Monetary Policy, Labor Income Inequality and Credit: Evidence from Matched Employee-Employer and Credit Registers*

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Abstract

We document the heterogeneous effects of monetary policy on labor market outcomes via credit channel. Using employee-employer and credit registers in Portugal, we show that falling rates increase wages, hours worked and employment more in financially constrained small and young firms. Consistent with the capital-skill complementarity mechanism, we document an increase in the skill premium and show that financially constrained firms increase both physical and human capital investment the most. We uncover a central role of the credit channel with stronger state-dependent effects during crises. The effects are fully driven by firms with bank credit.

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In recent years inequality has received a great deal of attention in the monetary policy debate (e.g., Bernanke, 2015; BIS, 2021; Bullard, 2014; Lagarde, 2020; Mersch, 2014; Powell, 2019; Yellen, 2014).[1] While monetary policy is not directly intended to redistribute income or wealth in the economy, a growing body of literature suggests that it is not immune to redistributive consequences (e.g., Doepke and Schneider, 2006; Kaplan et al., 2018). The bulk of the discussion centers on the relationship between monetary policy and wealth through its effects on asset prices.[2] However, earnings heterogeneity also represents a relevant source of redistribution (e.g., Auclert, 2019). Yet, the quantification of the distribution of these effects across different types of workers and firms in the economy as well as the underlying mechanisms remain open questions.

The estimation of the redistributive effects of monetary policy on labor market outcomes is challenging as it requires an exploration of its effects across both workers and firms. The increase in the dispersion of average earnings *between* firms is one of the main reasons behind the rise in income inequality.[3] In addition, firm financial frictions are crucial in determining how monetary policy transmits to firm-level employment and investment (Cloyne et al., 2018; Gertler and Gilchrist, 1994; Ottonello and Winberry, 2020). It follows that, the assessment of the redistributive effects of monetary policy on worker labor market outcomes should consider firm characteristics and financial frictions, in addition to worker characteristics.[4]

This paper provides novel evidence on the heterogeneous effects of monetary policy on worker

[1] According to the comprehensive overview of central banks' speeches both in advanced and emerging markets in BIS (2021), about 10% of all recent central bankers' communications mentions keywords "inequality" or "distributional consequences/impact of monetary policy". Inequality and the need for monetary policy to take it into account was also among the most debated topics at the listening events of the Federal Reserve and the ECB monetary policy strategy review.

[2] A number of studies have show that softer monetary policy boosts stock prices (Bernanke and Kuttner, 2005), corporate bond prices (Gertler and Karadi, 2015) and government bond prices (Hanson and Stein, 2015). As richer household hold a disproportionate share of stock and bonds, it has been argued that monetary easing fuels capital income and wealth inequality (see e.g., Bernanke et al., 1996; BIS, 2021).

[3] See e.g. Song et al. (2018) for the evidence in the U.S.

[4] To date, the main evidence on monetary policy and income inequality relies on consumer survey data (e.g., Coibion et al., 2017) and, hence, it cannot observe firms or follow workers over time as they move across firms to disentangle to importance of worker and firm characteristics on wages.

labor market outcomes, and on the importance of the credit channel. We exploit a unique granular administrative dataset that matches linked employee-employer data and firm loan-level credit registry in Portugal since the Eurozone creation. Expansionary monetary policy disproportionately increases worker-level wages and hours worked and firm-level employment in small and young firms, which tend to be more financially constrained. Further, we provide new evidence on the effects of monetary policy on the capital-skill complementarity. Following a monetary policy expansion, small and young firms are able to increase both their physical and human capital investment the most. In addition, we document a rise in the skill premium by showing that high-skilled workers benefit the most both in terms of wages and hours worked. Our paper highlights the central role played by the credit channel in the transmission of monetary policy to labor income inequality. Finally, we show that these effects are substantially stronger during crisis times, i.e. when financial constraints are the most severe.

Our setting allows us to overcome key data and endogeneity challenges. First, we exploit an unparalleled match of granular longitudinal data on workers, firms, banks and loans in Portugal. The administrative employee-employer data covers all private sector workers over two full monetary policy cycles (1999–2013). The dataset includes rich information on workers (e.g., occupation, education, regular wage, any additional wage supplements, hours worked) as well as employers (e.g., industry, region, age, sales, investment). Hence, it allows us to analyze all critical labor market outcomes (wages, hours worked and employment) and follow workers over many years as they move across firms. Furthermore, a novelty of this paper is that we match the administrative employee-employer data with the universal coverage of loans from the credit registry to investigate the importance of the credit channel.[5] To the best of our knowledge, this is the first paper that makes use of the universal credit registry matched with administrative employee-employer data

[5]The high-quality granular credit registry in Portugal collects information on all firm credit above the reporting threshold of just EUR 50. In addition to the loan amounts, the credit register includes information on other key loan characteristics, such as the maturity, currency and loan type.

covering the entirety of the private sector employees to study the labor market effects of monetary policy. This allows us to highlight the critical role played by firm and worker characteristics for the redistributive effects of monetary policy on labor market outcomes and uncover the underlying mechanism associated with the existence of financial frictions. Hence, the availability of such a comprehensive and novel dataset enables us to make key contributions to the literature.

Second, the institutional setting helps us overcome potential reverse causality issues between monetary policy and the labor market. Since 1999 Portugal has been part of the Eurosystem and monetary policy has been jointly set by the European Central Bank (ECB) for all member states. We argue that euro area monetary policy has been mostly exogenous to the state of the Portuguese economy as (i) Portugal accounts to 1.8% of Eurozone GDP, (ii) the Portuguese business cycle has not yet converged to the one of the core euro area economies (Giannone et al., 2011), and (iii) the Portuguese economy was very sluggish at the Eurozone creation (Blanchard, 2007; Reis, 2013). We overcome remaining concerns regarding the endogeneity by using monetary policy surprises identified from high-frequency data as in Jarocinski and Karadi (2020). Finally, Portugal also represents a suitable laboratory to investigate the state-dependent labor market effects of monetary policy. As the country was severely hit by the Global Financial Crisis and the European Sovereign Debt Crisis, this setting allows us to study the importance of the credit channel not only in normal times, but also in crisis times, when credit frictions matter the most.

In this paper, we examine the redistributive effects of monetary policy on a number of labor market outcomes (wages, hours worked and employment) and the role of the credit channel. Our baseline measure of monetary policy conditions relies on monetary policy surprises (Jarocinski and Karadi, 2020).[6] Using the administrative employee-employer data, we follow workers over time as they move across firms to disentangle the time effects as well as permanent firm and

[6] We also show that the results are robust to the use of the shadow rate (Wu and Xia, 2016) and overnight interbank interest rate for the Eurozone (EONIA) as in Jimenez et al. (2014).

worker component in their labor market outcomes using time, firm and worker fixed effects. This modelling approach is consistent with the seminal contribution by Abowd et al. (1999). We build on this framework and explore heterogeneous responses across different firms and workers. In terms of firm heterogenieties, we start with firm size and age as proxies of financial constraints, and next we introduce micro-level credit data to directly measure firm-level credit sensitivity to monetary policy. In terms of worker heterogeneity, we explore the role of the skill premium as measured by educational attainment.[7]

We establish four findings. First, expansionary monetary policy disproportionately improves labor market outcomes in small and young firms, which tend to be financially constrained. Following a 25 basis point (bp) expansionary monetary policy shock, workers in small (young) firms experience 4.03 (1.62) stronger increase in wages in the following year compared to workers in large (old) firms. In addition to the wage effects, we show that softer monetary policy also increases employment and hours worked by more in small and young firms. Taken together, expansionary monetary policy improves labor market outcomes more in small and young firms that pay on average lower wages and hence reduces inequality between firms in the economy. In terms of magnitudes, a 25 bp expansionary monetary policy shock reduces the wage gap between small-large or young-old firms by approximately 18%.

Second, we take a step further and explore worker-level heterogeneity with respect to skill. The existing literature has provided substantial evidence that the composition of workers across firms plays a pivotal role in understanding wage dispersion in the economy (Abowd et al., 1999; Card, 1999; Card et al., 2013). We show that following a monetary policy softening, high-skilled workers benefit the most both in terms of wages and hours worked. A 25 bp expansionary monetary policy shock is associated with a 2.21 pp larger increase in wages for high-skilled workers relative to the

[7]The focus of this analysis is to study the redistributive labor market effects associated with monetary policy. To this end, in our estimations we control for the heterogeneous effects of the domestic business cycle and of the global financial cycle.

outcomes of low-skilled workers. Next, we combine worker and firm heterogeneity and show that the skill-premium effects are concentrated in small (young) firms. As high-skilled and high-wage workers tend to be mostly employed by large and high-wage firms (Engbom and Moser, 2017), expansionary monetary policy is associated with a labor reallocation of skilled workforce towards smaller firms. Consistent with the capital-skill complementarity mechanism, softer monetary policy allows financially constrained firms to increase both capital investment and employment of skilled workers. In addition, by exploiting the availability of detailed education coding in the micro-level data, we show that the increased employment of skilled workers and the rise in the skill-premium are more pronounced for workers with STEM degrees. Overall, our findings lend further support to the capital-skill complementary mechanism.

Third, we document the importance of the credit channel for the redistributive effects of monetary policy through the labor market. We start by comparing the effect on wages for firms with and without bank credit. We find that the redistributive effects are fully driven by firms with bank credit. Monetary policy is associated with economically and statistically significant increase in wage effects in small and young firms only for firms with previous bank-borrowing relationships. On the contrary, the effects are opposite or null for workers in firms that do not have any bank borrowing in the previous periods.

Next, we exploit the richness of the credit registry data and show that the credit channel plays an important role in explaining the heterogeneous effects of monetary policy on labor market outcomes. We analyze the firm balance-sheet channel by proposing a novel, agnostic approach that allows us to compute the firm-level credit sensitivity to monetary policy shocks.[8] While we validate that our measure relates to commonly used proxies for financial constraints such as size and age

[8] According to the firm balance-sheet channel, firms' borrowing ability is directly related to the value of their net worth, which gives rise to an external finance premium. Softer monetary policy increases firms' asset value and consequently decreases the external finance premium improving their capacity to raise external funds (Bernanke et al., 1996, 1999).

(see e.g., Cloyne et al., 2018), the proposed strategy offers a flexible approach that does not require to observe (or take an ex-ante stance on) which firm characteristics are the main drivers of the heterogeneous response to monetary policy.[9]

Fourth, we show that the redistributive effects of monetary policy are state dependent. The effects of softer monetary policy on worker labor market outcomes are stronger in crisis periods than in normal times. Crucially, the credit channel also displays stronger effects in crisis times. Our results suggest that expansionary monetary policy is particularly effective in alleviating firm financial constraints during periods of financial distress, thereby mitigating labor income inequality between firms.

Related literature. Our paper relates to four strands of the academic literature. First, we contribute to the recent and growing literature that studies the redistributive effects of monetary policy (e.g., Auclert, 2019; Coibion et al., 2017; Gornemann et al., 2016).[10] While existing papers mainly explore the relationship between monetary policy and wealth inequality (e.g., Andersen et al., 2021; Holm et al., 2021), we focus on labor income inequality. Auclert (2019) decomposes aggregate consumption into a number of channels and demonstrates that the earning heterogeneity channel is important for the transmission of monetary policy to consumption. We closely examine all relevant margins (wages, hours worked and employment) and uncover the crucial role of both

[9]Importantly, in the estimation of the firm-level credit sensitivity to monetary policy changes we introduce bank-time fixed effects to control for the time-varying bank-level credit supply, and industry-region-time fixed effects to absorb any heterogeneity at the industry-region-time including changes in the firm demand for credit which could be triggered by local and industry time-varying conditions. Our results are also robust to an alternative estimation that also controls for time-varying firm demand for credit using firm-time fixed effects.

[10]Our paper closely relates to Coibion et al. (2017) who, using survey data, show that expansionary monetary policy decreases inequality in the U.S.. The quantification of the redistributive effects of monetary policy on worker labor market outcomes based on the exploration of its effects across both workers and firms distinguishes our analysis from other existing work. Consumer survey data do not allow to observe firms (and measure their financial constraints) or to follow workers over time as they move across firms to disentangle the importance of worker and firm characteristics on wages. Instead, we use linked employee-employer administrative data (covering all private sector firms in Portugal), which allow us to observe workers over time as they move across different firms. This is crucial as it enables us to explore the critical role of firm heterogeneity on worker wages (see e.g., Song et al., 2018). Importantly, Song et al. (2018) finds that the increase in the dispersion of average earnings between firms is one of the main reasons behind the rise in income inequality in the United States. In addition, it also allow us to quantify the importance of the underlying mechanisms associated with firm and bank financial constraints, and hence their implications for the effects of monetary policy labor income inequality.

firms and workers characteristics for the redistributive effects of monetary policy on labor market outcomes.

Second, this paper connects to the literature at the intersection of labor and finance. Specifically, we relate to the literature documenting the role of financing frictions in the physical and human capital allocation (e.g., Bai et al., 2018; Barbosa et al., 2019; Fonseca and Van Doornik, 2022). We contribute to this literature by analyzing the interaction of monetary policy, firm financial frictions and the worker skill premium.

Third, we complement existing studies on the labor market effects of credit shocks (Berton et al., 2018; Chodorow-Reich, 2014; Giroud and Mueller, 2019; Moser et al., 2021). In particular, Chodorow-Reich (2014) exploits syndicated-loan data to show the heterogeneous effects of the Lehman crisis on U.S. firm-level employment outcomes. By using a rich dataset that matches the credit register loan-level information with employment data for workers, firms and banks, Berton et al. (2018) document the impact of credit supply shocks on employment across firms, workers, and job contracts in the Veneto region of Italy. More recently, Moser et al. (2021) use the ECB's negative interest rate policy as implemented in 2014 to explore the employment and wage effects of a credit supply shock in Germany. A number of distinctive features of our analysis makes our work complementary to other studies. First, our results are not related to a particular credit supply shock, but summarize the impact of monetary policy changes on labor earnings for the universe of Portuguese private sector workers over 14 years. Specifically, our sample includes normal and crisis times and enables us to show the state-dependent effects of the credit channel. Second, our comprehensive datasets allows us to analyze *all* private sector employees in the economy and the *full universe* of loan data.[11] This allows us to contribute to the existing literature by uncovering

[11] Moser et al. (2021) use syndicated-loan data in Germany which allows them to cover 36% of the labor force, primarily in large firms. Berton et al. (2018) analyze data from a single Italian region relying on the credit reporting threshold of 75,000 EUR (later 30, 000 EUR). We observe all credit contracts above just 50 EUR which allows us to (i) observe the entirety of bank borrowing of private sector non-financial firms in the economy, (ii) use firms that are not borrowing for external validity to corroborate the importance of the credit channel.

that workers in small firms benefit the most from a monetary policy softening.

Fourth, our work relates to the large literature that studies the role of the balance sheet positions and credit frictions are key elements in the heterogeneous transmission of monetary policy across firms and banks (e.g., Bernanke and Gertler, 1995; Gertler and Gilchrist, 1994; Kashyap and Stein, 2000; Drechsler et al., 2017). We build on the recent studies that use micro-level credit registry data to provide evidence on the impact of monetary policy (e.g., Jimenez et al., 2012, 2014) or other credit supply shocks (e.g., Amiti and Weinstein, 2018; Khwaja and Mian, 2008; Paravisini, 2008; Schnabl, 2012) on lending to firms and firm-level real outcomes. Our work also complements recent papers on the effects of monetary policy on firm-level outcomes (e.g., Bahaj et al., 2019; Cloyne et al., 2018). Existing papers focus on the investment and employment effects through the firm balance-sheet channel. We show that monetary policy has also important heterogeneous effects on worker wages and hours worked. Furthermore, the credit channel is important for the monetary policy transmission mechanism and is substantially stronger in crisis times. Finally, the effects are fully driven by firms with bank credit.

The remainder of the paper is organized as follows. Section 1 discusses data and methodology. We present the results on the redistributive monetary policy on wages in Section 2 and on employment and hours worked in Section 3. Section 4 explores the effects of capital-skill complementarity. Section 5 analyzes the role of the credit channel. Section 6 compares the effects in normal times and in crisis periods. Section 7 presents the robustness analysis. Finally, Section 8 concludes.

1 Data and Empirical Strategy

1.1 Data

We build a novel granular dataset that matches the employee-employer and credit registers in Portugal. It allows us to fully track the transmission of monetary policy via banks and firms to worker labor market outcomes. We focus on the period since the creation of the Eurozone in 1999 until 2013, i.e. a sample that covers two monetary policy cycles.

Employee-employer data. *Quadros de Pessoal* (QP) is the linked employee-employer dataset covering all private sector employees in Portugal constructed by the Portuguese Ministry of Labor, Solidarity and Social Security. Private sector firms in Portugal with at least one paid employee are required to submit information on their entire workforce on a yearly basis. The dataset includes information on employee's occupation, education, regular monthly salary, any additional wage supplements, hours worked, etc. On the employer's side, we observe the firm's industry, region, founding year and sales in the previous year. In addition to the rich description of worker and firm observables, the dataset also allows us to follow workers over time as they move across different firms.[12]

Credit register. One of the main contributions of this paper is to analyze the role of the credit channel in the transmission of monetary policy to labor market redistribution. For this purpose, we exploit the match of QP with the credit registry - *Central de Responsabilidades de Credito* (CRC) -

[12]There are the two limitations of the QP dataset. First, while the dataset covers the universe of private sector employees, it abstracts from government employees (approximately 20% of the Portuguese workforce). Second, QP provides a snapshot of labor market outcomes as of the reference month (October). Individuals who happen to be unemployed or out of the labor force at the time of the census have no labor market record for that year. We address these challenges by checking for any significant discrepancies in the coverage of the QP dataset. We match the QP data with the aggregate quarterly labor statistics and we do not identify any potential concerns for our analysis. In particular, we do not observe substantial flows of workers between the private and public sector over the sample period. In addition, the annual data collection occurs in late October and therefore, it does not suffer from significant flows of seasonal workers and appears to be representative of overall labor market conditions. The annual frequency of the data also does not pose any major challenge as wages are generally renegotiated only once per year. It is common in the literature to focus on annual data even if higher frequency data is available (see e.g., Patterson, 2019; Sorkin, 2018).

collected and managed by the Bank of Portugal. CRC reports monthly data on all loans above the reporting threshold of 50 EUR that firms receive from credit institutions supervised by the Bank of Portugal. The dataset includes information on loan amounts and key loan characteristics, such as maturity, currency, type of the loan, and guarantee/collateral used to secure the loan, if any. In this paper, we utilize the credit registry data on total credit (drawn credit as well as unused credit lines) between private NFCs and banks. We restrict the focus to domestic banks and domestic subsidiaries of foreign banks.

Additional bank and firm data. We augment the dataset with firm-level annual census data *Informacao Empresarial Simplificada* (IES) managed by the Bank of Portugal. IES provides detailed annual information on firm balance sheets, income statements, etc. We use this information to construct key firm-level variables such as size (total assets), total debt or investment. Additionally, we use a set of bank variables from the Bank of Portugal's proprietary dataset on bank balance sheet - *Balanco das Instituicoes Monetarias e Financeiras* - to construct a bank liquidity measure.

Monetary policy. Finally, we measure ECB monetary policy conditions using the annualized monetary policy surprises provided by Jarocinski and Karadi (2020). For robustness, we also use alternative monetary policy measures, namely the shadow rates constructed by Wu and Xia (2016) as well as the Euro Overnight Index Average (EONIA) as in Kashyap and Stein (2000) and Jimenez et al. (2014).

Table 1 summarizes the data. Our sample covers the 1999–2013 period.[13] We focus on worker's primary occupation in year t.[14] In total, we observe more than 5.5 million prime age workers employed for a total of almost 800,000 firms. 33% of all workers are employed in firms with fewer

[13]Due to restrictions to match the employee-employer and the credit registries, the analysis cannot be extended the analysis beyond 2013.

[14]If the worker has multiple occupations in year t, we define the primary occupation based on the years employed in the firm and the salary size.

than 50 employees and we denote these firms as small.[15] 11% of the workforce is employed in young firms, i.e. firms with an age below five years.[16] The average worker in our dataset is 38 years old. The fraction of workers above the age of 35 years is 57%. In addition, 61% of the workers have at least a high school degree and 23% have a college degree or higher. Finally, 45% of the workforce are women.

1.2 Empirical strategy

We examine the heterogeneous effects of monetary policy on worker's labor market outcomes by estimating the following regression:

$$\log\left(\mathrm{y}_{w,f,t}\right) = \alpha_t + \alpha_f + \alpha_w + \beta(H_{f/w} \times \Delta i_t) + \gamma(H_{f/w} \times \Delta X_{t-1}) + \zeta C_{w,t-1} + \epsilon_{w,f,t}. \quad (1)$$

We start by focusing on workers' wages. The outcome variable, $\log\left(\mathrm{y}_{w,f,t}\right)$, denotes the log of the hourly wage of worker w in firm f in year t. In line with Card et al. (2015), we construct hourly wages by dividing the sum of a worker's base salary plus earnings supplements by the hours worked.[17] Next, we shift the attention to hours worked and the outcome variable denotes the log of hours worked of worker w in firm f in year t.

In the baseline, we focus on monetary policy surprises as constructed by Jarocinski and Karadi (2020) and denote them as Δi_t. We also present the robustness using alternative monetary policy measures, such as the shadow rate by Wu and Xia (2016) or effective overnight reference rate (EONIA) as in Kashyap and Stein (2000) and Jimenez et al. (2014). The robustness results are

[15] The 50-employee cut-off is consistent with the staff headcount definition of small and medium-sized enterprises (SMEs) in the European Union.

[16] Our age categorization is consistent with other papers in the literature (e.g., Haltiwanger et al., 2013; Babina et al., 2019).

[17] We focus on hourly instead of monthly wages to disentangle the impact of monetary policy directly on wages from any potential effects triggered by adjustments in the working time. Our results are robust to the use of the log of monthly wages.

reported in Section 7.

Firm or worker heterogeneity is denoted by H_f or H_w, respectively.[18] The estimate of β on the interaction between the monetary policy rate and firm/worker characteristics is our main coefficient of interest. It measures by how much more wages for workers of a certain type (H_w) or employed by a certain firm type (H_f) react to monetary rate changes compared to a reference group of workers.

Next, we also control for the heterogeneous effects on labor market outcomes of the domestic business cycle and the global financial cycle. Specifically ΔX_{t-1} denotes the lagged real GDP growth for Portugal and the lagged log level of the U.S. VIX.[19] This setting allows us to control for the heterogeneous firm effects driven by business cycle dynamics and financial distress, and to focus on the effects associated with monetary policy.[20]

Using the administrative employee-employer data, we follow workers over many years as they move across different firms in the labor market to disentangle the permanent worker and firm component in wages using fixed effects. This modelling approach is consistent with the seminal framework proposed by Abowd et al. (1999). We progressively saturate our specification with fixed effects until we reach the benchmark specification (Equation 1). To absorb time variation as well as the unobserved permanent worker and firm components of the individual's annual wage, we use time, firm and worker fixed effects denoted as α_t, α_f and α_w, respectively. We also add controls for worker characteristics ($C_{w,t-1}$), namely a quadratic polynomial in worker age. We cluster standard errors at the firm and worker level.

[18] When applicable, we consider both a time-varying and a time-invariant versions of worker and firm characteristics, such as lagged level of worker's education or the highest attained education.

[19] We also show robustness to the additional inclusion of euro area macro controls in Section 7. In line with the standard Taylor (1993) rule logic, we include Eurozone GDP growth and inflation.

[20] In Online Appendix Table A1, we present the results on the relationship between monetary policy, economic conditions and wage dynamics in Portugal. In all specifications, the relationship of wages and the monetary policy rate is negative, whereas it is positive with the Portuguese GDP growth.

2 Redistributive Wage Effects

We start by reporting the heterogeneous effect of monetary policy on worker wages across firms of different size and age. Our focus on these firm characteristics is motivated by theoretical literature on the role of credit market frictions in the transmission of monetary policy (see e.g., Kiyotaki and Moore, 1997). Furthermore, previous empirical literature has documented a stronger response to monetary policy shocks for small and young firms which are presumably more financially constrained (see e.g., Gertler and Gilchrist, 1994; Kashyap et al., 1994; Cloyne et al., 2018; Bahaj et al., 2019).

Firm size. Table 2 Columns (1)–(4) present the estimates of Equation 1 where we interact the monetary policy with the firm size. A dummy variable SmallFirm_f takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. We run several additional specifications with different combinations of fixed effects to corroborate the robustness of our results. We start with the empirical specification without any fixed effects (Column 1) and saturate it gradually with time, firm and worker fixed effects until we reach the baseline specification in Column (4) corresponding to Equation 1. We find that small firms increase wages by more than large firms following softer monetary policy conditions. The baseline estimate in Column (4) shows that a 25 basis point (bp) expansionary monetary policy shock is associated with a 4.03 percentage point (pp) larger increase in wages of workers in small firms compared to large firms.[21]

The effect is quantitatively very similar also when we account for additional industry/region time-varying fixed effects (see Online Appendix Table A2 Columns (2)–(4)). The results are not driven by the presence of micro firms in which all workers might have close ties to the owner and/or mobility patters could substantially differ. Following Andrews et al. (2008), we eliminate firms at bottom 10th and 25th percentile and we find that these estimates are consistent with the results

[21] Column (1) reports a sanity check in the full sample without the use of any fixed effects. The estimates suggest that following an expansionary monetary policy, wages on average increase and the rise is larger for small firms. The effect on the wage dispersion between small and large firms continues to be economically and statistically significant even after saturating the model with the relevant time, worker and firm fixed effects.

reported in the main sample (see Online Appendix Table A3).

Figure 1 Panel (a) shows the effect of monetary policy conditions on log hourly worker wages for each quintile of firm size. Each point represents the coefficient estimate for each bin (quintile) of firm size interacted with the monetary policy. We omit the top quintile (80-100 percentile) which we use as a reference category. Consistent with the results in Table 2, workers in the bottom quintiles of the firm size distribution (small firms) benefit the most from monetary policy softening. In addition, the effects appear to be markedly linear in firm size – the workers in the smallest firms benefit the most and the effect progressively decreases in firm size.

Our findings relate to the large literature showing that smaller firms are more exposed to the propagation of the monetary policy (e.g., Gertler and Gilchrist, 1994; Kashyap et al., 1994; Cloyne et al., 2018). This result has often been interpreted as supporting evidence on the importance of the credit channel. We explore these implications more formally in Section 5. More broadly, small firms are also found to be more vulnerable to credit supply shocks (see e.g., Khwaja and Mian, 2008; Chodorow-Reich, 2014; Greenstone et al., 2020).

Firm age. Table 2 Columns (5)–(8) show that following a monetary policy expansion, young firms increase wages by more than old firms. Using Equation 1, we interact the monetary policy with a dummy variable $\text{YoungFirm}_{f,t-1}$ that takes value of 1 if the firm is younger than five years, and 0 otherwise. The baseline estimate in Column (8) show that a 25bp expansionary monetary policy shock is associated with a 1.62 pp larger increase in wages for workers in young firms compared to workers in old firms. This relationship remains robust when we introduce additional time-varying region and/or industry fixed effects (see Online Appendix Table A2 Columns (5)–(7)).

Figure 1 Panel (b) illustrates the heterogeneous effects of monetary policy conditions for workers by quintiles of firm age. We show that the effect is the largest for the workers in the youngest firms (bottom quintile). In addition, the effect of monetary policy on wages for the two lowest quantities

(p0–p20 and p20–p40) is statically significantly different from the estimates for workers in the oldest firms (our reference group). Our results complement recent papers on the effects of monetary policy on labor market outcomes at the firm level. In particular, Bahaj et al. (2019) show that young firms are more sensitive to monetary policy and react more in terms of firm-level employment. We show that workers in young firms are also more strongly affected in terms of wages.

Finally, in Online Appendix Table A2, we show that both the firm size and the age margin are economically relevant. In Column (1), we horse-race the effects of monetary policy interacted with small firms and young firms respectively and find that both estimates remain negative and statistically significant.

Existing literature has highlighted that workers in small or young firms tend to earn lower wages (see e.g., Brown and Medoff, 1989; Oi and Idson, 1999). In Appendix Table A4, we compute the wage gaps by comparing wages of workers in the same region, industry and job title across small-large and young-old firms. We find that the wage differential is around 23% for small vs. large firms, 9% for young vs. old firms. Taken together, our findings highlight that softer monetary policy contributes to a decrease in the wage dispersion across firms in the economy. In terms of magnitudes, a 25 bp expansionary monetary policy shock reduces the the inequality between small-large or young-old firms by approximately 18%.[22]

In Figure 1 Panel (c), we further corroborate this finding by splitting firms into quintiles according to their position in the wage distribution in year $t-1$. We find that following a monetary policy softening, the wages of workers in low-wage firms increase more than the wages of workers in high-wage firms. Therefore, our results highlight that expansionary monetary policy reduces income inequality between firms.

[22]Specifically, the wage gap between small and large firms shrinks by approximately 17.52%, and between young and old firms by about 18% following a 25 bp expansionary monetary policy shock.

3 Redistributive Employment Effects and Hours Worked

So far, we have showed that expansionary monetary policy reduces workers wage differentials across firms and workers in the economy. In this section, we investigate the redistributive effects of monetary policy across different types of firms with a focus on employment and hours worked.

First, we analyze the heterogeneous effect of monetary policy on workers' total hours worked by estimating the Equation 1 where the outcome variable is total hours worked by worker w in firm f in year t. Second, we focus on employment at the firm level and estimate the following regression:

$$\log\left(\text{employment}_{f,t}\right) = \alpha_{i,t} + \alpha_{r,t} + \alpha_f + \beta(H_f \times \Delta i_t) + \gamma(H_f \times \Delta X_{t-1}) + \epsilon_{w,f,t}. \tag{2}$$

The outcome variable, $\log\left(\text{employment}_{f,t}\right)$, denotes log of the number of workers employed in firm f at time t. As in our previous analysis, Δi_t captures monetary policy shocks and H_f denotes firms characteristics. The estimate of β on the interaction between the monetary policy rate and firms' characteristics is our main coefficient of interest. We further saturate the specification with firm, industry-time and region-time fixed effects. The standard errors are clustered at the firm level.

Table 3 presents the results of the interaction of the monetary policy rate with the firm size and age. Columns (1) and (2) report the effects for worker-level hours worked following Equation 1. A 25 bp expansionary monetary policy shock is associated with a 13.4 pp (12 pp) stronger increase in hours worked in small (young) firms compared to large (old) firms. In Columns (3) and (4), we report the effects on firm-level employment following the specification in Equation 2. Similarly, a monetary policy softening implies a larger expansion in firm-level employment in small (young) firms compared to large (old) firms.

4 Capital-Skill Complementarity

Our findings on firm heterogeneity highlight that workers in low-wage (small and young) firms benefit the most from a monetary policy softening. In this section, we investigate the effects of monetary policy on worker-level heterogeneity by comparing high- vs. low- skilled workers. The focus on the skill premium is motivated by the large body of labor literature that has investigated the link between educational attainment (skill) and labor market outcomes (e.g., Autor et al., 2008; Card, 2001; Mincer et al., 1974) and the importance of the capital-skill complementarity (e.g., Acemoglu, 1998; Krusell et al., 2000). Recently, the finance literature has also documented the effects of financial friction on firm-level employment (Berton et al., 2018), and labor and capital reallocation (Bai et al., 2018; Fonseca and Van Doornik, 2022). In what follows, we contribute to the above literature by analyzing the interaction of monetary policy, firm financial frictions and the worker skill premium.

4.1 Monetary policy and skill premium

First, we revisit the empirical specification described in Equation 1 which we use to analyze the heterogeneous effects of monetary policy on wages and hours worked. We replace the firm heterogeneity with the worker heterogeneity. Specifically, we proxy for skill with education and we define a dummy variable College_w which takes the value of 1 if the maximum educational attainment of worker w is at least a college degree, and 0 otherwise.[23] Table 4 Column (1) shows that following a monetary policy softening, the wages of high-skilled (college educated) workers increase by more than the wages of low-skilled workers. A 25 bp expansionary monetary policy shock is associated with a 2.21 pp larger increase in wages for high-skilled workers relative to the outcomes of low-

[23] In the baseline, we define the variable College as an invariant (maximum) educational attainment. Our results are robust to the time-varying definition, i.e. the degree of education of worker w in year $t-1$ (see Online Appendix Table A5).

skilled workers. Similarly, Column (3) shows that high-skilled workers also benefit in terms of hours worked.[24]

The richness of our administrative employee-employer data allows to further differentiate the skill premium across workers. While college graduates might on average have higher skills, new technologies might be more complementary to specific fields and workers performing non-routine cognitive tasks (Acemoglu and Autor, 2011; Fonseca and Van Doornik, 2022). To this end, we differentiate the educational attainment into the college degree obtained in the STEM fields or other (non-STEM) fields.[25] The results are reported in Columns (2) and (4) of Table 4. We find that while monetary policy increases the effect of college premium for all high-skilled workers, the benefit is concentrated in the wages and hours worked of STEM-degree high-skilled workers.

4.2 Firm heterogeneity and capital-skill complementarity

How is the rise in skill premium related to firm heterogeneity? In Figure 2, we report the estimates of the triple interaction of firm size, worker skill premium and monetary policy. We examine the heterogeneous effects of monetary policy on hours worked using the college educated workers in large firms as a reference category. We find that while college premium rises both in large and small firms, the effect on hours worked is most pronounced for high-skilled workers in small firms. Figure 2 shows that the largest effects accrue to high-skilled workers in small firms. As high-skilled (high-wage) workers tend to be mostly employed by large (high-wage) firms (Engbom and Moser, 2017), monetary easing is associated with a labor reallocation of skilled workforce towards smaller firms. Low-skilled workers in small firms benefit disproportionately more than their low-skilled peers in large firms. This is consistent with our findings in Section 3 which highlights a stronger

[24]The main results are reported across firms using worker, firm and time fixed effects as in Equation 1. In Online Appendix Table A5, we show that there results also hold within firm by saturating the regression analysis with firm-time fixed effects.

[25]We denote as STEM the degrees in Natural Sciences, Technology, Engineering, Economics and Math. Our results are robust to the exclusion of the Economics/Business degrees.

labor market response to monetary policy for small firms. Interestingly, the effect for low-skilled workers in small firms is statistically similar to high-skilled workers in large firms (our reference category). Finally, low-skilled workers in large firms benefit the least.

In Table 5, we focus on the final missing piece of the capital-skill complementarity: the effect of monetary policy on firm capital investment. Using firm balance sheet data, we construct the outcome variable as the year-on-year change in capital scaled to the lagged value of firm's total assets. In line with the previous analysis, we explore the heterogeneous effect of monetary policy by firm size and age and find that expansionary monetary policy is also associated with a stronger increase in investment in small and young firms.

Overall, we provide new evidence on the effects of monetary policy on capital-skill complementarity at the most granular firm- and worker-level. Our findings relate to Dolado et al. (2021) who using aggregate and industry level document that a monetary policy easing exacerbates labor income inequality between high- and low-skilled workers, and that the increase in high-skill employment encourages capital investment. We complement the literature by stressing the importance of the firm identity on inequality (see e.g., Card et al., 2013; Song et al., 2018). In particular, we show that the redistributive effects of monetary policy are primarily driven by small and young firms. Following a monetary policy softening, small and young firms are able to disproportionately increase their capital investment as well as wages and hours worked of their high-skilled workers. Furthermore, in the next section we directly connect our evidence to the credit channel, and show that credit plays a critical role in the transmission of monetary policy towards small and young firms and it affects the dispersion of the labor market outcomes of workers.

5 Credit Channel

In the previous sections, we have shown that following a monetary policy softening, labor market outcomes of workers employed in smaller and younger firms improve more than in larger and older firms. A natural next step is to examine the channel through which monetary policy changes heterogeneously affect wages and employment across firms in the economy. Guided by the large body of literature that emphasizes the crucial role played by financial frictions for small firms, we investigate the importance of the credit channel. Balance sheet positions and credit frictions are key elements in the heterogeneous transmission of monetary policy across firms and banks (e.g., Gertler and Gilchrist, 1994; Kashyap and Stein, 2000; Jimenez et al., 2012; Drechsler et al., 2017). Furthermore, financial market imperfections contribute to shape wage contracts (e.g., Michelacci and Quadrini, 2009; Guiso et al., 2013). Still, the literature lacks a systematic empirical investigation of the importance of the effects of the credit channel for the transmission of monetary policy to worker-level labor market outcomes.

We exploit a novel dataset which links the employee-employer and credit registries to investigate the role of credit in the transmission mechanism of monetary policy to worker-level wages and hours worked and firm-level employment. We examine the effect of the firm balance-sheet to show that credit plays a important role in explaining the redistribute labor income effects of monetary policy.

We start by showing the overall importance of bank credit. To this purpose, we augment Equation 1 with a triple interaction of monetary policy, firm heterogeneity (size or age) and variable capturing the importance of bank credit at the firm level. Since not all firms in Portugal have active bank borrowing relationship, we compare the labor market outcomes for workers in small (young) firm with and without bank credit. To this end, we define a dummy variable $\text{ExistCredit}_{f,t-1}$ that takes the value of 1 if the firm had an existing bank borrowing relationship in previous periods, and 0 otherwise.

Table 6 reports the results. The estimates in Column (1) show that the wage effects for workers in small firms are fully driven by firms with existing bank borrowing relationship. We find no redistributive effects for small firms without bank credit. In Column (2), we repeat the estimation for young vs. old firms. Similarly, only workers in young firms with existing bank borrowing relationship benefit from monetary policy softening. Instead, the coefficient estimate for young firms without bank credit has the opposite (positive) sign.

5.1 Firm balance-sheet channel

Next, we study the role of the firm balance-sheet channel by proposing a novel, agnostic approach that allows us to compute the sensitivity of the individual firm credit to monetary policy. According to the firm-balance sheet channel, softer monetary policy increases firms' asset value and net worth, and thus extends firms' capacity to raise external funds (Bernanke and Gertler, 1995). If this channel is also associated with the redistributive labor market effects, monetary policy should propagate more strongly to wages and hours worked in firms with higher credit sensitivity to monetary policy. To test this hypothesis, we develop a strategy that does not require to take an explicit stance regarding which firm characteristics are the main drivers of the firm heterogeneous responses to monetary policy.

Our methodology consists of two steps. First, we use loan-level credit data to estimate the following regression:

$$\log(\text{credit}_{f,b,t}) = \kappa_{b,t} + \kappa_{i,r,t} + \beta_f \Delta i_t + \gamma_f \Delta X_{t-1} + \epsilon_{f,b,t}, \tag{3}$$

where the outcome variable $\log(\text{credit}_{f,b,t})$ denotes the log level of total credit that firm f borrows from bank b at time (quarter) t. Our main coefficient of interest β_f denotes the firm-level credit sensitivity to monetary policy in an agnostic manner. That is, using loan-level credit data, we

estimate the sensitivity for each firm to monetary policy without taking a stance which observable firm characteristics are the main drivers of the transmission mechanism. Given that a decrease in interest rates on average leads to an increase in credit available to a firm, a more negative β_f is associated with a stronger sensitivity of firm level credit to monetary policy. In the rest of the credit analysis, we use this estimated firm-level credit sensitivity to monetary policy as a proxy for the firm-balance sheet channel and we denote it as FBC_f.

Estimating the effect of monetary policy through the credit transmission mechanism poses two important identification challenges. First, in addition to the firm-level credit sensitivity, individual firms are connected to different banks which can respond heterogeneously to monetary policy in terms of their credit supply effects. For instance, an ample body of the bank-lending channel literature has shown that banks with worse balance sheet health (Bernanke and Blinder, 1988; Jimenez et al., 2012; Amiti and Weinstein, 2018) or less liquid banks (Kashyap and Stein, 2000) tend to be have more sensitive credit supply response to monetary policy. In Equation 3, we address this concern by introducing bank-firm fixed effects ($\kappa_{b,t}$) to control for the time-varying bank-level credit supply.

Second, in addition to monetary policy, firm-level credit sensitivity can also be driven by other firm, industry or region specific changes that could affect the results. We address this concern in a number of ways. In the baseline specification (Equation 3), we saturate our model with industry-region-time fixed effects ($\kappa_{i,r,t}$) to control for any heterogeneity at the industry-region-time including changes in the firm demand for credit which could be triggered by local and industry time-varying conditions. As detailed in Online Appendix B, we show that our results are also robust to an alternative specification in which we control for time-varying firm demand shocks with firm-time fixed effects (Khwaja and Mian, 2008). This strategy first estimates the credit sensitivity to monetary policy for the bank-firm loan pair and then aggregates the bank-firm FBC estimates to

the firm-level FBC using firm credit exposure to different banks as weights.

We estimate Equation 3 using quarterly credit registry data for Portuguese firms for the 1999–2013 period. In order to provide systematic evidence for the external validity of our measure of firm-level credit sensitivity to monetary policy, we investigate whether our agnostic FBC_f measure is consistent with commonly used proxy measures of the firm balance-sheet channel such as firm size or age (see e.g., Cloyne et al., 2018). According to the existing literature, smaller and younger firms tend to be more financially constrained, and consequently benefit more from softer monetary policy. Table 7 summarizes the results of the range of univariate and multivariate regressions which examine the relationship between FBC_f and firm size or/and age. We find that our agnostic firm-level credit sensitivity to the monetary policy rate is correlated with the proxies previously used by the literature. Specifically, younger and smaller firms exhibit stronger sensitivity of their credit to monetary policy (i.e., more negative FBC_f). These findings also support the capital-skill complementarity mechanism by showing that in response to softer monetary policy, financially constrained firms increase both physical and human capital investment.

While we validate that this agnostic measure of firm-level credit sensitivity to monetary policy relates to more explicit proxies (size, age), our proposed measure offers a novel and flexible approach to examine the heterogeneous effects of monetary policy without having access to or taking an ex-ante stance on the role of specific firm-level observables as main drivers of such heterogeneity. Next, we use the estimate of the agnostic firm-level credit sensitivity to monetary policy as a source of heterogeneity in the labor market regressions:

$$\log\left(\mathrm{y}_{w,f,t}\right) = \alpha_t + \alpha_f + \alpha_w + \theta(FBC_f \times \Delta i_t) + \gamma(FBC_f \times \Delta X_{t-1}) + \zeta C_{w,t-1} + \epsilon_{w,f,t}. \quad (4)$$

If the firm balance-sheet transmission mechanism is at work in shaping the labor market out-

comes, we should expect that wages, hours worked or employment of workers associated with firms with a stronger sensitivity of their credit to monetary policy (low FBC_f firms) would increase by more compared to workers associated with firms with a weaker sensitivity (high FBC_f firms). Hence, we would expect the coefficient θ to be positive and statistically significant.

5.2 Results

In this section, we present the results of the analysis on the credit channel of monetary policy on a range on labor market outcomes. Table 8 summarizes the results. Column (1) reports the estimates for the firm-balance sheet channel on worker's wages. Consistent with our hypothesis, we find that following an expansionary monetary policy, wages of workers in firms with stronger credit sensitivity to monetary policy increase by more compared to firms with a weaker credit sensitivity.

In Columns (2) and (3), we examine the effect on the credit channel on worker-level hours worked and firm-level employment. Similarly to the wage analysis, we report positive and statistically significant coefficients across all specifications. This suggests that the credit channel plays an important role in the transmission of monetary policy also for employment and hours worked. Finally, in Column (4), we present an alternative approach to construct the proxy of firm balance sheet channel by directly controlling for firm demand for credit with firm-time fixed effects as in Khwaja and Mian (2008).[26]

Our findings relate to the long standing empirical macroeconomic literature that studies the importance of the firms' balance sheet strength as a mechanism through which monetary policy interacts with credit market imperfections and affect firms' outcomes (e.g., Gertler and Gilchrist, 1994; Bernanke and Gertler, 1995). Our results show that firms more reliant on banks as their primary source of funding are more responsive to monetary policy. Furthermore, we uncover the

[26] We discuss the details behind this approach in Online Appendix B.

importance of this channel for the previously undocumented redistributive effects of monetary policy on labor market outcomes.

6 Monetary policy in crisis times

So far, we have discussed the average effects of monetary policy on labor income redistribution. In this section, we explore whether the impact of monetary policy on wages also depends on the state of the economy. In particular, we analyze to what extend a monetary policy softening affects labor income inequality differently in good times and in times of crisis, i.e. when financial frictions are more pronounced.

In Table 9, we revisit our main findings and augment the analysis by introducing a triple interaction term of monetary policy, firm heterogeneity and the state of the economy. For simplicity, we use the dummy variable Crisis_{t-1} that takes the value of 1 if the Portuguese economy suffered from a negative GDP growth in the previous year. In Columns (1) and (2), we proxy firm financial constraints by size and age. In both cases we find that workers in small and young firms benefit more from softer monetary policy and these effects are amplified in crisis periods. In Column (3), we use our agnostic measure of the firm balance-sheet channel. We find that the benefit of softer monetary policy for workers in firms with higher credit sensitivity are substantially larger in crisis times.

Overall, our results demonstrate that the effects of monetary policy through the credit channel are stronger in crisis periods compared to normal times. This finding provides evidence in support of the effectiveness of monetary policy in alleviating financing constraints especially when they are needed the most.

Our findings contribute to the recent and growing literature on the effects of monetary policy on firm-level outcomes (e.g., Bahaj et al., 2019; Cloyne et al., 2018) by showing important het-

erogeneous effects of monetary policy changes on worker-level wages and hours worked though the credit channel. In addition, we also complement recent work that documents positive firm-level employment effects of monetary policy though the credit channel (see e.g., Luck and Zimmermann, 2020; Jasova et al., 2021), by showing that the same channel is also important for the transmission of a monetary policy to labor income inequality across workers in the economy. Finally, we provide novel evidence on the state-dependent effects of the credit channel of the transmission of monetary policy to labor income.

7 Robustness to alternative monetary policy measures

In what follows we show that our results are robust to the use of different measures of monetary policy conditions. To this end, we re-estimate key heterogeneities using alternative monetary policy measures and report the results for the wage heterogeneity in the Online Appendix Table C1 and for hours worked in the Online Appendix Table C2.

First, we present the results using Euro Overnight Index Average (EONIA) as in Kashyap and Stein (2000) and Jimenez et al. (2014). Euro area monetary policy has been rather exogenous to the state of the Portuguese economy. Specifically, Portugal joined the Eurozone in 1999 and monetary policy is jointly set for all of its member states by the ECB. Portuguese GDP constitutes on average only 1.8% of the euro area GDP. Importantly, the Portuguese economy was very sluggish following the Eurozone creation (Blanchard, 2007; Reis, 2013) and its business cycle has not converged to that of the core countries (Giannone et al., 2011). It is important to highlight while the onset of the Sovereign Debt Crisis could potentially impact the endogeneity in the final two years of our sample (2010–2013). In fact, the ECB *raised* monetary rates in 2011 when Portugal was in the middle of an economic and financial downturn and did not introduce quantitative easing.

Second, we augment the EONIA measure with additional macroeconomic controls for the euro

area. The macroeconomic literature largely summarizes the conduct of monetary policy with the Taylor rule, according to which the policy interest rate is set as a function of contemporaneous deviations in inflation and activity (see e.g., Christiano et al., 1999). In line with the standard Taylor (1993) rule logic, we complement the baseline macro controls (GDP growth in Portugal and VIX) with additional terms and interact the firm heterogeneity with the lagged values of euro area GDP growth and inflation, respectively.

Third, to take into account the overall stance of monetary policy beyond what is strictly observed through the change in policy interest rates, we use the euro area shadow rate computed by Wu and Xia (2016). The shadow rate is a measure of monetary policy conditions that also summarizes the use of unconventional policy measures. Thus, unlike EONIA, it also accounts for additional monetary expansions associated with for instance fixed-rate full allotment or LTRO liquidity operations.[27]

To summarize, Online Appendix Tables C1 and C2 report that all our key findings are robust to the use of EONIA, additional macro controls or shadow rates.[28]

8 Conclusion

We analyze how monetary policy affects labor income redistribution across both workers and firms via the credit channel. We show that a monetary policy expansion is associated with improved labor market outcomes and higher capital investment, especially in small and young firms. Since small and young firms tend to offer lower wages, softer monetary policy narrows the wage differential between

[27] It is important to note that the most important unconventional monetary policy measures (negative rates and quantitative easing) did not occur during our sample period 1999–2013. The ECB reduced the deposit facility rate into negative territory for the first time only in June 2014 and it launched expanded asset purchase program only in March 2015.

[28] Online Appendix C reports the robustness to macro controls, shadow rates and monetary policy surprises for the baseline wage and hours worked outcomes with respect to firm heterogeneities and the measures of the credit channel. The results for all other margins are also robust to these alternative measures of monetary policy and are available upon request.

firms in the economy. In addition, small and young firms are able to increase their investment in both physical capital and human capital, in line with the capital-skill complementarity mechanism.

We find that monetary policy is associated with strong effects only for small and young firms with existing borrowing relationships. By exploiting the richness of the credit registry data, we show the key role of the credit channel for the heterogeneous effects of monetary policy on labor market outcomes. To analyze the importance of the credit channel, we develop a novel approach that estimates the firm-level credit sensitivity to monetary policy.

Our paper has several important implications. We show that the redistributive effects of monetary policy are mainly driven by small and young firms. By showing that firm and bank financial constraints play a critical role for the redistributive effects of monetary policy, and especially so in crisis times, we also uncover new insights into the importance of the credit channel.

Our findings also have relevant implications for the growing heterogeneous agent literature (e.g., Auclert, 2019; Kaplan et al., 2018). We show the importance of the heterogeneous effects of monetary policy on labor market outcomes and the central role played by the credit channel. By highlighting the critical role of firms and workers characteristics for the redistributive effects of monetary policy on labor market outcomes, our empirical evidence suggests that heterogeneous agents models should not neglect the impact of monetary policy across both workers and firms when studying the redistributive effects of monetary policy. Our results also advocate that the modelling of firm and bank financial constraints is vital to understand the heterogeneous effects of monetary policy on labor market outcomes. Furthermore, our paper increases awareness of the key margins of the distributional consequences of central banking actions and are thus, informative for the future conduct of monetary policy.

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Graphs and Tables

Table 1: Descriptive statistics

Firms:	
Fraction of workers in small firms	0.3321
Fraction of workers in young firms	0.1101
Mean share of college educated workers in a firm	0.1250
Workers:	
Mean age	38.16
Fraction $>$ 35 years old	0.5712
Fraction with high school degree	0.6152
Fraction with college degree	0.2295
Fraction females	0.4469
Mean weekly hours	38.8134
Std. weekly hours	4.1300
Mean log hourly wage	2.9935
Std. log hourly wage	0.6484
Number of workers	5,587,862
Number of firms	795,369

Notes: The sample consists of yearly data from 1999 to 2013.

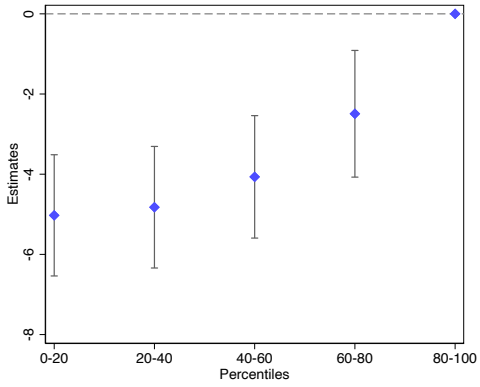
Table 2: Monetary policy, wages and firm heterogeneity

	$\log(\text{wage}_{w,f,t})$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{SmallFirm}_f \times \Delta i_t$	-5.86***	-6.10***	-5.67***	-4.03***				
	(0.938)	(0.957)	(0.466)	(0.400)				
$\text{YoungFirm}_{f,t-1} \times \Delta i_t$					-3.69**	-5.10***	-2.06***	-1.62***
					(1.672)	(1.618)	(0.411)	(0.341)
Δi_t	-7.14***				-9.96***			
	(0.946)				(0.435)			
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE		Yes	Yes	Yes		Yes	Yes	Yes
Firm FE			Yes	Yes			Yes	Yes
Worker FE				Yes				Yes
N	23,440,467	23,440,467	23,407,226	22,583,567	28,448,100	28,448,100	28,371,823	27,577,576
R^2	0.11	0.12	0.55	0.83	0.03	0.04	0.53	0.82

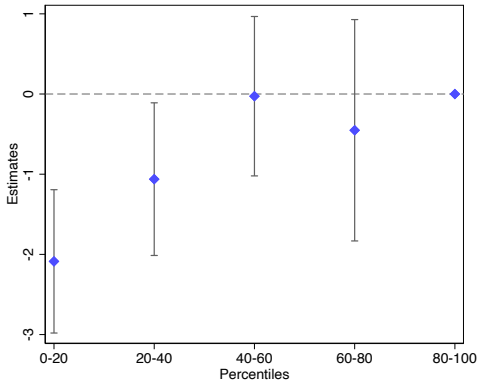
Notes: This table shows the worker-level wage effects of 25 bp expansionary monetary policy shock, as described in Equation 1. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). SmallFirm_f is a dummy variable that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. $\text{YoungFirm}_{f,t-1}$ is a dummy variable that takes a value of 1 if the firm is younger than five years, and 0 otherwise. Controls denote additional variation of small (young) firm and GDP and VIX, as well as the polynomial of worker's age. Standard errors are two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1: Firm heterogeneities by quintiles

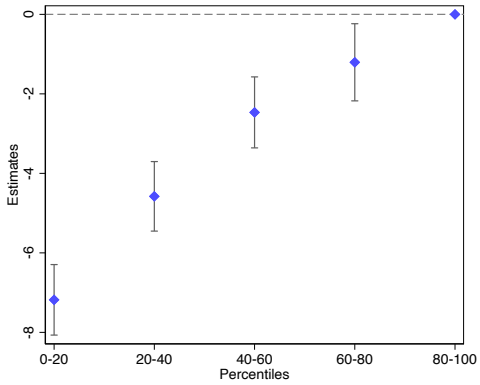
(a) Firm size



(b) Firm age



(c) Firm wage



Notes: This figure presents the redistributive wage effects of a 25 bp expansionary monetary policy shock using firm heterogeneities. Each point represents a coefficient estimate from the Equation 1 with separate independent variables for each bin (quintile) of distribution ordered by firm size (Panel (a)), firm age (Panel (b)) and median firm wages in $t-1$ (Panel (c)). The top quintile (p80–p100) is the reference (omitted) category. Standard errors are two-way clustered at the firm and worker level. Vertical lines denote 95% confidence intervals.

Table 3: Monetary policy, employment and hours worked

	$\log(\text{hours}_{w,f,t})$		$\log(\text{employment}_{f,t})$	
	(1)	(2)	(3)	(4)
$\text{SmallFirm}_f \times \Delta i_t$	-13.42***		-0.09***	
	(1.458)		(0.051)	
$\text{YoungFirm}_{f,t-1} \times \Delta i_t$		-11.95***		-0.57***
		(2.296)		(0.014)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes		
Worker FE	Yes	Yes	n/a	n/a
Industry-Time FE			Yes	Yes
Region-Time FE			Yes	Yes
N	26,919,089	36,078,494	3,794,154	3,875,384
R^2	0.27	0.25	0.8963	0.902

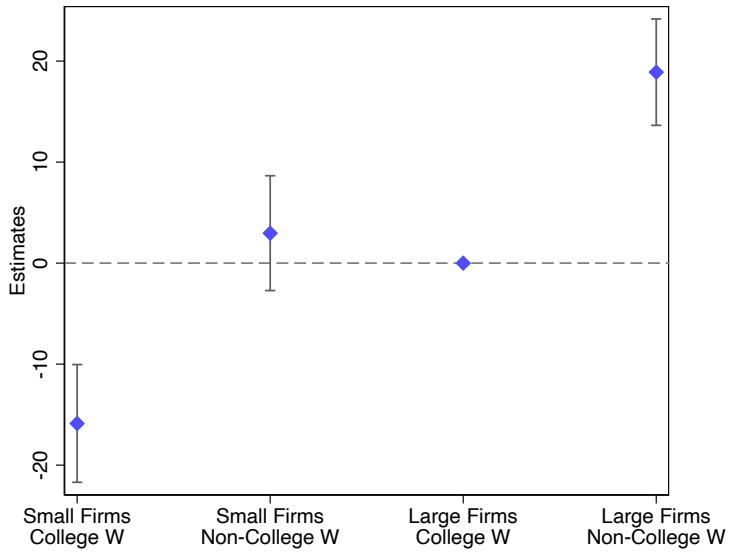
Notes: This table shows the worker-level hours worked effects (Equation 1) and firm-level employment effects (Equation 2) of a 25 bp expansionary monetary policy shock. The outcome variable in Columns (1)–(2) measures total hours worked by worker w in firm f in year t. The outcome variable in Columns (3)–(4) denotes the log of the number of workers employed in firm f at time t. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). SmallFirm_f is a dummy variable that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. $\text{YoungFirm}_{f,t-1}$ is a dummy variable that takes a value of 1 if the firm is younger than five years, and 0 otherwise. Controls denote additional variation of small (young) firm and GDP and VIX, and in Columns (1)–(2) also the polynomial of worker's age. n/a stands for not applicable. Standard errors two-way clustered at the firm and worker level in Columns (1)–(2) and at the firm level in Columns (3)–(4). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Monetary policy and skill premium

	$\log(\text{wage}_{w,f,t})$		$\log(\text{hours}_{w,f,t})$	
	(1)	(2)	(3)	(4)
$\text{College}_w \times \Delta i_t$	-2.21***		-33.55***	
	(0.265)		(1.163)	
$\text{STEM College}_w \times \Delta i_t$		-3.72***		-56.04***
		(0.327)		(1.316)
$\text{Other College}_w \times \Delta i_t$		-1.02***		-17.88***
		(0.275)		(1.418)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Worker FE	Yes	Yes	Yes	Yes
N	22,451,149	22,451,149	30,433,138	36,776,868
R^2	0.82	0.082	0.25	0.25

Notes: This table shows the worker-level heterogeneity on wages and hours worked of a 25 bp expansionary monetary policy shock (Equation 1). The outcome variable in Columns (1)–(2) denotes a log of hourly wage of worker w in firm f in year t. The outcome variable in Columns (3)–(4) measures total hours worked by worker w in firm f in year t. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). College_w takes the value of 1 if the highest educational attainment of worker w is at least a college degree, and 0 otherwise. We further split College into two subcategories STEM College_w takes the value of 1 if a worker received a degree in STEM fields and Other College_w denotes non-STEM degrees. Controls denote additional variation of college variable(s) and GDP and VIX, as well as the polynomial of worker's age. Standard errors two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 2: Firm and worker heterogeneity



Notes: This figure presents the redistributive effects of 25 bp expansionary monetary policy shock using a combination of firm and worker heterogeneity. The outcome variable is log hours worked. Firms with fewer than 50 employees are denoted as Small Firms, and as Large Firms otherwise. Workers are denoted as College Workers if their highest educational attainment is at least a college degree. College educated workers in large firm are taken as the reference (omitted) category. Standard errors are two-way clustered at the firm and worker level. Vertical lines denote 95% confidence intervals.

Table 5: Monetary policy and investment

	ΔCapital$_{f,t}$ / TA$_{t-1}$			
	(1)	(2)	(3)	(4)
SmallFirm$_f \times \Delta i_t$	-6.97***	-6.95***		
	(0.479)	(0.469)		
YoungFirm$_{f,t-1} \times \Delta i_t$			-4.10***	-19.32***
			(0.387)	(0.473)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Firm FE		Yes		Yes
N	620,886	578,000	619,856	577,022
R^2	0.0119	0.4152	0.0347	0.421

Notes: This table shows the estimates of the heterogeneous effects on monetary policy on firm-level investment of a 25 bp expansionary monetary policy shock. The outcome variable as the year-on-year change in capital scaled to the lagged value of firm's total assets. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). SmallFirm$_f$ is a dummy that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. YoungFirm$_{f,t-1}$ is a dummy that takes a value of 1 if the firm is younger than five years, and 0 otherwise. Controls denote additional variation of small (young) firm and GDP and VIX. Standard errors are clustered at the firm level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Importance of the credit channel

	$\log(\text{wage}_{w,f,t})$	
	(1)	(2)
$\text{SmallFirm}_f \times \Delta i_t$	1.08	
	(1.991)	
$\text{SmallFirm}_f \times \Delta i_t \times \text{ExistCredit}_{f,t-1}$	-6.05***	
	(2.048)	
$\text{YoungFirm}_f \times \Delta i_t$		4.13**
		(1.608)
$\text{YoungFirm}_f \times \Delta i_t \times \text{ExistCredit}_{f,t-1}$		-5.83***
		(1.718)
Controls	Yes	Yes
Time FE	Yes	Yes
Firm FE	Yes	Yes
Worker FE	Yes	Yes
N	14,661,241	18,351,663
R^2	0.82	0.80

Notes: This table shows the worker-level wage effects of a 25 bp expansionary monetary policy shock. We expand Equation 1 with additional interaction capturing the importance of bank credit. $\text{ExistCredit}_{f,t-1}$ takes the value of 1 if the firm has ever had an existing bank borrowing relationship, and 0 otherwise. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). SmallFirm_f is a dummy that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. $\text{YoungFirm}_{f,t-1}$ is a dummy that takes a value of 1 if the firm is younger than five years, and 0 otherwise. Controls denote interaction terms of small (young) firms and the respective credit proxy, triple interaction of small (young) firms, credit proxy and GDP/VIX, double interactions of credit proxy and GDP / VIX / monetary policy rate, double interaction of small (young) firms and GDP / VIX, as well as the polynomial of worker's age. Standard errors are two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Relationship between firm credit sensitivity to monetary policy rate and proxy variables

	FBC_f					
	(1)	(2)	(3)	(4)	(5)	(6)
Age_f	0.17***					
	(0.008)					
$\log(TotalAssets_f)$		0.27***				
		(0.061)				
$\log(Employment_f)$			0.23***			
			(0.097)			
$YoungFirm_f$				-5.99***		-6.03***
				(0.002)		(0.003)
$SmallFirm_f$					-7.04***	-5.47***
					(0.877)	(0.993)
N	272,042	284,881	272,645	272,042	257,783	257,232
R^2	0.0015	0.0002	0.0002	0.0022	0.0002	0.0024

Notes: This table presents coefficients from firm-level univariate regressions $FBC_f = \alpha + \phi X_f + \epsilon_f$, where FBC_f denotes firm-balance sheet channel which is estimated as a firm-level credit sensitivity to monetary policy conditions from loan-level regression following Equation 3. X_f represents average size or age of firm f over the sample period. $YoungFirm_f$ is a dummy that takes a value of 1 if the firm is younger than five years, and 0 otherwise. $SmallFirm_f$ is a dummy that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Firm balance sheet channel

	$\log(\text{wage}_{w,f,t})$	$\log(\text{hours}_{w,f,t})$	$\log(\text{employment}_{w,f})$	$\log(\text{wage}_{w,f,t})$
	(1)	(2)	(3)	(4)
$\text{FBC}_f \times \Delta i_t$	1.70***	4.96***	11.47***	
	(0.463)	(1.881)	(0.287)	
$\overline{FBC}_f \times \Delta i_t$				0.74**
				(0.335)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Worker FE	Yes	Yes	n/a	Yes
N	18,616,018	22,066,437	1,634,604	12,625,774
R^2	0.79	0.26	0.91	0.80

Notes: This table shows the coefficients from the credit channel analysis following a 25 bp expansionary monetary policy shock, as described in Equation 4. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). FBC_f denotes the firm balance-sheet channel measure, as described in Equation 4. Controls denote additional variation of FBC and GDP and VIX. n/a stands for not applicable. Standard errors are clustered at the firm level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Heterogeneity of monetary policy in crisis times

	$\log(\text{wage}_{w,f,t})$		
	(1)	(2)	(3)
$\text{SmallFirm}_f \times \Delta i_t$	-3.56***		
	(0.351)		
$\text{SmallFirm}_f \times \Delta i_t \times \text{Crisis}_{t-1}$	-1.51***		
	(0.519)		
$\text{YoungFirm}_{f,t-1} \times \Delta i_t$		-1.40***	
		(0.373)	
$\text{YoungFirm}_{f,t-1} \times \Delta i_t \times \text{Crisis}_{t-1}$		-1.73***	
		(0.419)	
$\text{FBC}_f \times \Delta i_t$			1.19***
			(0.456)
$\text{FBC}_f \times \Delta i_t \times \text{Crisis}_{t-1}$			1.05*
			(0.600)
Controls	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Worker FE	Yes	Yes	Yes
N	22,583,567	27,577,576	18,616,018
R^2	0.83	0.814	0.7911

Notes: This table summarized the state-dependent effects of 25 bp expansionary monetary policy shock on labor income redistribution. SmalFirm_f is a dummy that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. $\text{YoungFirm}_{f,t-1}$ is a dummy that takes a value of 1 if the firm is younger than five years, and 0 otherwise. FBC_f denotes the firm balance-sheet channel measure, as described in Equation 4. Crisis_{t-1} is a dummy variable if the economy suffered from a negative GDP growth in the previous year. Controls denote additional variation of the respective key firm characteristic and GDP and VIX, as well as the polynomial of worker's age. Standard errors are two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Online Appendix

Monetary Policy, Labor Income Redistribution and the Credit Channel: Evidence from Matched Employer-Employee and Credit Registers

A Additional Figures and Tables

Table A1: Monetary policy, economic conditions and wage dynamics

	$\log(\text{wage}_{w,f,t})$			$\log(\text{hours}_{w,f,t})$		
	(1)	(2)	(3)	(4)	(5)	(6)
Δi_t	-13.76***	-10.11***	-11.98***	-20.64***	-18.31***	-14.59***
	(0.460)	(0.225)	(0.192)	(0.706)	(0.673)	(0.733)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE		Yes	Yes		Yes	Yes
Worker FE			Yes			Yes
N	28,778,666	28,701,026	27,906,048	36,824,799	36,806,902	36,776,868
R^2	0.0092	0.5139	0.8058	0.0027	0.1057	0.2433

Notes: This table shows the coefficients from worker-level wage and hours worked sensitivity of wages to a 1 pp increase in the monetary policy rate. R_{t-1} is a lagged value of EONIA rate. ΔGDP_{t-1} denotes lagged values of the Portuguese GDP growth. Controls denote the polynomial of worker's age. Standard errors are two-way clustered at the firm and worker level. *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A2: Firm heterogeneity robustness: small and young firms

	log(wage$_{w,f,t}$)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SmallFirm$_f \times \Delta i_t$	-3.90***	-4.03***	-3.37***	-3.22***			
	(0.394)	(0.400)	(0.389)	(0.306)			
YoungFirm$_{f,t-1} \times \Delta i_t$	-0.75**				-1.62***	-1.38***	-1.40***
	(0.305)				(0.341)	(0.270)	(0.229)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes			Yes		
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Worker FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Time FE			Yes			Yes	
Region-Time FE			Yes			Yes	
Sector-Region-Time FE				Yes			Yes
N	22,325,223	22,583,567	22,583,547	22,582,781	27,577,576	27,577,557	27,576,832
R^2	0.83	0.83	0.83	0.83	0.82	0.82	0.82

Notes: This table shows the worker-level wage effects of 25 bp expansionary monetary policy shock, as described in Equation 1. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). SmallFirm$_f$ is a dummy variable that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. YoungFirm$_{f,t-1}$ is a dummy variable that takes a value of 1 if the firm is younger than five years, and 0 otherwise. Controls denote additional variation of small (young) firm and GDP and VIX, as well as the polynomial of worker's age. Standard errors are two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: Firm heterogeneity: small vs large firms and sample cutoffs

	log(wage$_{w,f,t}$)		
	Baseline	p10 cutoff	p25 cutoff
	(1)	(2)	(3)
SmallFirm$_f \times \Delta i_t$	-4.03***	-4.01***	-3.87***
	(0.400)	(0.399)	(0.398)
Controls	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Worker FE	Yes	Yes	Yes
N	22,583,567	21,151,016	18,568,775
R^2	0.83	0.83	0.83

Notes: This table shows the worker-level wage effects of 25 bp expansionary monetary policy shock, as described in Equation 1. From the baseline sample in Column (1), we eliminate firms below the 10th and 25th percentile of employment, respectively. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). SmallFirm$_f$ is a dummy variable that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. Controls denote additional variation of small (young) firm and GDP and VIX, as well as the polynomial of worker's age. Standard errors are two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: Wage gap between firms

	$\log(\text{wage}_{w,f,t})$					
	(1)	(2)	(3)	(4)	(5)	(6)
SmallFirm_f	-0.265***	-0.233***	-0.233***			
	(0.090)	(0.006)	(0.006)			
$\text{YoungFirm}_{f,t-1}$				-0.103***	-0.091***	-0.090***
				(0.005)	(0.003)	(0.003)
Sector-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Region-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Job Title FE		Yes	-		Yes	-
Job Title-Time FE			Yes			Yes
N	23,441,303	23,441,263	23,440,268	28,449,265	28,449,230	28,448,302
R^2	0.31	0.51	0.51	0.27	0.48	0.48

Notes: This table shows the coefficients of the wage gap for workers in small vs. large firms in Columns (1)–(3), and young vs. old firms in Columns (4)–(6). SmallFirm_f is is a dummy variable that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. $\text{YoungFirm}_{f,t-1}$ is a dummy variable that takes a value of 1 if the firm is younger than five years, and 0 otherwise. Standard errors are two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Monetary policy and skill premium: Robustness

	$\log(\text{wage}_{w,f,t})$		
	Baseline		
	(1)	(2)	(3)
$\text{College}_w \times \Delta i_t$	-2.21***		-2.72***
	(0.265)		(0.155)
$\text{College}_{w,t-1} \times \Delta i_t$		-3.05***	
		(0.316)	
Controls	Yes	Yes	Yes
Worker FE	Yes	Yes	Yes
Time FE	Yes	Yes	-
Firm FE	Yes	Yes	-
Firm-Time FE			Yes
N	22,451,149	22,451,149	22,451,149
R^2	0.8165	0.8167	0.8167

Notes: This table shows the robustness to worker-level heterogeneity analysis on wages following a 25 bp expansinary monetary policy shock. Δi_t denotes monetary policy surprises as in Jarocinski and Karadi (2020). In the baseline, we define College_w as a time-invariant dummy variable that takes the value of 1 if the highest educational attainment of worker w is at least a college degree, and 0 otherwise. In the robustness, we use time-varying college measure $\text{College}_{w,t-1}$ that takes the value of 1 when the last year's educational attainment is at least a college degree, and 0 otherwise. Controls denote additional variation of the respective college measure and GDP and VIX, as well as the polynomial of worker's age. Standard errors two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B Firm balance sheet channel: Robustness

As a robustness for the firm balance-sheet channel methodology presented in Section 5.1 of the paper, we consider an alternative specification of Equation 3 that estimates the firm-level credit sensitivity to monetary policy using the following regression that controls for additional firm-time variation of credit:

$$\log(\text{credit}_{f,b,t}) = \kappa_{b,t} + \kappa_{f,t} + \beta_{f,b}\Delta i_t + \gamma_{f,b}\Delta GDP_t + \epsilon_{f,b,t}. \tag{B1}$$

We estimate the sensitivity to monetary policy for each bank-firm pair ($\beta_{f,b}$). Next, we compute a credit weighted average of these estimates to obtain sensitivity to monetary policy at the firm level where

$$\overline{\text{FBC}}_f = \sum_b \frac{\hat{\beta}_{f,b} \times credit_{b,f,t-1}}{credit_{b,f,t-1}}. \tag{B2}$$

Equation B1 allows us to introduce firm-time fixed effects to further control for time-varying firm-level variation (that could have potentially remained unaddressed by previously used sector-region-time fixed effects in Equation 3 in the main text). Using firm-time fixed effects, we cannot estimate the credit sensitivity to monetary policy at the firm level. Instead, we identify the credit sensitivity $\beta_{f,b}$ for each bank-firm pair and then aggregate the sensitivity at the firm level (Equation B2). The implementation of firm-time fixed effects requires the existence of multiple borrowing relationships for firm f at time t (for details see e.g., Khwaja and Mian, 2008). The broad coverage of Portuguese credit registry (reporting threshold of 50 EUR) allows us to introduce firm-time fixed effects without any significant loss of generality. Note that on average, firms in Portugal have credit relationship with two banks.

Finally, following the same approach as in the main text, we estimate of the worker-level wage heterogeneity:

$$\log(\text{wage}_{w,f,t}) = \alpha_t + \alpha_w + \alpha_f + \theta(\overline{\text{FBC}}_f \times \Delta i_t) + \zeta \text{C}_{w,t-1} + \epsilon_{w,f,t}. \tag{B3}$$

The results are presented in Column (4) of Table 8. With softer monetary policy, wages of workers in firms with a stronger credit sensitivity to monetary policy at the bank-firm level increase by more compared to wages in firms with weaker credit sensitivity. This suggests that even after controlling for time-varying credit demand and supply in the loan regression, the firm balance sheet channel is important in shaping the responses of wages to monetary policy changes.

C Robustness to different measures of monetary policy

Table C1: Robustness to different measures of monetary policy: Wages

	$\log(\text{wage}_{w,f,t})$								
	EONIA			EONIA + Macro controls			Shadow rates		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\text{SmallFirm}_f \times R_{t-1}$	-1.16***			-1.00***			-1.12***		
	(0.163)			(0.153)			(0.147)		
$\text{YoungFirm}_{f,t-1} \times R_{t-1}$		-0.40***			-0.37***			-0.42***	
		(0.118)			(0.116)			(0.099)	
$FBC_f \times R_{t-1}$			0.73***			0.70***			0.68***
			(0.16)			(0.16)			(0.15)
Controls	Yes	Yes	Yes	Yes‡	Yes‡	Yes‡	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Worker FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	22,584,310	27,578,607	18,616,412	22,584,310	27,578,607	18,616,412	22,584,310	27,578,607	18,616,412
R^2	0.83	0.82	0.79	0.83	0.82	0.79	0.83	0.82	0.79

Notes: This table shows the robustness to the the worker-level wage analysis of 1 pp increase in the monetary policy rate, as described in Equations 1. R_{t-1} denotes different measures of monetary policy: Columns (1)–(4) use the EONIA rate and Columns (5) and (6) use shadow rate computed by Wu and Xia (2016). SmallFirm_f is a dummy that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. Young $\text{Firm}_{f,t-1}$ is a dummy that takes a value of 1 if the firm is younger than five years, and 0 otherwise. FBC_f denotes the firm balance-sheet channel measure, as described in Equation 4. Controls denote additional variation of small (young) firm and GDP and VIX, as well as the polynomial of worker's age. In addition, Columns (3) and (4) further control for lagged values of EA GDP growth and inflation (denoted with ‡). Standard errors are two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C2: Robustness to different measures of monetary policy: Hours worked

	$\log(\text{hours}_{w,f,t})$								
	EONIA			EONIA + Macro controls			Shadow rates		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\text{SmallFirm}_f \times R_{t-1}$	-7.03***			-8.47***			-7.63***		
	(0.61)			(0.672)			(0.564)		
$\text{YoungFirm}_{f,t-1} \times R_{t-1}$		-2.87***			-4.12***			-4.36***	
		(0.79)			(0.755)			(0.662)	
$FBC_f \times R_{t-1}$			2.39***			2.91***			2.62***
			(0.70)			(0.08)			(0.66)
Controls	Yes	Yes	Yes	Yes‡	Yes‡	Yes‡	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Worker FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	26,919,089	36,078,494	22,066,437	26,919,089	36,078,494	22,066,437	26,919,089	36,078,494	22,066,437
R^2	0.27	0.25	0.26	0.27	0.25	0.26	0.27	0.25	0.26

Notes: This table shows the robustness to the the worker-level hours worked analysis of 1 pp increase in the monetary policy rate, as described in Equations 1. R_{t-1} denotes different measures of monetary policy: Columns (1)–(4) use the EONIA rate and Columns (5) and (6) use shadow rate computed by Wu and Xia (2016). SmallFirm_f is a dummy that takes a value of 1 if the firm has fewer than 50 employees, and 0 otherwise. Young $\text{Firm}_{f,t-1}$ is a dummy that takes a value of 1 if the firm is younger than five years, and 0 otherwise. FBC_f denotes the firm balance-sheet channel measure, as described in Equation 4. Controls denote additional variation of small (young) firm and GDP and VIX, as well as the polynomial of worker's age. In addition, Columns (3) and (4) further control for lagged values of EA GDP growth and inflation (denoted with ‡). Standard errors are two-way clustered at the firm and worker level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.