epsilon_{ij}, \tag{S.58}$$

where b is a reference wage level, and the ϵ_{ij} are independent draws from a type-I extreme value distribution. Workers then have logit choice probabilities of working at firm j:

$$p_j = \frac{(\omega_j - b)^\lambda}{\sum_{k=1}^{J}(w_k - b)^\lambda}, \tag{S.59}$$

with J denoting the number of firms in the market. Assuming that the number of firms is large, the firm-specific labor supply function is

$$\ln l(\omega_j) = \ln(p_j \cdot L) = \ln(C) + \lambda \ln(\omega_j - b), \tag{S.60}$$

where C is common to all firms in the market:

$$C = L\Big(\sum_{k=1}^{J}(w_k - b)^\lambda\Big)^{-1}, \tag{S.61}$$

Note, that aggregate labor supply is inelastic – aggregate labor supply equals to L:

$$\sum_{k=1}^{J} l(\omega_k) = C\sum_{k=1}^{J}(\omega_k - b)^\lambda = L. \tag{S.62}$$

The elasticity of firm-level labor supply is

$$e_j = \frac{\lambda\omega_j}{\omega_j - b}, \tag{S.63}$$

which is decreasing in w_j (higher paying firms face a more inelastic labor supply).

Firms' production function is $Y_j = y_j f(l(\omega_j))$, where y_j is productivity. Firms solve the cost minimization problem, where τ is the tax cut:

$$\min_{\omega_j}(\omega_j - \tau)l(\omega_j) \text{ such that } y_j f(l(\omega_j)) \geq Y. \tag{S.64}$$

The first-order condition equates the marginal factor cost to the marginal revenue product:

$$(\omega_j - \tau)\frac{1 + e_j}{e_j} = y_j f_l \mu_j, \tag{S.65}$$

where e_j is the elasticity of labor supply, and μ_j is the marginal cost of production which is equal to marginal revenue at the optimal Y. To simplify the following derivations, we make two assumptions. First, we assume that the production function is linear in $l(\omega_j)$, therefore $f_l = 1$. Second, we assume that the marginal revenue is a fixed constant (i.e., there is a fixed output price), normalized to one. Using these simplifying assumptions and plugging in the elasticity of labor supply formula,

$$(\omega_j - \tau)\frac{\omega_j - b + \lambda\omega_j}{\lambda\omega_j} = y_j. \tag{S.66}$$

After rearrangement,

$$\omega_j\frac{1+\lambda}{\lambda} - \frac{b}{\lambda} - \tau\Big(\frac{1+\lambda}{\lambda} - \frac{b}{\lambda\omega_j}\Big) = y_j, \tag{S.67}$$

$$\omega_j = y_j\frac{\lambda}{1+\lambda} + \frac{b}{1+\lambda} + \tau\Big(1 - \frac{b}{(1+\lambda)\omega_j}\Big). \tag{S.68}$$

This leads to the quadratic equation:

$$\omega_j^2 - \Big(y_j\frac{\lambda}{1+\lambda} + \frac{b}{1+\lambda} + \tau\Big)\omega_j + \frac{\tau b}{1+\lambda} = 0. \tag{S.69}$$

Using that $\omega_j \geq b$, the unique viable solution of the wage equation is:

$$\begin{aligned}\omega_j = \frac{1}{2}\Bigg[& y_j\frac{\lambda}{1+\lambda} + \frac{b}{1+\lambda} + \tau + \\ & + \left(\Big(y_j\frac{\lambda}{1+\lambda}\Big)^2 + \Big(\frac{b}{1+\lambda}\Big)^2 + \tau^2 + y_j\frac{2\lambda b}{(1+\lambda)^2} + \frac{2\tau}{1+\lambda}(y_j\lambda - b)\right)^{1/2}\Bigg].\end{aligned} \tag{S.70}$$

Differentiating the wage equation with respect to τ shows that the impact of the tax cut on the wage is positive and the pass-through rate is between 0 and 1:

$$\frac{\partial\omega_j}{\partial\tau} = \frac{1}{2} + \frac{1}{2}\left[\frac{\Big(\tau + \frac{y_j\lambda - b}{1+\lambda}\Big)^2}{\Big(\tau + \frac{y_j\lambda - b}{1+\lambda}\Big)^2 + \frac{4y\lambda b}{(1+\lambda)^2}}\right]^{1/2}, \tag{S.71}$$

Also, the pass-through rate of τ increases in firm productivity y_j if $y_j\lambda + b > \tau(1+\lambda)$, which holds if τ is relatively small.

Turning to the impact of the tax cut on employment, we use the labor supply result that $l(\omega_j) = C(\omega_j - b)^\lambda$, and plug in the above solution for the wage. We assume that the number of firms (J) is large and the impact of y_j on C is (approximately) zero. With this assumption,

$$\begin{aligned}\frac{\partial^2 l(\omega_j)}{\partial\tau\partial y_j} &= \frac{\partial\Big(C\lambda(\omega_j - b)^{\lambda-1}\frac{\partial\omega_j}{\partial y_j}\Big)}{\partial\tau} = \\ &= C\lambda(\omega_j - b)^{\lambda-1}\frac{\partial^2\omega_j}{\partial\tau\partial y_j} + C\lambda(\lambda-1)(\omega_j - b)^{\lambda-2}\frac{\partial\omega_j}{\partial y_j}\frac{\partial\omega_j}{\partial\tau} + \frac{\partial C}{\partial\tau}\lambda(\omega_j - b)^{\lambda-1}\frac{\partial\omega_j}{\partial y_j}.\end{aligned} \tag{S.72}$$

Card, Cardoso, Heining and Kline (2018) argue that a labor supply elasticity of 4 is in line with a supply-side parameter of $\lambda \approx 0.08$, thus the $\lambda < 1$ assumption is reasonable. Under this assumption, if the wage effect of the tax cut increases in firm productivity, the second and the last terms in equation (S.72) are negative (also using that C decreases in the tax cut), the first term is positive.

We do not have an analytic solution for the sign of $\frac{\partial^2 l(\omega_j)}{\partial\tau\partial y_j}$ if $b > 0$. In this case, we look at the effect of the tax cut on employment at the extreme cases. The effect of the tax cut on employment is:

$$\frac{\partial l(w_j)}{\partial\tau} = \frac{\partial C}{\partial\tau}(w_j - b)^{\lambda} + C\lambda(w_j - b)^{\lambda-1}\frac{\partial w_j}{\partial\tau}. \tag{S.73}$$

In this expression, the first term is negative, the second term is positive. At the lowest productivity firm, $w_j \to b$, thus the first term in equation (S.73) approaches zero and the second term goes to infinity (using that $\frac{\partial w_j}{\partial\tau}$ is finite, between 0 and 1, and $\lambda < 1$). On the other hand, if firm productivity approaches infinity then $w_j \to \infty$, thus the first first term in equation (S.73) approaches $-\infty$ (using that $\frac{\partial C}{\partial\tau} < 0$) and the second term goes to zero.

It therefore follows that, under reasonable assumptions, the positive impact of the tax cut on wages increases with firm productivity. Intuitively, as more productive firms face a less elastic part of the labor supply curve, they need to increase wages more to attract more workers. At the same time, the share of workers employed at the most productive firms decreases.

Note, that if aggregate labor supply is allowed to be elastic then employment may increase at all firms as a consequence of the tax cut, similar to what we find under the search and matching model with sequential bargaining.

When $b = 0$, we have a special case where the elasticity of labor supply is constant (see equation (S.63)). In that case, there is full pass-through of the tax cut to wages without heterogeneity in the pass-through across firms. This is because if $b = 0$, the wage equation (equation (S.70)) simplifies to:

$$\omega_j = \frac{1}{2}\left[y_j\frac{\lambda}{1+\lambda} + \tau + \left(\left(y_j\frac{\lambda}{1+\lambda}\right)^2 + \tau^2 + \frac{2\tau}{1+\lambda}y_j\lambda\right)^{1/2}\right] = y_j\frac{\lambda}{1+\lambda} + \tau. \tag{S.74}$$

Under this specific case, the employment effect of the tax cut decreases with firm productivity. This follows from equation (S.73), setting $b = 0$ and plugging in the formula of C:

$$\frac{\partial l(w_j)}{\partial\tau} = L\left(\sum_{k=1}^{J}\omega_k^{\lambda}\right)^{-2}\frac{\lambda}{\lambda+1}\left[\omega_j^{\lambda-1}\sum_{k=1}^{J}\omega_k^{\lambda} - \omega_j^{\lambda}\sum_{k=1}^{J}\omega_k^{\lambda-1}\right], \tag{S.75}$$

where the expression in the square brackets is clearly positive at the lowest productivity (lowest wage) firm and negative at the highest productivity (highest wage) firm.

S.5 Firm Heterogeneity with Perfectly Competitive Labor Market

We build on the seminal model of Melitz (2003) to analyze the impact of the tax cut in a model with monopolistically competitive firms. Production requires labor only. As standard in this literature, we assume that labor is inelastically supplied at its aggregate level L.

Later we will relax this assumption. Each worker earns a common wage ω.[34] Consumers have constant elasticity of substitution (CES) preferences with elasticity of substitution $\sigma > 1$. There are M firms on the market, with M endogenously determined. Firms draw their random productivity y from cumulative distribution function $\Psi(\cdot)$. Entry and exit from the market is free and firms know their productivity before entry. The distribution of the productivity of firms operating in the market is given by $\mu(.)$.

Consumers' utility is

$$U = \left[\int_{j\in\Omega} x(j)^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}}, \tag{S.76}$$

where Ω is the set of available goods, $x(j)$ is the consumption of good j, and $\sigma > 1$. Consumers' budget constraint is

$$\int_{j\in\Omega} p(j)x(j)dj = I, \tag{S.77}$$

where $p(j)$ is the price of good j, and I is total income. In this setting, the demand function is

$$x(j) = \frac{1}{p(j)} \left(\frac{P}{p(j)} \right)^{\sigma-1} I, \tag{S.78}$$

where P is the aggregate price:

$$P = \left[\int_{j\in\Omega} p(j)^{1-\sigma} dj \right]^{\frac{1}{1-\sigma}}. \tag{S.79}$$

To produce $x(y)$ unit of goods, firms must hire $\frac{1}{y}x(y)$ workers, plus need to pay f fixed labor cost (to which the tax cut does not apply).[35] The profit function with τ as the tax cut is:

$$\pi(y) = p(y)x(y) - \frac{\omega-\tau}{y}x(y) - f. \tag{S.80}$$

Assuming monopolistic competition, firms do not consider their influence on aggregate price. The first order condition for the price level is:

$$p(y) = \frac{\sigma}{\sigma-1}\frac{\omega-\tau}{y}. \tag{S.81}$$

There is a productivity cut-off y^* with $\pi(y^*) = 0$, below which productivity firms do not operate. It also follows that

$$P = \frac{\sigma}{\sigma-1}(\omega-\tau) \left[\int_{y^*}^{y_{max}} y^{\sigma-1} M\mu(y)dy \right]^{\frac{1}{1-\sigma}}, \tag{S.82}$$

[34] Following Melitz (2003), we normalize the nominal wage to 1 and, therefore, focus on the real wage.
[35] We follow the standard approach in the literature and use $x(j)$ and $x(y)$ interchangeably as each variety j is produced by one firm characterized by productivity y, thus the output can be written as a function of y.

$$x(y) = y^{\sigma} \frac{I}{\omega - \tau} \frac{\sigma - 1}{\sigma} \left[\int_{y^*}^{y_{max}} y^{\sigma-1} M\mu(y) dy \right]^{-1}, \tag{S.83}$$

and the real wage is

$$\frac{\omega}{P} = \frac{\sigma - 1}{\sigma} \left[\int_{y^*}^{y_{max}} y^{\sigma-1} M\mu(y) dy \right]^{\frac{1}{\sigma-1}} + \frac{\tau}{P}. \tag{S.84}$$

Since the tax cut decreases the cost of production, a larger tax cut implies that the productivity cut-off y^* decreases, i.e., less productive firms enter the market. The impact of the tax cut on the common real wage is positive. Neglecting the effect on the productivity cut-off, there is full pass-through of the tax cut to the real wage. The pass-through is further amplified by the effect on the productivity cut-off.[36]

The firm-specific employment is:

$$l(y, \tau) = y^{\sigma-1} \frac{I}{\omega - \tau} \frac{\sigma - 1}{\sigma} \left[\int_{y^*}^{y_{max}} y^{\sigma-1} M\mu(y) dy \right]^{-1} + f, \tag{S.85}$$

and aggregate employment is:

$$L = \int_{y^*}^{y_{max}} l(y, \tau) M\mu(y) dy = \frac{I}{\omega - \tau} \frac{\sigma - 1}{\sigma} + Mf. \tag{S.86}$$

Turning back to the profit function, and denoting the firm-specific revenue with $r(y)$, we can rewrite the profit function as:

$$\pi(y) = r(y) \Big(1 - \frac{\omega - \tau}{yp(y)} \Big) - f = \frac{r(y)}{\sigma} - f. \tag{S.87}$$

Denoting the average revenue with $\bar{r}$ and the average profit with $\bar{\pi}$, it follows that:

$$\sigma M\bar{\pi} = M\bar{r} - \sigma Mf = L - \sigma Mf, \tag{S.88}$$

where in the last step we used that in equilibrium, aggregate revenue needs to equal total payment to labor, and that $\omega = 1$. Now, it follows that after rearranging equation (S.86) and using that $\omega = 1$,

$$I = (1-\tau) \Big(\frac{\sigma}{\sigma - 1} L - \frac{\sigma}{\sigma - 1} Mf \Big) = (1-\tau) \Big(\frac{\sigma}{\sigma - 1} L - \frac{L - \sigma M\bar{\pi}}{\sigma - 1} \Big) = (1-\tau) \Big(L + \frac{\sigma}{\sigma - 1} M\bar{\pi} \Big). \tag{S.89}$$

[36] This finding is similar to the results of Bilbiie, Ghironi and Melitz (2012), who show that deregulation and higher productivity cause steady-state marginal cost to increase. Bilbiie, Ghironi and Melitz (2012) argue that this result is due to the endogenous number of firms—higher productivity (or in our case, the tax cut) results in a more attractive business environment, which leads to more entry and a larger number of firms. This puts pressure on labor demand which leads to higher long-run marginal cost.

Therefore, income equals unit labor cost multiplied by aggregate labor plus aggregate profits times the markup.

Looking at the employment effects of the tax cut, low-productivity firms enter the market, consequently, employment increases at low-productivity firms. Due to inelastic labor supply, aggregate employment remains unchanged, implying that employment has to decrease at least at some firms that were producing even before the tax cut (incumbent firms). The effect of the tax cut on employment is:

$$\frac{\partial l(y,\tau)}{\partial \tau} = \frac{\partial\Big(\frac{1}{y}x(y)+f\Big)}{\partial \tau} = y^{\sigma-1}\frac{\sigma-1}{\sigma}\frac{\partial\Big(\big(L+\frac{\sigma}{\sigma-1}M\bar{\pi}\big)\Big[\int_{y^*}^{y_{max}} y^{\sigma-1}M\mu(y)dy\Big]^{-1}\Big)}{\partial \tau}. \tag{S.90}$$

Since the partial derivative in the last expression is the same for each firm, it follows that if the effect of the tax cut is negative on the employment at an incumbent firm then it has to be negative for all incumbent firms. Using that $\sigma > 1$, it also follows that the effect of the tax cut on employment decreases with firm productivity:

$$\frac{\partial^2 l(y,\tau)}{\partial \tau \partial y} = (\sigma-1)y^{\sigma-2}\frac{\sigma-1}{\sigma}\frac{\partial\Big(\big(L+\frac{\sigma}{\sigma-1}M\bar{\pi}\big)\Big[\int_{y^*}^{y_{max}} y^{\sigma-1}M\mu(y)dy\Big]^{-1}\Big)}{\partial \tau} = \frac{\sigma-1}{y}\frac{\partial l(y,\tau)}{\partial \tau} < 0. \tag{S.91}$$

If we relax the assumption of inelastic labor supply, the positive effect of the tax cut on real wage still holds. Aggregate employment may then increase as a consequence of the tax cut, but the heterogeneity of the effect is ambiguous. Moreover, Kushnir, Tarasov and Zubrickas (2021) show that the existence of the equilibrium is not guaranteed for higher values of the labor supply elasticity.