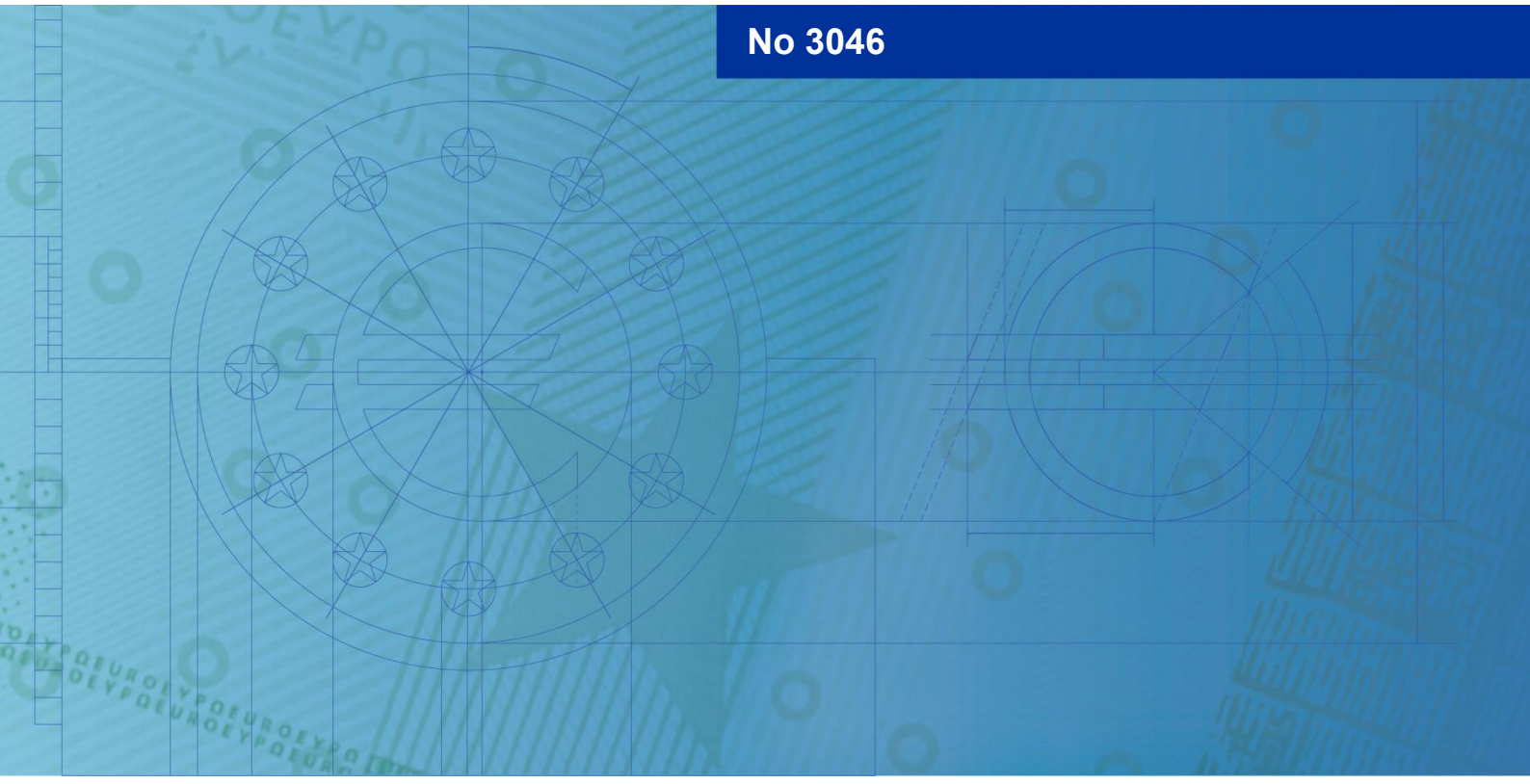
EUROPEAN CENTRAL BANK

Working Paper Series

Alina Bobasu, Amalia Repele

Effects of monetary policy on labor income: the role of the employer

No 3046



Abstract

This paper investigates the role of firms in the transmission of monetary policy to individual labor market outcomes, both the intensive and extensive margins. Using German matched employer-employee administrative data, we study the effects of monetary policy shocks on individual employment and labor income conditioning on the firm characteristics. First, we find that the employment of workers in young firms are especially sensitive to monetary policy shocks. Second, wages of workers in large firms react relatively more, with some pronounced asymmetries: differences between large and small firms are more evident during monetary policy easing. The differential wage response is driven by above-median workers and cannot be fully explained by a worker component. Notably, larger firms adjust wages more significantly despite experiencing similar changes in investment and turnover compared to smaller firms. Furthermore, monetary policy tightening disproportionately impacts low-skilled and low-wage earners, while easings amplify inequality due to substantial wage increases for top earners. Overall, the effect of monetary policy on inequalities is however larger in easing periods – driven by a large increase in wages for top earners.

Keywords: labor market, workers type, employment, monetary policy.
JEL-Classification: E24, E52, E58.

Non-technical summary

The effects of monetary policy on economic inequality have gained attention in the public debate, fueled by the extensive asset purchase programs central banks have undertaken over the last decade, and more recently by the sharp tightening implemented by central banks in response to rising inflation. The impact and distributional effects of monetary policy on individual labor market outcomes, both in the intensive and extensive margins, remains an open question in the literature, and is relevant as labor is the major source of income for most households.

In this paper, we characterize at the micro level the impact of monetary policy interventions on employment probabilities and labor income outcomes within and across heterogeneous firms and workers. We focus on Germany (1999 to 2018) and use a matched employer-employee dataset.

We start by investigating whether firms' size and age determine differential workers' employment response to monetary policy shocks. We show that workers in young firms have an employment probability that moves more with monetary policy interventions compared to workers in more established firms. Inversely, firm size is not a relevant dimension for differential employment response. The response of employment seems to be driven by a combination of firm and worker effects.

Second, we focus on the individual wage response to monetary policy shocks. We find that monetary policy shocks affect wages of workers employed in small firms by relatively less, compared to wages of workers in bigger firms. The differential is present within industries and across regions, and is robust to a series of sensitivity analyses. We find strong evidence of asymmetric effects, with wages reacting more in easing than in tightening episodes, and the difference between small and large firms more exacerbated in easings. Using quantile regressions, we then show that the differential response by firm type is only significant for above-median earners. Instead, we find that firm age is irrelevant. We also show that the estimated coefficient is not driven by workers changing employer, neither by the form of collective bargaining agreement nor minimum wages. Moreover, the worker type alone cannot explain the differential response, and highlight a potential role played by the pass-through of firms' profit to wages. Moving to firm-level regressions, we find that while firm size does not determine differential reaction of firm investment or turnover to monetary policy shocks, it does so for total wage bill. Consistently, we find that our baseline effect is particularly strong in firms offering a variable pay structure, with potential indexation of wages to equity or profits. Overall, our analysis points to a heterogeneous ability of firms to adapt wages, larger ones having more space to do so.

Finally, we explore the effect of monetary policy shocks on inequality by focusing on the differential effect of the shocks by worker type. We find evidence that wages of "high-type" workers generally react more to monetary policy shocks. However, tightenings systematically disadvantage low skilled and low wage workers, on both the employment and wage margin. Instead, easings benefit particularly the top of the wage distributions, who experiences relatively larger wage in-

creases. Monetary policy easings thus increase inequality because of the top, while tightenings increase inequality at the bottom (although to a smaller extent).

1 Introduction

The effects of monetary policy on labour market outcomes have gained attention in the public debate, fueled by the extensive asset purchase programs central banks have undertaken over the last decade, and more recently by the sharp tightening implemented in response to rising inflation. The impact and distributional effects of monetary policy on both the extensive and intensive margins of the labour market remains an open question in the literature, and is relevant as labor is the major source of income for most households.

Although there is no direct theoretical link between monetary policy shocks and individual employment and labor income developments, workers are likely to be systematically affected by monetary policy through their work relationship. First, firms may be differently affected by monetary policy shocks through indirect general equilibrium effect. Recent literature in heterogeneous agent macroeconomics underlines the economic relevance of such indirect channels (Violante, 2021). Moreover, a long literature since the seminal paper of Gertler and Gilchrist (1994) highlights a credit channel of monetary policy transmission, whereby tightening affect small and young firms more strongly because the latter typically face larger credit frictions. Monetary policy may also affect firms' profits (Lieberknecht and Hartwig, 2020; González et al., 2022). Such differential firm exposure implies differential worker exposure to monetary policy shocks, which may be systematical in the presence of labor market sorting.[1] Second, even if all firms are affected to the same degree by monetary policy, they might still decide to pass through the shock differently to their workforce. In other words, different firms may offer different income insurance to their workers. Finally, institutional features such as collective wage bargaining agreements and minimum wage policies may also shape the way firms are able to adjust wages or employment following shocks. The different channels together determine the combined response of wages and employment, with a possible interaction between the two margins. In that sense, firms characteristics may affect the transmission of monetary policy as well as labor income inequality.

In this paper, we characterize at the micro level the impact of monetary policy interventions on employment probabilities and labor income outcomes within and across heterogeneous firms and workers. We focus on Germany (1999 to 2018) and use a matched employer-employee dataset compiled by the Federal Employment Agency that allows us to track employment histories to the day and offers good-quality wage data. We merge this granular data to the Euro Area monetary

[1] In Germany, Lochner and Schulz (2016) document a strong and increasing sorting between workers and firms in the labor market. Hagedorn et al. (2017) also find a strong degree of sorting with a rank correlation of 0.75 correlation between firm and worker type in Germany. Therefore, if a certain type of firm is more affected by monetary policy, it is likely that certain workers will also be systematically more affected.

policy shocks exogenously identified by Jarociński and Karadi (2020). Our methodology builds on Abowd et al. (1999), extending their fixed effects panel regressions to include monetary policy shocks as well as firms' (and workers') characteristics.

We start by investigating whether firm size and age determine the differential impact on workers' employment response to monetary policy shocks. We then repeat the exercise focusing on the individual wage response and asses different potential underlying channels. Finally, we explore the effects of monetary policy shocks on labor income inequality by focusing on the differential effect of the shocks by worker type.

The results can be summarized in three points. First, mirroring previous findings in the literature, we show that workers in young firms have an employment probability that is more responsive to monetary policy interventions compared to that of workers in more established (older) firms. This is consistent with the credit channel of transmission of monetary policy shocks, whereby credit constrained firms (in our case, young ones) adjust their labor force by relatively more. Conversely, firm size is not a relevant determinant for differential employment response. Both firms and workers' characteristics contribute to the higher elasticity of employment to monetary surprises in young firms.

Second, we find that monetary policy shocks affect wages of workers employed in small firms by relatively less, compared to wages of workers in bigger firms. The differential is present within industries and across regions, and is robust to a series of sensitivity analyses. We also find strong evidence of asymmetric effects, with wages reacting more in easing than in tightening episodes (consistent with the existence of downward wage rigidities), and with the the difference between small and large firms becoming more pronounced during easing episodes. Using quantile regressions, we then show that the differential response by firm type is only significant for above-median earners. Instead, firm age does not seem to be a relevant determinant of differential wage response to monetary policy shocks. We show that the estimated coefficient is driven by workers changing employer, but not by the form of collective bargaining agreement nor minimum wages. We find that the worker type alone cannot explain the differential response, and highlight a potential role played by the pass-through of firms' profit to wages. Moving to firm-level regressions, we find that while firm size does not determine differential reaction of firm investment or turnover to monetary policy shocks, it does so for the total wage bill. Consistent with this, we find that our baseline effect is particularly strong in firms offering a variable pay structure, with potential indexation of wages to equity or profits. Overall, our analysis is therefore consistent with the existence of a heterogeneous ability of firms to adjust wages, larger ones having more space to do so.

Third, we find evidence that wages of workers ranked higher in the firm's wage distribution, those in the upper permanent wage distribution quintile, and the higher-skilled generally react more to monetary policy shocks. However, tightenings systematically disadvantage low-skilled and low wage workers, on both the employment and wage margin. Instead, easings benefit particularly

the top of the wage distributions, who experience relatively larger wage increases. Monetary policy easings thus increase inequality because of the top, while tightenings increase inequality at the bottom (although to a smaller extent).

Overall, our results highlight the importance of considering both the wage and employment margins of firms' adjustment to monetary policy shocks. While high-type firms react strongly on the wage margin, young firms react more strongly on the employment margin, especially by adjusting labor of low-skilled workers.

Related literature This paper speaks to three different strands of literature. First, our paper adds to the recent literature empirically assessing the effect of monetary policy on individual labor market outcomes. In this sense, Jasova et al. (2021) find that monetary expansions are associated with increase in wages and employment outcomes for workers working in firms that face liquidity constraints in Portugal, highlighting a central role of the credit channel of monetary policy. Our results on wages are in contrast with theirs. Moreover, we separate between the worker and the firm role in explaining the wage and employment responses to monetary policy. Using a quasi-experiment in Sweden, Coglianese et al. (2021) find that the surprise tightening induced a broad decrease in employment across firms, with a little role for credit frictions. They however find a critical role of nominal rigidities, with sectors with more rigid contracts witnessing a higher unemployment. Our paper differs in that we additionally consider wage responses to monetary policy shocks, which we find crucial to understand the overall transmission channels. Moreover, our results add to these papers as they highlight other channels of transmission at play beyond credit frictions and contract rigidities. In particular, we uncover a role of heterogeneous pass-through of firm-level shocks to wages. Our conclusion for the effect of monetary policy on labor income inequalities are thus also different from previous research. Broer et al. (2021) analyze the heterogeneous effect of monetary policy shocks on labor earnings using administrative matched employer-employee data in Germany. They focus on the employment, employment transitions and earning growth responses by income quantile, but do not consider the role of firms in the transmission mechanism of monetary policy on individual labor market outcomes, which is our main focus. Moreover, within the same literature stream, our results also add to the (small) literature on asymmetric effects of monetary policy on labor market outcomes by providing evidence for the German economy. In the US, Singh et al. (2021) empirically assess the effect of monetary surprises on heterogeneous firms' employment and wages, finding evidence of asymmetric effects. Garibaldi (1997) focuses on asymmetric responses of job creation and destruction. Furceri et al. (2018) provide evidence of the effect of monetary policy shocks on income inequality among 32 advanced and developing countries. Using a non-linear empirical SVAR, Debortoli et al. (2020) find strong asymmetric effects of monetary policy, which they rationalize with a simple model of downward nominal wage rigidities.

Second, our paper is related to the literature on the transmission channels of monetary policy across heterogeneous firms. In this regard, the seminal work of Gertler and Gilchrist (1994) established an unequal effect of monetary policy interventions on firms, particularly linked to their size and financial constraints. The credit channel has also found ground to explain employment dynamics across firms and over the business cycle (Fort et al., 2013; Chodorow-Reich, 2014; Abo-Zaid and Zervou, 2020; Lee et al., 2022; Popov and Rocholl, 2018). Related, Schoefer (2021) presents a model in which credit friction materializes in combination with nominal frictions, whereby firms subject to high nominal wage rigidities are forced to cut hiring due to financial constraints in recessions. Moving away from the credit channel, Baqaee et al. (2021) highlights that low-markup firms tend to pass a higher portion of marginal cost changes into prices, so that a monetary easing systematically reallocates resources from low-markup to high-markup firms. Lieberknecht and Hartwig (2020) instead finds a positive correlation between monetary policy and firms' profits. We contribute to this literature by conducting an analysis on both wages and employment responses. Moreover, we capture different channels of transmission of monetary policy shock together since our focus is on workers' outcomes.

Third, the paper contributes to the empirical literature on the implications of monetary policy interventions on income inequality (Coibion, 2012). Holm et al. (2021) show that contractionary monetary policy shocks reduce non-financial incomes, but most so at the bottom of the liquid asset distribution. Coibion et al. (2017) studies the effects of monetary policy on income and consumption inequality for the US economy, finding that contractionary monetary policy increases inequality in labor earnings and total income. In the Euro Area, Lenza and Slacalek (2018) study the effect of quantitative easing on inequality. They find that quantitative easing compresses income inequality since many low-income households become employed. Samarina and Nguyen (2019) examine how monetary policy affected income inequality in the Euro Area between 1999 and 2014. They distinguish macroeconomic (wages and employment) and financial (asset prices and returns) channels through which monetary policy may have distributional effects. The two channels have opposite effects on inequality. Karaki (2020) analyses sectoral responses of job creation and destruction to monetary policy shocks. McKay and Wolf (2023) propose a unified framework to assess the overall effect of monetary policy on households, taking into account all traditional transmission mechanisms of monetary policy. A distinguishing feature of our analysis is its focus on the distributional effects of monetary policy-induced shocks on labor income via the firms to which workers are associated. Moreover, within this framework, we explore effects both on the wage and employment margins.

The remainder of the paper proceeds as follows. Section 2 introduces the data and discusses the institutional framework. Section 3 presents the empirical models that we use throughout the analysis. The empirical results are presented in Section 4, and finally Section 5 concludes.

2 Institutional framework and data

Wage inequality in Germany increased since the mid-90s, mostly within skill and occupation groups (Felbermayr et al., 2014). Between companies differences explain up to 75% of the raised inequalities, highlighting the dominant role of plant characteristics in this phenomenon. In fact, a skill composition effect of the workforce only explains around 10-20% of the rise in income inequality between 1996-2010 – high-skilled workers having a larger wage dispersion and having become a more prominent share of the workforce. It is therefore an interesting laboratory to explore the role that firms play in the transmission mechanism of monetary policy shocks to individual wages and employment probabilities. Let's first review some of the structural characteristics of the German labour market.

First, the German labor market historically features institutions protecting wages as well as sectoral collective agreements – around 54% of wages in Germany are set through unions or collective agreements in 2010. However, industry collective bargaining has been on a declining trend and firm-level agreements have become more common, implying a growing firm wage differentiation. These trends, together with labor market reforms in the nineties have had a positive impact on labor market flexibility, though leading to an increase in inequalities (Felbermayr et al., 2018). In the period we consider for our analysis (1999-2018), companies already have a relatively high degree of decision power in the wage-setting process. Wage negotiations typically take place at the end of the year.[2] Joining a collective bargaining agreement is associated with increased wages (see Addison et al. 2014) and could introduce a more downward wage rigidities.

Secondly, the so-called "wage cushions" moderate the rigidity of contracts for firms covered by collective bargaining agreements. In fact, Jung and Schnabel (2011) document that almost half of those firms pay a wage above the stipulated level. They find that the premium varies with the firms' profits, offering a way for firms to adapt their labor costs with their individual and aggregate conditions even when they are covered by a sectoral wage agreement.

Thirdly, in response to the low-wage sector increase, the government introduced a minimum wage of 8.5eur/hour of work in January 2015 (industry-level collective agreements paying less than the minimum wage were still valid until January 2017). The latter de facto implies complete downward wage rigidities, and also probably bunching around that minimum wage. However, only few full time jobs were subject to minimum wages: 884000 (around 2.4%) were paying less than 8.5eur/hour in 2014; and between 0.6% and 0.8% paid the minimum wage from 2015 to 2017, most of them in East Germany.[3]

Finally, the labor markets in East and West Germany are structurally quite different. For

[2] `https://www.worker-participation.eu/National-Industrial-Relations/Countries/Germany/Collective-Bargaining`

[3] Statistisches Bundesamt (Destatis), Erhebung über die Wirkung des gesetzlichen Mindestlohns, 2018; own computations based on report's Table 4 and Table 5.

example, collective bargaining agreements are much more common in West Germany, while wage levels is lower in East Germany. Accordingly, wage cushions are more common in the West while the share of workers subject to the minimum wage is larger in the East. Because the level and structure of wages differ substantially between these regions, many have concentrated the analysis on West Germany (see e.g. Dustmann et al. 2009). We consider Germany as a whole in our main analysis, but show in the Appendix that our results are robust to separating between East and West.

2.1 Data and descriptive statistics

Micro-data

We use the Sample of Integrated Labor Market Biographies (SIAB), an administrative matched employer-employee dataset of German workers and establishments. This data is compiled by the Federal Employment Agency (BA) at the Institute for Employment Research (IAB), and provides labor market histories since 1975. [4] On the workers' side, we have information on income, unemployment spells, occupation, region, etc. On the establishment side, there is information on the size in terms of number of employees, the first and last appearance, sector of economic activities, total wage bill, worker flows and the region. There is no way to link establishments belonging to the same mother-firm, because of how the data is gathered. We thus conduct the whole analysis at the establishment level, which we use interchangeably with "firms" in the paper. The dataset provides a 2% random and representative sample of the German workforce. Data cleaning consists mostly of the sample selection, panel transformation, and censoring of wages. We give some details in the following paragraphs, but generally follow Dauth and Eppelsheimer (2020).

The data does not contain precise information on the number of hours worked; we only know whether the worker is part-time (defined as working less than 30 hours per week), full time or marginally employed (the last one since 1999). Following Card et al. (2013), we focus our analysis on full-time workers, to avoid extra noise given by changes in hours worked. We select all men and women between 20 and 60 years old. We treat men and women separately in a robustness check and verify that results hold across groups. We define three skills level corresponding to three education categories, following the literature (university degree, vocational training, or neither of those). Firm size reflects the number of employees; in our baseline we flag a firm as small in a certain year if the number of employees is less than fifty. Similarly, we flag a firm as young if the difference between the current year and the first appearance of the firm is less than five. We start the sample in 1999, when Germany started using the euro, for two reasons. First, the SIAB data has not been subject to major changes since that date (while the computation of daily unemployment benefits changed in 1998 for example); and second to maintain a stable monetary policy environment through our

[4] The SIAB dataset is not publicly accessible for data protection reasons. However, the Research Data Center (FDZ) at the Institute for Employment Research (IAB) makes this data set available to the scientific community. Please consult the disclaimer on this at the end of the references section.

analysis.[5]

The data identifies employment spells, which we transform, in line with the literature, to annual frequency (from January to December) as follows. We start by summing all employment spells by establishment and year for every worker. We then add up total earnings by establishment and year, and select as the main employer the one who contributed to the highest salary for that worker in a given year. We define as employed every individual who spent most of her time employed in a certain year. Unemployed are those who spent most time receiving unemployment benefits. We do not consider individuals who are neither employed nor receiving benefits, hence abstracting from the participation margin.

The income for each employment spell is reported as the average daily wage over the spell. Since 1984, the daily wage measure includes bonus payments and there is no systematic way to disentangle bonuses from base rates. Wages are right-censored, in particular those exceeding the upper earnings limit for statutory pension insurance are only reported up to this limit. To avoid biased estimation, we impute the upper tail of daily wages with a Tobit model, following methods developed and used in Gartner et al. (2005); Dustmann et al. (2009); Card et al. (2013). Figure A1 in Appendix shows the wage distribution with and without imputed values for two arbitrary years.

When exploring the transmission channels related to firm types, we make use of the linked employer-employee dataset of the IAB (LIAB). While the administrative data content is the same as in the SIAB, the LIAB sample is representative for establishments and, importantly for us, it is merged with a firm survey data – see Gartner et al. (2005) for a detailed description of the data product. The survey offers rich information on investment, turnover, types of wage contracts, coverage by collective bargaining agreements, firm legal form, etc. We clean the administrative matched employer-employee part of the data in the same way as SIAB, explained above.

The upper panel of Appendix Figure A3 shows the wage distribution for workers in small and big firms. On the bottom panel, we differentiate instead the wage distribution by workers' skills. The wage distribution shows that wages are on average lower in small firms, which is not surprising given that size is expected to be correlated with productivity. The large wage gap between low and high skilled is easily observable, while medium skilled have a wage distribution quite similar to the whole population.

[5]The current version (SIAB 7519) includes complete data until 2016. For the years 2017 and 2018, the 18-month files were used, and the observations for 2019 originate from a 6-month file (complete data corresponds to inclusion of 36-month files). We therefore stop the analysis in 2018, and verify that all results hold when stopping in 2016.

Monetary policy and aggregate data

For the monetary policy shocks, we use monthly monetary policy surprises for the Euro Area from the work of Jarociński and Karadi (2020). We aggregate them to a yearly frequency by adding up the monthly shocks. For interpretation purposes, in the analysis we standardize the shocks to have a mean of zero and standard deviation of 25btps. Figure A2 in the Appendix plots the non-standardized yearly series for our estimation sample. Most of the variation happens in the first half of the sample; nevertheless the second half also still features some shocks. In a robustness test, we use the shadow interest rate as computed by Wu and Xia (2016). We take first differences – for comparability with the notion of "surprise" of our baseline analysis – and also standardised in a similar manner (WX_t). We also perform a robustness test using the EONIA deposit rate (D_t), transformed in the same way as WX_t.

As far as the other variables employed in the analysis are concerned, all nominal variables are deflated using German CPI. As control variables, we use as a proxy for the business cycle the real GDP growth, and also the changes aggregate unemployment for the German economy in a separate robustness exercise. The data for real GDP, inflation, unemployment and different proxies for the monetary policy interventions are all collected from Haver Analytics. All variables entering the regressions are described in table A1 in the Appendix. Table A2 in the Appendix present the summary statistics of our main variables. The data cleaning leaves us with a baseline estimation sample size of quasi eight million observations.

3 Empirical methodology

In this section, we lay down the empirical approach that we use to estimate the effects of monetary policy shocks on labor market outcomes, namely for both the employment and wage margins, among a chosen dimension of heterogeneity. We first focus on the effects of monetary policy shocks on individual employment probabilities. We next asses the heterogeneous responses by firm type, also allowing for asymmetric responses. We next explore potential non-linear effects with a quantile regression. In all models, we make use of the matched employer-employee data features to estimate models that can identify workers' and firms' fixed effects. As we do not aim to identify sorting between workers and firms but merely are interested to quantify exposure to monetary policy shocks, we base our methodology on the seminal contribution of Abowd et al. (1999) (hereafter AKM) and perform fixed effects regressions. We augment it to include monetary policy shocks (as explained in the previous section) as well as firms and workers' characteristics.

Baseline model

Let $\mathbb{J}(i,t)$ identify the *unique* establishment employing worker i in time t. We assume that workers' log-wages $y_{i,t}$ are generated by a model composed by a worker component α_i, an establishment component $\Psi_{\mathbb{J}(i,t)}$, a set of time varying controls $x_{i,t}$ (including time fixed effects) and an an error capturing all other factors $\varepsilon_{i,t}$.[6] α_i represents the contribution of personal attributes in the workers' wage, while $\Psi_{\mathbb{J}(i,t)}$ represents a wage premium that is paid by a certain establishment to all employees for that period of time.

$$y_{i,t} = \alpha_i + \Psi_{\mathbb{J}(i,t)} + x'_{i,t}\beta + \varepsilon_{i,t}$$

Identification of fixed effects is achieved by observing movers across firms. We assume that the conditional expectation of $\varepsilon_{i,t}$ is independent of the worker's job history ("exogenous mobility"), so that OLS yields unbiased coefficients. Previous empirical work supports the validity of the exogenous mobility assumption for Germany (Gerard et al., 2021). We cluster standard errors at the firm and worker level throughout the analysis.

We then introduce exogenous monetary policy shocks (MP) into the equation. Let $F_{\mathbb{J}(i,t)}$ represents a firm heterogeneity dimension of interest. To simplify notation, we write (j,t) instead of $\mathbb{J}(i,t)$. In order to estimate how differently monetary policy affects workers along the heterogeneity dimension, we interact MP_{t-1} with $F_{j,t}$. Although the shocks series is assumed to be exogenous, we attempt to treat any remaining endogeneity by further controlling by Germany's GDP growth, again interacted with MP.[7] Our baseline regression is thus:

$$y_{i,t} = \alpha_i + \Psi_{j,t} + x'_{i,t}\beta + \gamma\ MP_{t-1} \times F_{j,t-1} + \zeta \Delta \ln GDP_{t-1} \times F_{j,t-1} + \varepsilon_{i,t} \tag{1}$$

γ is our coefficient of interest, and can be interpreted as the difference between wages responses along the heterogeneity dimension of interest that cannot be explained by workers and firms observed and unobserved characteristics.

On the firm side, we consider heterogeneity in terms of size, age and the firm's position in the average firm wage distribution. In particular, dummies for small and young firms, $S_{j,t-1}$ and $Y_{j,t-1}$ and a dummy equal to one if the firm pays on average a low wage $FR_{j,t-1}$.[8] On the worker side, we

[6] We use education and an age polynomial as our baseline control variables. In the Appendix Table A5, we also show results further controlling for tenure and with aggregate employment instead of GDP, but this has practically no influence on our results.

[7] The monetary policy shocks are estimated residuals from a VAR (Jarociński and Karadi, 2020). Endogeneity would arise if monetary surprises nevertheless respond to aggregate conditions in Germany, which themselves are likely to affect wages. Controlling for such aggregate condition thus alleviates the potential concern.

[8] According to the EU commission definition, small firms are those with less than 50 employees and mini firms are those with less than 10 employees. We consider a firm "young" if it exists since less than 5 years. FR instead indicates firms that pay on average less than the mean of firms' wages in a specific year.

consider heterogeneity in terms of the worker's rank in the firm's wage distribution (a dummy equal to one if the worker's pay is larger than the firm's average wage), her position in the permanent income distribution, as well as skills, respectively denoted by $WR_{i,t-1}$, $\bar{y}^{p}_{i,t-1}$ and $\text{skill}_{i,t-1}$.

We also differentiate between accommodative and restrictive monetary policy shocks by further interacting our coefficients of interest with a dummy variable equal to one if the monetary policy shock is negative (accommodative), and zero otherwise.

The identification strategy for the employment probability regressions follows the same idea as the wage regressions. We abstain from binary choice models, but verify that OLS predicts reasonable employment probabilities. Our specification is thus as Eq. (1), but with the dependent variable being an indicator of employment status (one if employed, zero if unemployed).

When estimating firm-level regressions, we use the following model

$$\ln H_{j,t} = \Psi_{j,t} + \beta_t + \gamma\ MP_{t-1} \times F_{j,t-1} + \zeta \Delta \ln GDP_{t-1} \times F_{j,t-1} + \varepsilon_{j,t} \tag{2}$$

, where we choose the dependent variable $H_{j,t}$ to be either firms' total real investment, turnover or wage bill.

Quantile regression

We then estimate an unconditional quantile treatment effect at key percentiles of the income distribution. This regression allows to test for heterogeneous effects of monetary policy shocks across the labor income distribution. We use the two-step estimation introduced by Borgen et al. (2021). The procedure first regresses our interaction of interest on the control variables using OLS and saves the residuals – assuming that they are independent of the outcome variable.

$$I_{i,t} = \alpha_i + \Psi_{j,t} + x'_{i,t}\beta + \zeta \Delta \ln GDP_{t-1} \times F_{j,t-1} + \nu_{i,t}$$

Where $I_{i,t} = MP_{t-1} \times F_{j,t-1}$. The second step uses the residuals as an independent variable in a quantile regression model.

$$\ln y_{i,t,\tau} = \beta_\tau \hat{\nu}_{i,t} + \epsilon_\tau \tag{3}$$

We bootstrap standard errors for both steps using 50 repetitions, re-sampling the data with replacement. In each re-sample, both steps are estimated.[9] This approach allows to perform quantile regressions with controls and multi-dimensional fixed effects (see their paper for more details).

[9]Practically, we make use of the RQR command in Stata developed by (Borgen et al., 2022).

4 Empirical results

In this section, we first characterize the effects of monetary policy shocks on individual employment, highlighting the role of firm type in the transmission mechanism. We then move to the response of individual wages. Finally, we explore what our results imply for the role of monetary policy interventions on labor income inequality.

4.1 Employment margin

We start by analyzing the job loss and job finding channels in our empirical framework. These may be important especially when the labor market features substantial rigidities on wage setting. Moreover, employment is also the relevant margin of adjustment estimated in the literature on the transmission of shocks through credit constraints (see e.g. Chodorow-Reich, 2014).[10]

In what follows, we estimate individual employment probabilities by firm type, following a monetary policy shock. Note here that the estimated coefficients may be a combination of labor demand or labor supply responses.[11]

Table 1 presents the regressions' results. Columns (1) and (2) show coefficients for firm size, while columns (3) to (5) for firm age. Columns (1) and (3) show the regression with no fixed effects or controls. The point estimates suggest that a 25bpt surprise tightening reduces the individual baseline employment probability by 0.17%. Moreover, the probability to become unemployed if working in small and young firms is higher relative to big and older firms. With the inclusion of fixed effects and controls, the probability of becoming unemployed if working in a young firm is significantly higher than if working in an older firm, of around 0.05% (see Column (4)). The coefficient on firm size instead becomes insignificant and essentially zero (see Column (2)). Generally, the magnitudes are quite small, reflecting the little variation of the employment status measure at the yearly frequency.

A natural question is whether the differential effect is the result of a worker component, a firm component or a combination of the two. The findings might be driven by workers' skills, with differences between firm types arising due to sorting of low-skilled worker into smaller firms. Alternatively, it could be a purely firm story, with different types of firm being differently affected by monetary policy and passing these effects through to their workforce in the same way, or firms being affected the same way but with different pass-through of shocks, or both. Finally, it could be that the phenomenon only happens for specific matches, in particular only for high-skilled who, through sorting, work in large firms.

[10] Burya et al. (2022) explore the effect of labor market power in the transmission of monetary policy shocks, and also find that in the US workers are mainly affected through the employment margin rather than wage margin.

[11] Generally, we focus on workers who are attached to the labor market. In a recent paper, Graves et al. (2023) show that labor supply responses are much stronger than what was typically assumed in the literature. Nevertheless, their results are mostly driven by movements from and to the non-participation margin of employment, a dimension which we abstract from. Therefore, in our context, the results likely mostly reflect labor demand adjustments.

Table 1: Employment probabilities on monetary policy shocks

	(1)	(2)	(3)	(4)	(5)
MP_{t-1}	-0.0017***		-0.0017***		
	(0.00010)		(0.000080)		
MP_{t-1}					
$\times$ $S_{j,t-1}$	-0.00073***	-0.0000030			
	(0.00016)	(0.00014)			
$\times$ $Y_{j,t-1}$			-0.0019***	-0.00052**	-0.00044**
			(0.00028)	(0.00024)	(0.00024)
$\times$ l skill$_{j,t-1}$					-0.00052**
					(0.00028)
$\times$ l skill$_{j,t-1}$ $\times$ $Y_{j,t-1}$					-0.00099
					(0.0010)
Controls & FEs	N	Y	N	Y	Y
N	7702906	7598813	7702906	7598813	7598813
R-sq	0.000	0.378	0.001	0.378	0.378

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year; $Y_{j,t-1}$ is a dummy equal to 1 if the firm exists since less than 5 years; and l skill$_{i,t-1}$ is a dummy equal to 1 if the workers' education level is: no diploma.

In the following, we show that both firms' and workers' characteristics can explain the differential effects of monetary policy shocks on individual employment. For this, we introduce a triple interaction between monetary policy shocks, a firm and a worker characteristic of interest. Relevant coefficients are shown in Column (5). The interactions between monetary policy and both the firm and worker characteristic are both significantly negative. This indicates that both firm age and worker skills independently matter for the impact of monetary policy on employment probabilities. Interestingly, the skill component appears to be additive, as the magnitude of the interaction coefficient with firm age changes very little from Column (4). Also, the coefficient on skills is of larger magnitude compared to the one corresponding to firm age (0.052% versus 0.044%). We explore the unequal effect of monetary policy shocks by worker types in Section 4.3. Nevertheless, while worker skills and firm age are significant independently, the interaction between young firms and low-skilled workers does not seem to induce significant differential impact of monetary policy on the employment probability, as shown in the last triple interaction coefficient of column (5). These results suggest that sorting alone cannot fully account for the greater sensitivity of workers' employment probabilities in young firms to monetary policy shocks. Importantly, they highlight that firm age alone matters in the elasticity of individual employment to monetary policy shocks.

Additional robustness analysis considering sub-samples of skill type and firm type shows that, in small firms, there is no difference between the employment reaction of low- and high-skilled workers (Columns (1) and (2) in Table A7 in Appendix). If workers' skills are underlying these results, then we should expect high-skilled workers' wages to be more responsive to monetary policy regardless of firm type. Nevertheless, results in Columns (1) and (2) suggests this is not the case, as in small firms there is no difference between the wage reaction of low- and high-skilled workers.

If instead firm types drive the result, the difference between small and large firms should be evident across all worker types. The last three columns of Table A7 show that the difference between small and large firms is present and statistically significant only for the group of high-skilled, suggesting a particularly strong role of the combination of large firm and high-skilled workers driving our estimates.

Overall, our results are in line with well established literature. Moser et al. (2022) find that within firms, initially lower-paid workers are more likely to leave employment following an adverse monetary policy induced credit supply shock. Similarly, Coglianese et al. (2021) find that the increase in unemployment following a monetary policy tightening is larger for workers at small, young firms.

4.2 Heterogeneous effects on wages and identification of potential transmission mechanism

The second step consists of analyzing the effects of monetary policy shocks on wages across different firm types. We differentiate firms according to size, age and whether the firm's average paid wage is below or above the average wages paid by the other firms in the sample. Our main result points to the fact that wages of workers in smaller firms are less affected by monetary policy shocks as compared to wages of workers in bigger firms following monetary policy interventions.

Table 2 shows our preferred specification for firm size in Column (1). A 25bpt surprise monetary policy tightening decreases wages of workers in small firms by 0.63% less than for workers working in big firms. That is, half of the decrease in wages of workers in big firms. This result holds within industries and regions and is robust to a series of specification sensitivity and robustness analyses, as reported in the Appendix Tables A4 and A5. Results are comparable. Columns (1) to (4) of Appendix Table A3 presents the results of regressing Equation (1), gradually saturating the regression with fixed effects and controls. The first column shows a result of monetary policy non-neutrality, whereby a monetary policy surprise tightening shock decreases wages by 1.7% in our sample. As we include fixed effects, the R^2 increases from 0.15 to 0.90 and the coefficient in the interaction becomes smaller, but remain statistically significant, suggesting that some of the effects of monetary policy shocks go through firms, workers, industry and region fixed effects.

Next, we present evidence that firm size matters on its own for the differential effect of monetary policy shocks on wages. The regression presented in Column (2) below introduces a triple interaction between monetary policy, workers skills and firm size (similarly to Column (5) in Table 1). Interestingly, the triple interaction coefficient is insignificant and our main coefficient remains almost unchanged. In other words, firm size matters on its own for the elasticity of wages to monetary policy shocks. Workers skills also imply a differential wage response to monetary policy shocks, though the magnitude is half of the firm size coefficient.

Depending on the underlying channels at play, easing and tightening could affect wages in an asymmetric manner. In fact, we find that wages in big firms – our baseline category – react in

Table 2: Individual wages on monetary policy shocks by firm type

	(1)	(2)	(3)	(4)	(5)
MP_{t-1}					
$\times$ $S_{j,t-1}$	0.0063***	0.0066***	0.044***		
	(0.00065)	(0.00067)	(0.0015)		
$\times$ l skill$_{j,t-1}$		0.0033**			
		(0.00137)			
$\times$ l skill$_{j,t-1} \times S_{j,t-1}$		-0.0034			
		(0.0021)			
$\times$ $S_{j,t-1} \times MP_{t-1}^{<0}$			-0.22***		
			(0.0064)		
$\times$ $Y_{j,t-1}$				0.00036	
				(0.00098)	
$\times$ $FR_{j,t-1}$					0.0095***
					(0.00065)
N	7889680	7889680	7889680	7889680	7889680
R-sq	0.902	0.902	0.902	0.902	0.902

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. All regressions include year, worker, firm, industry (of the firm) and industry by year fixed effects; as well as aggregate GDP growth as a control variable. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year; $Y_{j,t-1}$ is a dummy equal to 1 if the firm exists since less than 5 years; $FR_{j,t-1}$ is a dummy equal to 1 if the firm's average wage is below average; and l skill$_{i,t-1}$ is a dummy equal to 1 if the workers' education level is: no diploma.

absolute terms about two and a half times more in easing than in tightening episodes. This is not that surprising in the presence of downward wage rigidities, but highlights a strong positive effect of monetary policy easings effects on wages. Our estimates suggest that a 25bpts monetary policy tightening decreases wages by 40% for workers in big firms, and by 35% for workers in small firms. In easings, wages increase by 104% in big firms and by 83% in small firms. Column (3) of Table 2 shows that the difference between small and large firms is more exacerbated when monetary policy eases (22% versus only 4% in tightening), both in terms of magnitude and percent of wage change.[12]

In Columns (4) and (5), we show our coefficient of interest for firm age and firm rank (a dummy equal to one if the firm is paying on average a lower wage relative to the other wages paid by firms included in the sample). First, we see that firm age is not a relevant dimension of heterogeneous wage responses to monetary policy shocks in Germany. Second, results sustain that low-paying firms adjust wages by almost 1% less, a coefficient slightly higher than firm size. Although size and pay are correlated, they capture something different, in particular they may differ in their implications

[12]The regression is the following,

$$\ln y_{i,t} = \alpha_i + \Psi_{j,t} + x'_{i,t}\beta + \gamma_1\ MP_{t-1} + \gamma_2\ F_{j,t-1} + \gamma_3\ MP_{t-1} \times F_{j,t-1} + \gamma_4\ n_t + \gamma_5\ n_t \times MP_{t-1} + \gamma_6\ n_t \times F_{j,t-1} + \gamma_7 n_t \times F_{j,t-1} \times MP_{t-1} + \zeta \Delta \ln GDP_{t-1} \times F_{j,t-1} + \varepsilon_{i,t} \quad (4)$$

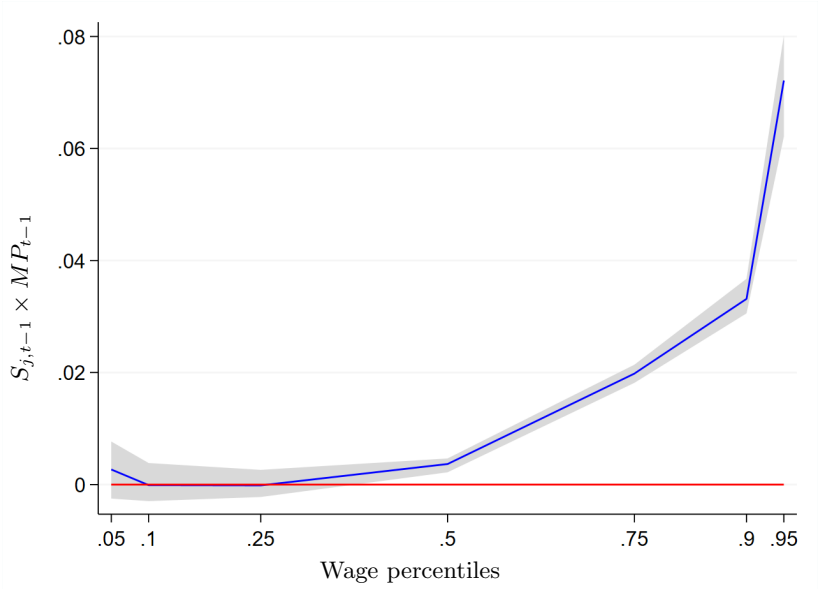
, where n_t is the dummy for the sign of the shock.
We only show the relevant interaction coefficients of Eq. (4), which can be interpreted as follows.

$$\begin{aligned} MP_{t-1} \times S_{j,t-1} &= \frac{\partial \ln y}{\partial \iota}|_{n=0;S=1} - \frac{\partial \ln y}{\partial \iota}|_{n=0;S=0} \\ MP_{t-1} \times S_{j,t-1} \times MP_{t-1}^{<0} &= \frac{\partial \ln y}{\partial \iota}|_{n=1;S=1} - \frac{\partial \ln y}{\partial \iota}|_{n=1;S=0} \end{aligned}$$

for sorting – in terms of workers characteristics. Column (2) of Table A4 in the Appendix shows the results of regressing Eq. (1) using a population-estimated AKM firm effect interacted with the monetary policy shock series. We find that wages of workers working in firms that are in the upper quartile of the firm AKM distribution are the ones reacting more to monetary policy shocks. As we argued previously, the AKM effect can be interpreted as a premium paid by the firm to their workers, which may come from a productivity component, different rent-sharing across firms, or also strategic firm behavior (Bellmann et al., 2020). Hence, while the coefficient cannot help to pin down one specific channel, it confirms the general idea that differences of monetary policy shock responses come mostly from high-paying, highly productive firms.

We next present the quantile regression results, to uncover potential non-linearities. Figure 1 shows our baseline estimated elasticities for firm size, estimated on various percentiles of the wage distribution. Interestingly, the effect is only significant for median and above earners – there is no difference between the responses of wages in small and large firms for the lowest paid quartile of the wage distribution. This suggests that large firms adjust their wages more and especially for high-earning workers following a monetary policy shock.[13]

Figure 1: Individual wages on monetary policy shocks by firm size



Note: Confidence bands at the 95% level. Errors are clustered at the individual and firm level. Standard errors are obtained by bootstrap with 50 repetitions. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year.

[13]Note that we do not plot the top 5% of the wage distribution, because most of the wages in that section are imputed. The graph would look even more non-linear if we would plot it. At the 90th percentile, less than 5% of observations are imputed and at the 90th around 50% are censored.

Composition effect Recent literature explains the observed wage pro-cyclicality with workers changing jobs, occupation and skill mismatch over the business cycle (see e.g. Gertler et al., 2020; Bauer and Lochner, 2020; Black and Figueiredo, 2022). We follow that literature and explore whether such a channel can be at play. In fact, our results could reflect a difference in the possibility to move on the job ladder between large and small firms, the former potentially having more (internal) opportunities. Column (7) and (8) in Appendix Table A4 show that our baseline results are driven by the population of job switchers, namely workers who were working in small and large firms, and then changed employer within two years. On the contrary, there is no significant difference in wages between stayers, i.e. those who remained working for the same employer for more than two years. These findings suggests that different poaching behavior across small and big firms might play a role in explaining the baseline results.

Heterogeneous pass-through of shocks to wages Results until now suggest that large firms adjust their wages more following monetary policy shocks, especially for their high-pay workers. We now seek the reason behind this, in particular we explore whether it is because they are affected more by monetary policy, or because their pass-through of shocks to wages is relatively higher. We discuss the role of collective bargaining in the next paragraph. For this analysis, we use firm-level data information from LIAB.

Table 3 present the results of estimating Eq. (2). There is no significant difference between small and large firms concerning the impact of monetary policy shocks on investment and turnover, as we can read from Columns (1) and (2). Therefore, it does not seem that our baseline results come from heterogeneous exposure of small and large firms to monetary policy shocks. In contrast, Column (3) shows that small and large firms adjust their wage bills in a different way, small firm decreasing it by relatively less.

Table 3: Firm-level variables on monetary policy shocks by firm size (LIAB)

	(1) investment	(2) turnover	(3) wages
$MP_{t-1} \times S_{j,t-1}$	0.46	0.21	0.043**
	(0.64)	(0.17)	(0.020)
N	5552400	4401851	6318541
R-sq	0.817	0.975	0.993

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year. In Column (1), the dependent variable is real total investment; in Column (2) it is real turnover; and in Column (3) total real wages.

Underlying transmission mechanisms Overall, our analysis seems consistent with a heterogeneous "wage cushion" response – or in general variable pay structure or bonuses, larger firms being more likely to use them. We stress here again that labor income in the German administrative data also accounts for bonuses, and those are typically concentrated in bigger firms. In fact, if monetary

policy tightening is associated with lower firm profits, bigger firms seem to have a greater ability to transfer this to their workers through the variable component.[14] We show direct suggestive evidence of this channel using information on whether the firm implements profit sharing. Columns (7) and (8) of Appendix Table A11 shows that the estimated difference of wage adjustments in big and small firms is bigger for those with profit sharing than those who do not use profit sharing.

We next discuss the role of institutional labor market characteristics of the German economy. Branten et al. (2018) present evidence from a survey in the Euro Area about nominal wage rigidities. While they find that wage adjustment frequency is positively correlated with firm size, it is not possible to disentangle optimal wage adjustments from true rigidity components in their analysis. This is crucial for us, as our baseline result can arise if smaller firms face higher rigidities. In what follows, we argue that institutional aspects alone cannot account for the significant difference in wages responses between small and large firms. First, (Dickens et al., 2007) find that greater union density shows a robust relationship with downward real wage rigidity. Secondly, evidence that the minimum wage affects mostly smaller firms (Dütsch and Himmelreicher, 2020) could introduce more downward rigidities for these firms and explain the lower sensitivity of small firm's wages to monetary policy interventions. However, Column (4) in Appendix Table A4 shows that the difference between small and large firms was present before the introduction of the minimum wage policy. Second, one may think that collective bargaining agreements introduce different wage flexibility and because larger firms are more likely to be in such agreements, the results mirror the effect of being in a collective bargaining agreement.[15] If anything, our analysis suggests rather that collective bargaining agreements have an effect on how firms decide to structure their wage contracts. Within the LIAB dataset, we show that our baseline result holds for all types of collective agreement coverage, although stronger so for those subject to a sectoral agreement (see Columns (4)-(6) of Appendix Table A11). Another piece of suggestive evidence is that the difference between small and large firms is also present in East Germany, where collective bargaining agreements are much less common (Columns (5) and (6) of Appendix Table A4).

Heterogeneous matching frictions across worker types in the sense of capital-skill complementarities (e.g. Dolado et al. (2021) support the hypothesis that high-paid workers are subject to lower matching frictions as these workers are more complementary to capital than substitutable unskilled ones are), cannot explain why firm size alone implies a differential wage response to monetary policy shocks.

Our results are supported by similar findings of Moser et al. (2022) indicating that higher-paid workers see relative bigger wage declines following a tightening in credit supply. However, they are different from Jasova et al. (2021) who find that in Portugal monetary policy interest rate cuts are

[14] In a different setting, Di Maggio et al. (2022) find that idiosyncratic firm uncertainty shocks are passed through wages of the top-earners through variable pay adjustments.

[15] The effect would still be ambiguous, as firms subject to an agreement are more likely to revise wages upward (Addison et al., 2014), but may also have more downward wage rigidities.

associated with a higher wage for workers working in small firms, through a firm relaxed liquidity constraint channel. They argue that in case of back-loaded wages, young and small firms should react more to monetary policy shock, in contrast with our findings.[16] In Germany, the credit channel does not materialize in the same way; in fact, we find the opposite wage response. If anything, we find that the credit channel materializes on the employment margin.

4.3 Effect on inequalities

So far, we characterized the effect of monetary policy shocks on individual wages and employment outcomes. We are next interested in assessing the overall effect on labor income inequalities. We first run our baseline model using worker's characteristics as the differentiating dimension. Our results mirror those of previous section, because of sorting in the labor market – e.g. low paid workers are more likely to work in smaller firms. We confirm whether the asymmetric effect of monetary policy on wages systematically affect workers ranked lower. Finally, we look at the effect on individual employment probability.

Columns (1) to (4) of Table 4 present results for the heterogeneous response of workers' wages to monetary surprises along three heterogeneity dimensions, namely the worker rank in the firm WR_t, their position in the permanent income distribution $\bar{y}^p$, and their skill level. We find that wages of workers ranked higher in the firm's income distribution (Column (1)), those in the upper permanent income distribution quintile (Column (2)), and the higher-skilled (Column (3)) react more to monetary policy shocks. Interpreting the three measures as proxies for worker productivity and in light of our baseline results, these results could mirror a strong positive labor sorting between workers and firms in Germany.[17] We also find some evidence of U-shaped effects, those in the middle of the permanent income and skill distribution being less affected by monetary policy shocks than those on the extremes. This reminds of findings by Guvenen et al. (2014). We show that our results are robust to a series of specifications and sample choices in the Appendix Tables A6 and A7, such as controlling for gender, sample (before 2015) and regions (East versus West).

Having concluded that low-skilled, low-payed and poorer workers have less variation in their wages due to monetary policy shocks, we next explore whether this is true both in tightening and easing periods. Our baseline category of highly-ranked workers (within firms) see their wages

[16] Firm size and age have been thought in the literature as proxies for a firm's credit access and financial constraints since Gertler and Gilchrist (1994). Against this, using the firm level survey data, we test whether another proxy of financial constraints can explain the results, but find no evidence there either (see column (3) in Appendix Table A11).

[17] The AKM model is unable to identify sorting between workers and firms, because the firm fixed effect is not independent of the worker' fixed effect (Eeckhout and Kircher, 2011; Bonhomme et al., 2023). Hagedorn et al. (2017) prove that one can identify the sign and magnitude of sorting using a matched employer-employee data, but estimating labor market sorting within the SIAB is outside of the scope of this paper.

Table 4: Individual wages on monetary policy shocks by worker type

	Wages				Employment	
	(1)	(2)	(3)	(4)	(5)	(6)
MP_{t-1}						
× $WR_{i,t-1}$	-0.0097***			-0.0088***	0.00052***	
	(0.00065)			(0.0014)	(0.00014)	
× $WR_{i,t-1} \times MP_{t-1}^{<0}$				-0.021***		
				(0.0055)		
× $\bar{y}^p_{i,t-1}$=3		0.012***				
		(0.0011)				
× $\bar{y}^p_{i,t-1}$=5		-0.015***				
		(0.0014)				
× $\text{skill}_{i,t-1}$=2			-0.00034			0.00047
			(0.0010)			(0.00029)
× $\text{skill}_{i,t-1}$=3			-0.011***			0.0011***
			(0.0016)			(0.00032)
N	7889680	6271208	7791504	7889680	7598813	7512590
R-sq	0.904	0.914	0.902	0.904	0.378	0.379

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $WR_{i,t-1}$ is a dummy equal to 1 if the worker's wage is below the firm mean wage; $\bar{y}^p_{t-1}$ is the quantile of the past 3 years' average income distribution; and $\text{skill}_{i,t-1}$ represents the workers' education level (1: no diploma, 2: vocational training, 3: university degree).

increase more in easing periods than they decrease in tightening periods (in absolute terms, more than 3 times more). Moreover, our results highlight that low-ranked workers are systematically disadvantaged: their wage decrease by relatively more in tightenings and increase by relatively less in easings (respectively by -0.9% and -2.1%). Overall, monetary policy increases wage inequalities in tightening by less than in easing. These results seem to confirm the evidence from (Marotzke et al., 2016). The authors argue that, while collective pay agreements reduce downward wage adjustments, the increase in the probability of downward base wage responses following a decrease in demand is significantly smaller than the increase in the probability of upward wage responses associated with an increase in demand. At the same time, our findings seem to stand in contrast with the analysis of Furceri et al. (2018) who conclude that inequality increases by more following a tightening than it declines when monetary policy eases.

On top of the effect going through sorting of high-skilled into larger firms, these results could reflect that an unexpected monetary easing favors high-skilled workers, in light of a capital-skill complementarity channel (see e.g. Dolado et al., 2021).

Moving on to the employment probability response to monetary policy shocks. The employment of high-ranked and high skilled workers are less exposed, as we read from the positive coefficients in Columns (5) and (6). On the one hand, hiring and firing costs are generally bigger in case of high-skilled than of low-skilled workers. Thus, shocks tend to affects more the unemployment of low-skilled workers for which adjustment costs of firms are smaller. Zens et al. (2020) also find looking into the US labor market that workers at the bottom of the skill distribution are disproportionately

affected by monetary policy interventions. Beyond the firm related channels that we discussed above, the phenomenon is consistent with models of frictional labor markets – such as the standard search-and-match – in which the replacement rate is an important driver of wage and employment dynamics. For example, in the model of Abbritti and Consolo (2022), low skilled prefer to get unemployed than to accept wage cuts because they have a relatively higher replacement value.

5 Conclusion

The transmission mechanisms of monetary policy to individual employment and wage margins are complex and not yet fully understood, although they are relevant for policy decisions considering their implications on welfare and consumption behavior. This paper sheds light on the role of firms in determining workers' employment and wage responses following monetary policy shocks.

We use high-quality administrative data that provides employment histories of a representative sample of German workers together with their relative employers. We find that workers in young firms have an employment probability that moves more with monetary policy interventions than workers in older firms. Moreover, firms respond differently on the wage margin following monetary policy shocks: workers in larger firms experiencing a relatively larger wage adjustment relative to workers in small firms. The effect is asymmetric, with wages reacting more in easing than in tightening episodes, and differences between large and small firms being more exacerbated in easings. We next show that wages of workers ranked higher in the firm's income distribution, those in the upper permanent income distribution quintile, and the higher-skilled react more to monetary policy shocks. However, their employment probability is less sensitive to monetary policy shocks compared to low-skilled workers. Overall, our results highlight the importance of considering both the wage and employment margins of firms' adjustment to monetary policy shocks.

While inequality remains outside central banks' objective, its distributional effects need to be considered due to their role in shaping the effectiveness of monetary policy transmission. Therefore, a deeper understanding of the interplay between monetary policy and labor market outcomes remains an important issue for debate going forward.

References

M. Abbritti and A. Consolo. Labour market skills, endogenous productivity and business cycles. 2022.

S. Abo-Zaid and A. Zervou. Financing of firms, labor reallocation, and the distributional role of monetary policy. *The Scandinavian Journal of Economics*, 122(2):790–823, 2020.

J. M. Abowd, F. Kramarz, and D. N. Margolis. High wage workers and high wage firms. *Econometrica*, 67 (2):251–333, 1999.

J. T. Addison, P. Teixeira, J. Stephani, and L. Bellmann. Union decline and the coverage wage gap in germany. 2014.

D. Baqaee, E. Farhi, and K. Sangani. The supply-side effects of monetary policy. Technical report, National Bureau of Economic Research, 2021.

A. Bauer and B. Lochner. History dependence in wages and cyclical selection: Evidence from germany. *Labour Economics*, 67:101932, 2020.

L. Bellmann, B. Lochner, S. Seth, S. Wolter, et al. Akm effects for german labour market data. Technical report, Institut für Arbeitsmarkt-und Berufsforschung (IAB), Nürnberg [Institute for . . . , 2020.

I. Black and A. Figueiredo. The false illusion of wage cyclicality. *Available at SSRN 4208152*, 2022.

S. Bonhomme, K. Holzheu, T. Lamadon, E. Manresa, M. Mogstad, and B. Setzler. How much should we trust estimates of firm effects and worker sorting? *Journal of Labor Economics*, 41(2):291–322, 2023.

N. T. Borgen, A. Haupt, and Ø. N. Wiborg. A new framework for estimation of unconditional quantile treatment effects: The residualized quantile regression (rqr) model. 2021.

N. T. Borgen, A. Haupt, and Ø. Wiborg. Rqr: Stata module to estimate the residualized quantile regression model. 2022.

E. Branten, A. Lamo, and T. Rõõm. Nominal wage rigidity in the EU countries before and after the Great Recession: evidence from the WDN surveys. Working Paper Series 2159, European Central Bank, June 2018. URL `https://ideas.repec.org/p/ecb/ecbwps/20182159.html`.

T. Broer, J. Kramer, and K. Mitman. The curious incidence of monetary policy shocks across the income distribution. Technical report, 2021.

A. Burya, R. C. Mano, Y. Timmer, and A. Weber. Monetary policy under labor market power. 2022.

D. Card, J. Heining, and P. Kline. Workplace heterogeneity and the rise of west german wage inequality. *The Quarterly journal of economics*, 128(3):967–1015, 2013.

G. Chodorow-Reich. The employment effects of credit market disruptions: Firm-level evidence from the 2008–9 financial crisis. *The Quarterly Journal of Economics*, 129(1):1–59, 2014.

J. Coglianese, M. Olsson, and C. Patterson. Monetary policy and the labor market: a quasi-experiment in sweden. Technical report, Working Paper, 2021.

O. Coibion. Are the effects of monetary policy shocks big or small? *American Economic Journal: Macroeconomics*, 4(2):1–32, 2012.

O. Coibion, Y. Gorodnichenko, L. Kueng, and J. Silvia. Innocent bystanders? monetary policy and inequality. *Journal of Monetary Economics*, 88:70–89, 2017.

W. Dauth and J. Eppelsheimer. Preparing the sample of integrated labour market biographies (siab) for scientific analysis: a guide. *Journal for Labour Market Research*, 54(1):1–14, 2020.

D. Debortoli, M. Forni, L. Gambetti, and L. Sala. Asymmetric effects of monetary policy easing and tightening. 2020.

M. Di Maggio, A. Kermani, R. Ramcharan, V. Yao, and E. Yu. The pass-through of uncertainty shocks to households. *Journal of Financial Economics*, 145(1):85–104, 2022.

W. Dickens, L. Goette, E. L. Groshen, S. Holden, J. Messina, M. Schweitzer, J. Turunen, and M. Ward. How Wages Change: Micro Evidence from the International Wage Flexibility Project. CSEF Working Papers 171, Centre for Studies in Economics and Finance (CSEF), University of Naples, Italy, Jan. 2007. URL `https://ideas.repec.org/p/sef/csefwp/171.html`.

J. J. Dolado, G. Motyovszki, and E. Pappa. Monetary policy and inequality under labor market frictions and capital-skill complementarity. *American Economic Journal: Macroeconomics*, 13(2):292–332, 2021.

C. Dustmann, J. Ludsteck, and U. Schönberg. Revisiting the german wage structure. *The Quarterly journal of economics*, 124(2):843–881, 2009.

M. Dütsch and R. Himmelreicher. Characteristics contributing to low-and minimum-wage labour in germany. *Jahrbücher für Nationalökonomie und Statistik*, 240(2-3):161–200, 2020.

J. Eeckhout and P. Kircher. Identifying sorting—in theory. *The Review of Economic Studies*, 78(3):872–906, 2011.

G. Felbermayr, D. Baumgarten, and S. Lehwald. Increasing wage inequality in germany: What role does global trade play? 2014.

G. Felbermayr, G. Impullitti, and J. Prat. Firm dynamics and residual inequality in open economies. *Journal of the European Economic Association*, 16(5):1476–1539, 2018.

T. C. Fort, J. Haltiwanger, R. S. Jarmin, and J. Miranda. How firms respond to business cycles: The role of firm age and firm size. *IMF Economic Review*, 61(3):520–559, 2013.

D. Furceri, P. Loungani, and A. Zdzienicka. The effects of monetary policy shocks on inequality. *Journal of International Money and Finance*, 85:168–186, 2018.

P. Garibaldi. The asymmetric effects of monetary policy on job creation and destructior. *IMF Staff Papers*, 1997(004), 1997.

H. Gartner et al. The imputation of wages above the contribution limit with the german iab employment sample. *FDZ Methodenreport*, 2(2005):2005, 2005.

F. Gerard, L. Lagos, E. Severnini, and D. Card. Assortative matching or exclusionary hiring? the impact of employment and pay policies on racial wage differences in brazil. *American Economic Review*, 111(10): 3418–57, 2021.

M. Gertler and S. Gilchrist. Monetary policy, business cycles, and the behavior of small manufacturing firms. *The Quarterly Journal of Economics*, 109(2):309–340, 1994.

M. Gertler, C. Huckfeldt, and A. Trigari. Unemployment fluctuations, match quality, and the wage cyclicality of new hires. *The Review of Economic Studies*, 87(4):1876–1914, 2020.

B. González, G. Nuño, D. Thaler, and S. Albrizio. Firm heterogeneity, capital misallocation and optimal monetary policy. 2022.

S. Graves, C. Huckfeldt, and E. T. Swanson. The labor demand and labor supply channels of monetary policy. Technical report, 2023.

F. Guvenen, S. Ozkan, and J. Song. The nature of countercyclical income risk. *Journal of Political Economy*, 122(3):621–660, 2014.

M. Hagedorn, T. H. Law, and I. Manovskii. Identifying equilibrium models of labor market sorting. *Econometrica*, 85(1):29–65, 2017.

M. B. Holm, P. Paul, and A. Tischbirek. The transmission of monetary policy under the microscope. *Journal of Political Economy*, 129(10):2861–2904, 2021.

M. Jarociński and P. Karadi. Deconstructing monetary policy surprises—the role of information shocks. *American Economic Journal: Macroeconomics*, 12(2):1–43, 2020.

M. Jasova, C. Mendicino, E. Panetti, J.-L. Peydró, and D. Supera. Monetary policy, labor income redistribution and the credit channel: Evidence from matched employer-employee and credit registers. 2021.

S. Jung and C. Schnabel. Paying more than necessary? the wage cushion in germany. *Labour*, 25(2):182–197, 2011.

M. B. Karaki. Monetary shocks and job flows: evidence from disaggregated data. *Empirical Economics*, 58 (6):2911–2936, 2020.

D. Lee, S. Doerr, and T. Drechsel. Income inequality and job creation. *FRB of New York Staff Report*, (1021), 2022.

M. Lenza and J. Slacalek. How does monetary policy affect income and wealth inequality? evidence from quantitative easing in the euro area. 2018.

P. Lieberknecht and B. Hartwig. Monetary policy, firm exit and productivity. 2020.

B. Lochner and B. Schulz. Labor market sorting in germany. 2016.

P. Marotzke, R. Anderton, A. Bairrao, C. Berson, and P. Tóth. Wage adjustment and employment in Europe. Technical report, 2016.

A. McKay and C. K. Wolf. Monetary policy and inequality. *Journal of Economic Perspectives*, 37(1):121–144, 2023.

C. Moser, F. Saidi, B. Wirth, and S. Wolter. Credit supply, firms, and earnings inequality. 2022.

A. Popov and J. Rocholl. Do credit shocks affect labor demand? evidence for employment and wages during the financial crisis. *Journal of Financial Intermediation*, 36:16–27, 2018.

A. Samarina and A. D. Nguyen. Does monetary policy affect income inequality in the euro area? 2019.

B. Schoefer. The financial channel of wage rigidity. Technical report, National Bureau of Economic Research, 2021.

A. Singh, J. Suda, and A. Zervou. Heterogeneous labour market response to monetary policy: small versus large firms. *Available at SSRN 3938544*, 2021.

G. L. Violante. What have we learned from hank models, thus far? *Beyond the pandemic: the future of monetary policy*, page 267, 2021.

J. C. Wu and F. D. Xia. Measuring the macroeconomic impact of monetary policy at the zero lower bound. *Journal of Money, Credit and Banking*, 48(2-3):253–291, 2016.

G. Zens, M. Böck, and T. O. Zörner. The heterogeneous impact of monetary policy on the us labor market. *Journal of Economic Dynamics and Control*, 119:103989, 2020.

*We acknowledge the data base and its documentation, conforming with the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) rules.
Berge, Philipp vom; Frodermann, Corinna; Ganzer, Andreas; Schmucker, Alexandra (2021): "Factually anonymous Version of the Sample of Integrated Labour Market Biographies (SIAB-Regionalfile) – Version 7519 v1". Research Data Centre of the Federal Employment Agency (BA) at the Institute for Employment Research (IAB). DOI: 10.5164/IAB.SIAB-R7519.de.en.v1 Data access was provided via a Scientific Use File supplied by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB).
Berge, Philipp vom; Frodermann, Corinna; Ganzer, Andreas; Schmucker, Alexandra (2021): Stichprobe der Integrierten Arbeitsmarktbiografien Regionalfile (SIAB-R) 1975 - 2019. FDZ-Datenreport, 05/2021 (de), Nürnberg. DOI: 10.5164/IAB.FDZD.2105.de.v1.
Berge, Philipp vom; Frodermann, Corinna; Ganzer, Andreas; Schmucker, Alexandra (2021): Sample of Integrated Labour Market Biographies Regional File (SIAB-R) 1975 - 2019. FDZ-Datenreport, 05/2021 (en), Nürnberg. DOI: 10.5164/IAB.FDZD.2105.en.v1.

Bellmann, Lutz; Brunner, Laura; Ellguth, Peter; Grunau, Philipp; Hohendanner, Christian; Kohaut, Susanne; Leber, Ute; Möller, Iris; Schwengler, Barbara; Stegmaier, Jens; Schmucker, Alexandra; Walz, Hannes; Wolter, Stefanie; Nußbeck, Viktoria (2021): "IAB Establishment Panel (IAB BP) – Version 9320 v1". Research Data Centre of the Federal Employment Agency (BA) at the Institute for Employment Research (IAB). DOI: 10.5164/IAB.IABBP9320.de.en.v1

Fischer, Gabriele; Janik, Florian; Müller, Dana; Schmucker, Alexandra (2009): The IAB Establishment Panel – things users should know. In: Schmollers Jahrbuch. Zeitschrift für Wirtschafts- und Sozialwissenschaften, Jg. 129, H. 1, S. 133-148.

Ellguth, Peter; Kohaut, Susanne; Möller, Iris (2014): The IAB Establishment Panel - methodological essentials and data quality. In: Journal for Labour Market Research, Vol. 47, No. 1-2, S. 27-41.

Appendix

1. Data description and sources

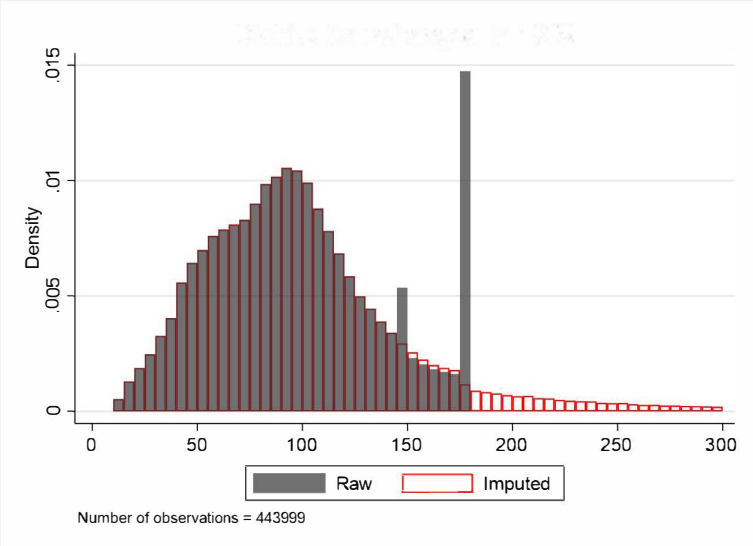
The variables, including the individual wages, enter the regressions in real terms. All nominal variables are deflated using German CPI. As control variables, the analysis employees as a proxy for the business cycle real GDP growth, and also the unemployment rate for the German economy in a robustness regression. The control data such as real GDP, inflation, unemployment rate and different proxies for the monetary policy interventions are all collected from Haver Analytics.

Table A1: Variables Used in the baseline regressions

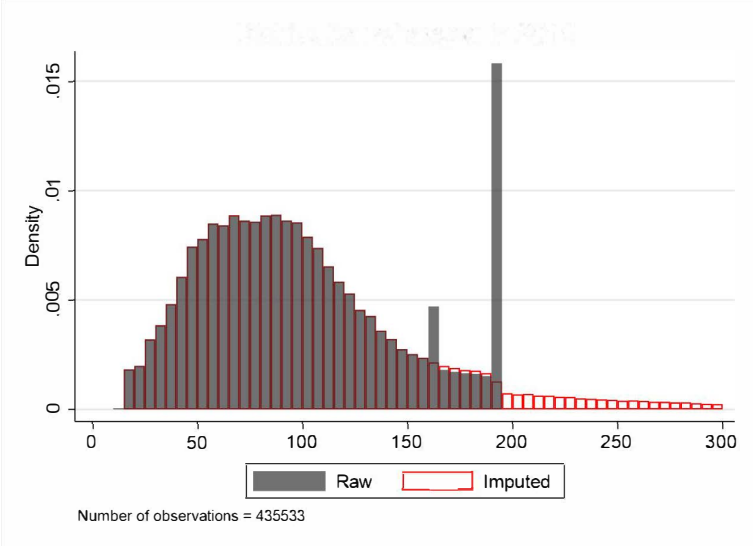
Variable	**Description**	**Source**
Individual wages	Deflated with HICP	SIAB (LIAB)
Individual employment status	1 if employed, 0 if unemployed	SIAB (LIAB)
Monetary policy shocks	Standardized onetary policy surprises	Jarocinski and Karadi (2020)
Economic growth	Real gross domestic product (SA)	Haver (Eurostat)
Consumer price inflation	Harm. Index of Consumer Prices (SA)	Haver (Eurostat)
Unemployment	Unemployment rate (SA)	Haver(Eurostat)

2. Wage imputations and summary statistics

Figure A1: distribution of ln-wages in different years



(a) 1999



(b) 2014

Table A2: Summary statistics of main variables of interest

	Mean	**SD**	**Min**	**Max**
Age	41	10	20	59
Education	2.1	.48	1	3
Female	.45	.5	0	1
East	.19	.39	0	1
ln-wage	4.48	.62	2.3	8.1
H^s	.45	.5	0	1
H^y	.14	.35	0	1
Employed	0.998	.05	0	1
MP	0	.25	-.33	.5
$MP^{<0}$	.44	.5	0	1
$\Delta \ln Y$	.011	.019	-.043	.035
Observations	7980952			

Figure A2: Monetary policy shocks

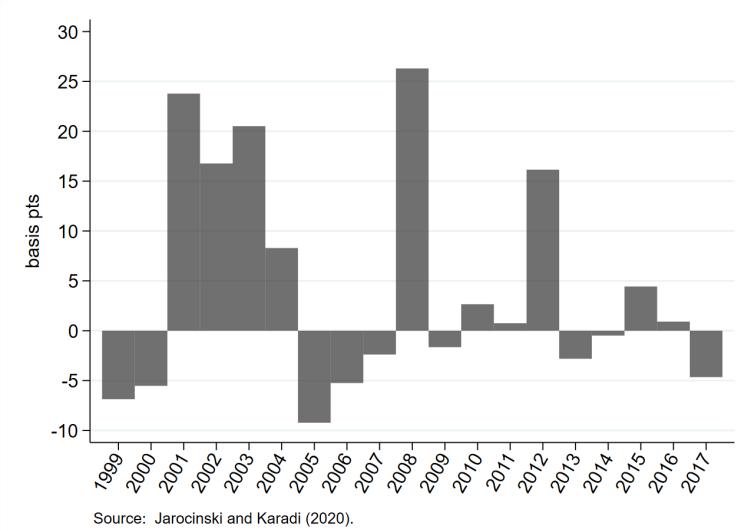
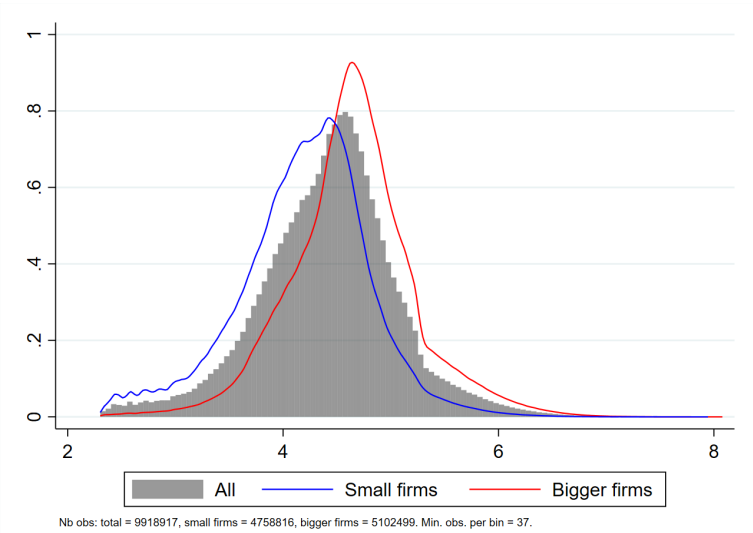
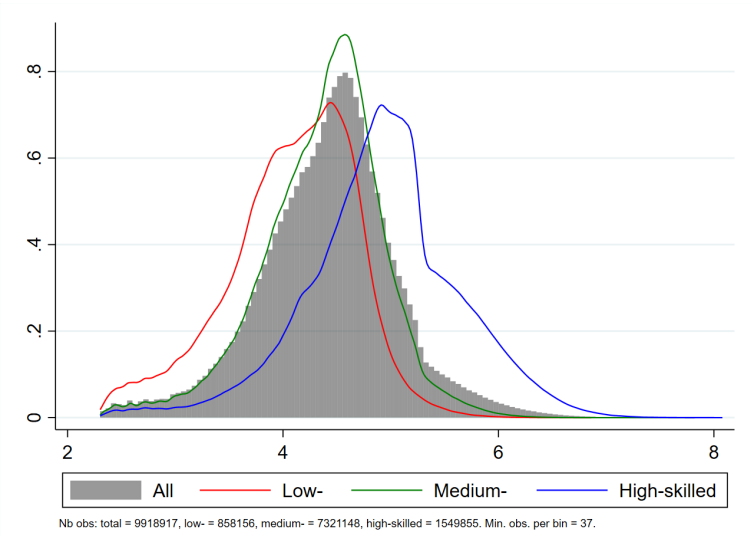


Figure A3: Kernel density of ln-wages by type



(a) Firm size



(b) Worker skills

3. Additional results

Table A3: Individual wages on monetary policy shocks by firm type, sequential adding of fixed effects

	(1)	(2)	(3)	(4)
$S_{j,t-1}$	-0.41***			
	(0.0046)			
MP_{t-1}	-0.017***	-0.63***	-0.63***	-0.46***
	(0.00100)	(0.011)	(0.011)	(0.053)
$\times \quad S_{j,t-1}$	0.024***	0.010***	0.010***	0.0063***
	(0.0016)	(0.00068)	(0.00068)	(0.00065)
Agg. Controls	N	Y	Y	Y
Fixed Effects				
AKM	N	Y	Y	Y
Industry	N	N	Y	Y
Industry × Yr	N	N	N	Y
N	7980952	7906742	7889680	7889680
R-sq	0.151	0.902	0.902	0.902

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year; $Y_{j,t-1}$ is a dummy equal to 1 if the firm exists since less than 5 years; $FR_{j,t-1}$ is a dummy equal to 1 if the firm's average wage is below average.

Table A4: Individual wages on monetary policy shocks by firm size, different subsamples

	(1) mini	(2) AKM	(3) male	(4) < 2015	(5) west	(6) east	(7) stayers	(8) switchers
$MP_{t-1}\times$								
$S^{m}_{j,t-1}$	0.0072***							
	(0.00071)							
AKM^{F}_{t-1}=2		-0.00058						
		(0.0015)						
AKM^{F}_{t-1}=3		-0.0026*						
		(0.0014)						
AKM^{F}_{t-1}=4		-0.0087***						
		(0.0014)						
$S_{j,t-1}$			0.0069***	0.0058***	0.0065***	0.0051***	0.0026	0.0068***
			(0.00086)	(0.00064)	(0.00074)	(0.0013)	(0.0090)	(0.00066)
N	7889680	7583056	4326061	6431716	638014 1	1497344	244129	7240532
R-sq	0.902	0.897	0.896	0.911	0.89 9	0.914	0.928	0.907

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S^{m}_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 10 employees in a certain year; AKM^{F}_{t-1} are AKM effects quantiles estimated on the whole population; $S^{s}_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year; $WR_{i,t-1}$ is a dummy equal to 1 if the worker's wage is below the firm mean wage.

Table A5: Individual wages on monetary policy shocks by firm size, sensitivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$S_{j,t-1} \times MP_t$	0.020***						
	(0.00077)						
$S_{j,t-1} \times MP_{t-1}$		0.0062***	0.012***	0.0028***	0.0016***		
		(0.00065)	(0.00068)	(0.00055)	(0.00015)		
$\text{tenure}_{i,t-1}$		0.000016***					
		(0.00000024)					
$S_{j,t-1} \times \Delta WX_{t-1}$						0.046***	
						(0.0034)	
$S_{j,t-1} \times \Delta D_{t-1}$							0.063***
							(0.0025)
N	7889680	7889680	7076227	7883007	788968 0	4451899	6180086
R-sq	0.902	0.903	0.909	0.914	0.902	0.919	0.909

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year; Column (1) shows the $t-t$ model, Column (2) controls for tenure, Column (3) controls for the unemployment rate instead of GDP, Column (4) uses the non-imputed wage measure, and Column (5) divides the measure of wages by the average wage. WX_{t-1} is the shadow interest rate as computed by Wu and Xia (2016); and D_{t-1} the EONIA deposit rate.

Table A6: Individual wages on monetary policy shocks by worker rank, different subsamples

	(1)	(2)	(3)	(4)
	male	< 2015	west	east
$WR_{i,t-1} \times MP_{t-1}$	-0.012***	-0.0099***	-0.011***	-0.0056***
	(0.00095)	(0.00064)	(0.00075)	(0.0013)
N	4326061	6431716	6380141	1497344
R-sq	0.897	0.912	0.901	0.916

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $WR_{i,t-1}$ is a dummy equal to 1 if the worker's wage is below the firm mean wage.

Table A7: Individual wages on monetary policy shocks by worker type, sensitivity

	(1)	(2)	(3)	(4)	(5)
$MP_t \times WR_{i,t-1}$	-0.0059***				
	(0.00071)				
$MP_{t-1} \times WR_{i,t-1}$		-0.0097***	-0.0069***	-0.0045***	-0.0024***
		(0.00065)	(0.00067)	(0.00055)	(0.00015)
$\text{tenure}_{i,t-1}$		0.000014***			
		(0.00000023)			
N	7889680	7889680	7076227	7883007	7889680
R-sq	0.904	0.904	0.910	0.916	0.904

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $WR^{s}_{i,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year; Column (1) shows the $t-t$ model, Column (2) controls for tenure, Column (3) controls for aggregate unemployment instead of GDP, Column (4) uses the non-imputed wage measure, and Column (5) divides the measure of wages by the average wage.

Table A8: Employment probabilities, role of firms' and workers' effects

	Firm type		Education type		
	small	*large*	*low*	*medium*	*high*
	(1)	(2)	(3)	(4)	(5)
MP_{t-1} ×					
$\text{skill}_{i,t-1}$=2	0.00037	0.00046			
	(0.00046)	(0.00034)			
$\text{skill}_{i,t-1}$=3	0.00046	0.0011***			
	(0.00053)	(0.00038)			
$S_{j,t-1}$			-0.00056	0.00012	-0.00072**
			(0.00055)	(0.00016)	(0.00034)
N	3274085	4152403	525311	5718022	122257 1
R-sq	0.477	0.346	0.480	0.406	0.382

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year; and $\text{skill}_{i,t-1}$ represents the workers' education level (1: no diploma, 2: vocational training, 3: university degree).

Table A9: Employment probabilities, role of firms' and workers' effects

	Firm type		Worker rank	
	small	*large*	*low*	*high*
	(1)	(2)	(3)	(4)
$MP_{t-1}\times$				
$WR_{i,t-1}$	0.00046**	0.00049***		
	(0.00021)	(0.00017)		
$S_{j,t-1}$			-0.00011	0.00015
			(0.00016)	(0.00022)
N	3326894	4184192	3516444	3886889
R-sq	0.477	0.346	0.468	0.456

Table A10: Role of the firms' and workers' effects

	Firm type		Worker rank	
	small	*large*	*bottom*	*top*
	(1)	(2)	(3)	(4)
$WR_{i,t-1} \times MP_{t-1}$	-0.0057***	-0.013***		
	(0.00086)	(0.00094)		
$S_{j,t-1} \times MP_{t-1}$			0.0076***	0.0031***
			(0.00075)	(0.00086)
N	3471081	4321231	3606133	4070038
R-sq	0.928	0.869	0.922	0.912

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year; and $\text{skill}_{i,t-1}$ represents the workers' education level (1: no diploma, 2: vocational training, 3: university degree).

Table A11: Individual wages on monetary policy shocks by firm size (LIAB)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP_{t-1}	-0.012***							
	(0.0047)							
$\times$ $S_{j,t-1}$	0.021***	0.011***	0.011***	0.0079*	0.022**	0.018***	0.048***	0.12***
	(0.0051)	(0.0026)	(0.0026)	(0.0048)	(0.011)	(0.0068)	(0.0075)	(0.022)
Controls & FEs	N	Y	Y	Y	Y	Y	Y	Y
N	14128181	14128181	14102718	979636	1559824	4144978	1468888	1120151
R-sq	0.187	0.880	0.880	0.924	0.845	0.875	0.907	0.845

Note: standard errors in parenthesis; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Errors are clustered at the individual and firm level. Monetary policy shocks are standardized series from Jarociński and Karadi (2020). $S_{j,t-1}$ is a dummy equal to 1 if the firm employs less than 50 employees in a certain year. Column (1) and (2) replicate our basline results in the LIAB data. Column (3) uses the subsamples of non-credit constrained firms; Column (4)-(6) use subsamples with different collective representation (none, inhouse, and sectoral respectively); Column (7) uses the subsample of firms not sharing profits in the pay while Column (8) uses the subsample of firms implementing profit sharing.

Acknowledgements

We are grateful for the comments and suggestions received during multiple seminar presentations and from an anonymous referee. The authors are particularly thankful to Maarten Dossche, Beatrice Pierluigi, Jirka Slacalek, Antonella Trigari and Thomas Warmedinger. The views expressed here do not necessarily reflect those of the European Central Bank or the Eurosystem.

Alina Bobasu
European Central Bank, Frankfurt am Main, Germany; email: alina.bobasu@ecb.europa.eu

Amalia Repele
Bocconi University, Milan, Italy; email: amalia.repele@phd.unibocconi.it

PDF ISBN 978-92-899-7218-5 ISSN 1725-2806 doi:10.2866/0975498 QB-01-25-104-EN-N