Heterogeneity in labor market response to monetary policy: small versus large firms*

Aarti Singh[a] Jacek Suda[b] Anastasia Zervou[c]

November 7, 2023

Abstract

We study the effects of monetary policy on the labor market in small and large firms in the United States. We find that: (i) There is an asymmetry in the effects of monetary contractions versus expansions with respect to firms' employment and hiring growth. A monetary contraction reduces small firms' employment and hiring growth *less* than in large firms while a monetary expansion boosts employment and hiring growth in small firms *more* than in large firms. (ii) Failing to account for this asymmetry can lead to the erroneous conclusion that small firms respond stronger than large firms to monetary policy shocks. (iii) The employment response is weaker than that of hiring, highlighting the importance of considering labor market flows. (iv) In both monetary contractions and expansions, the growth of the average earnings of new hires decreases. We study a model with heterogeneous firms, a working capital constraint, the financial accelerator effect, and the marginal cost effect; we supplement this model with the employees' earnings effect summarized in result (iv). We demonstrate how this additional effect can account for the differential response of employment and hiring growth in small and large firms as noted in result (i).

JEL classification: $D22$, $E24$, $E52$, $J23$, $L25$
Keywords: Heterogeneous firms, financing constraints, labor market, monetary policy

*We thank Saroj Bhattarai, Christoph E. Boehm, James Cloyne, Olivier Coibion, Chris Edmond, Niklas Kroner, Yusuf Mercan, James Morley, Giuseppe Moscarini, Andreas I. Mueller, Ayşegül Şahin, Faisal Sohail as well as conference and seminar participants at the University of Texas-Austin, Monash University, Canadian Economic Association 2021 (virtual), American Economic Association 2022 (virtual), IAAE 2022 (London), CRETE 2022 (Greece), Money Macro Finance Workshop 2022, CEF 2023 (Nice), National and Kapodistrian University of Athens (virtual), De Nederlandsche Bank, Bank of International Settlements, University of Groningen, National Taiwan University, Iowa State University, Athens University of Economics and Business, the Central Bank of Greece, University of Melbourne, and University of Queensland for helpful comments. Finally, we thank Zhenghao Li for providing excellent research assistance. The usual disclaimers apply.

[a]School of Economics, University of Sydney; aarti.singh@sydney.edu.au.
[b]Narodowy Bank Polski and SGH Warsaw School of Economics; jacek.suda@nbp.pl.
[c]Corresponding author: Department of Economics, the University of Texas at San Antonio; zervoua@gmail.com.

1 Introduction

The Federal Reserve operates under a Congressional mandate that includes promoting "effectively the goals of maximum employment [..]". Implicit in this mandate is the belief that monetary policy has an impact on employment. Our analysis offers new empirical evidence indicating that the effects of monetary policy on the labor market depend on both the size of the firm and the direction of the monetary policy shock.

Examining how monetary policy influences the employment dynamics of small and large firms is important for several reasons. First, recent literature has found weak evidence of monetary policy effects on aggregate variables (see Ramey, 2016). By exploring disaggregated data and worker flows, we re-examine the effects of monetary policy on the labor market and find them to be significant. Second, examining the effects of monetary policy on heterogeneous firms is essential for a better understanding of the channels of monetary policy transmission. This approach has been widely adopted in the literature that focuses on the effects of monetary policy on investment (e.g., Gertler and Gilchrist, 1994; Cloyne, Ferreira, Froemel, and Surico, 2021; Ottonello and Winberry, 2020), but it has been less explored in the context of the labor market (e.g., Abo-Zaid and Zervou, 2020; Yu, 2021; Bahaj, Foulis, Pinter, and Surico, 2022). Third, there is a noticeable trend in the United States, with an increasing share of workers employed in large firms and a decreasing share of workers in small firms (see Figure A.2.1 in the Appendix for firms above 500 employees versus firms with fewer than 20 employees). The employment response of small versus large firms during the cycle has been examined in the literature (e.g., Sharpe, 1994; Davis and Haltiwanger, 1999; Moscarini and Postel-Vinay, 2012; Fort, Haltiwanger, Jarmin, and Miranda, 2013; Chodorow-Reich, 2014), however there is less research on the relative employment response of small versus large firms to monetary policy shocks. Moreover, the relative employment by firm size is important because it has been at the forefront of policy discussions, often leading to policy enactment.[1]

In our empirical analysis, we use the publicly available Quarterly Workforce Indica-

[1] For example, the U.S. Small Business Administration (SBA), established in 1953, is a cabinet-level federal agency that provides counseling, capital, and contracting expertise for small businesses. Information about recent federal measures targeting small businesses, including the large-scale Paycheck Protection Program, can be found at https://home.treasury.gov/policy-issues/coronavirus/assistance-for-small-businesses.

tors (QWI) dataset from the Census (2020). We employ the Jordà (2005) local projections method to compute impulse responses of labor market variables to the high-frequency monetary policy shocks of Swanson (2021). Importantly, we account for the sign of monetary policy shocks and the size of firms affected by those shocks when examining how monetary policy impacts the U.S. labor market.

In our empirical analysis, we uncover several novel findings: (i) A monetary contraction decreases employment and hiring growth, but less so for small firms relative to large ones. However, a monetary expansion increases employment and hiring growth more for small firms compared to larger firms. This response heterogeneity is striking and reveals that monetary policy mitigates the recent trend of employment concentration in large firms in the U.S. (ii) There is an asymmetry in the effects of monetary policy contractions and expansions on the labor market. Ignoring this asymmetry leads to the misleading conclusion that the employment and hiring growth of small firms respond more than that of large firms to monetary policy shocks. In addition, examining the sign asymmetry reveals that the effects of monetary contractions are realized fast, while the consequences of monetary expansions take time to manifest. (iii) The response of employment growth to monetary policy shocks is weaker than that of hiring growth, highlighting the importance of studying flows for understanding the effects of monetary policy on the labor market.

To interpret the asymmetric results we employ a heterogeneous firm model featuring a working capital constraint, the financial accelerator effect of Bernanke, Gertler, and Gilchrist (1999), and the marginal cost channel of Ottonello and Winberry (2020). We proxy financially constrained firms in the model with small firms in the data and financially unconstrained firms in the model with large firms in the data.[2] To explain result (i) with this model, one would need to assume that the financial accelerator effect is weaker relative to the marginal cost effect when there is a contractionary shock, and the opposite when there is an expansionary shock. Our theoretical contribution is to incorporate in the above model our fourth empirical finding (iv), according to which both contractionary and expansionary monetary policy shocks reduce the growth rate of average earnings paid to new hires.[3]

[2]This assumption has been used before in the literature, e.g. by Gertler and Gilchrist (1994), based on earlier findings, e.g. of Fazzari, Hubbard, and Petersen (1988), that small firms face tighter financing constraints.

[3]As discussed in Gertler, Huckfeldt, and Trigari (2020) and Hazell and Taska (2020), average earnings

Incorporating the *employees' earnings channel* in the model, rationalizes our empirical result (i). To understand the role of this channel, consider first a decrease in employees' earnings paid by the firms. Even if the decreases in employee payments are homogeneous across firms, the responses of employment and hiring are heterogeneous. This is because constrained firms pay a spread on the amount that they borrow, and the spread decreases when firms borrow less. Through the decline in the spread, this channel suggests that employment and hiring in constrained firms increase more than in large firms following a decrease in the average employees' earnings paid by the firms. The employee's earnings channel allows small firms to expand their hiring and employment growth more during a monetary expansion and reduce their hiring and employment growth less during a monetary contraction, relative to large firms.

Related literature

The empirical analysis in our paper relates to the continuously growing literature that explores the sensitivity of heterogeneous firms to macroeconomic shocks and over the cycle. A strand of this literature has focused on the effects of monetary policy on the investment and sales of heterogeneous firms, e.g., Gertler and Gilchrist (1994), Chari, Christiano, and Kehoe (2013), Kudlyak and Sanchez (2017), Jeenas (2019), Crouzet and Mehrotra (2020), Ottonello and Winberry (2020), Howes (2021), Kroner (2021), Gnewuch and Zhang (2022) among others. Another strand has examined heterogeneity in employment responses to other variables, e.g., Sharpe (1994), Davis and Haltiwanger (1999), Moscarini and Postel-Vinay (2012), Fort, Haltiwanger, Jarmin, and Miranda (2013), Haltiwanger, Jarmin, and Miranda (2013), but not to monetary policy shocks. Our paper stands at the intersection of these two strands of the literature and examines the effects of monetary policy on employment among heterogeneous firms.

The first strand of the literature mentioned above explores the monetary transmission mechanism. Based on earlier findings that small firms face tighter financing constraints (e.g. Fazzari, Hubbard, and Petersen, 1988), Gertler and Gilchrist (1994) show that after tight money episodes sales and inventories of small (in terms of assets) firms are more responsive

response does not necessarily translate into the equivalent wage changes, given composition effects that could be triggered after monetary policy shocks. As such, our findings that average earnings decline after a monetary expansion and contraction, do not necessarily imply that the wages of all workers decrease; it does imply though that the cost of external financing declines. We discuss this further in Section 4.2.

than those of larger firms. Their paper emphasizes the credit channel and the financial accelerator mechanism of Bernanke, Gertler, and Gilchrist (1999). Recent research by Jeenas (2019), Ottonello and Winberry (2020), and Cloyne, Ferreira, Froemel, and Surico (2021) explores the strength of the investment channel. Similarly to those papers, we explore the effects of monetary policy shocks on heterogeneous firms and emphasize the role of financing frictions. Our focus, however, is on the labor market rather than on investment.

Apart from our empirical contribution to the above literature of established monetary transmission channels, we find empirical support for an additional channel, the employees' earnings channel, and use this evidence to extend an existing model of financing frictions. A related channel, exploiting changes in wages, but in theoretical considerations and in different environment was also considered by Zervou (2014) and Manea (2020).[4] To our knowledge, we are the first to use a data set to show empirically that monetary policy affects the average earnings paid to employees, and embed that fact into a model to explain employment and hiring responses of large and small firms, recovered from the same dataset.

The second strand of the literature that we contribute to explores the cyclicality of employment margins of heterogeneous firms. Focusing on size heterogeneity, Moscarini and Postel-Vinay (2012) find that the net job creation of large (in terms of employment) firms, relative to small firms, is more responsive to unemployment. Their results are supported by the theoretical work of Moscarini and Postel-Vinay (2013) based on labor market frictions, where firms' size is treated as a proxy for firms' productivity. Our paper contributes to this literature by studying the differential response of employment dynamics of large and small firms to monetary policy shocks, rather than the cycle.[5] Additionally, a robustness exercise that we call Q1-robustness, provides a way of addressing the reclassification bias in the QWI data. We discuss this further in Section 3.3.

The first paper to examine empirically the effects of monetary policy shocks on the

[4] Relative to Zervou (2014), where the wage changes introduce heterogeneous employment response to monetary policy across firms due to constrained firms using external finance versus unconstrained firms that do not, and Manea (2020), where output responses across firms differ due to constrained firms using collateral to finance labor while unconstrained do not, heterogeneity in employment in our work is due to changes in the spread paid by constrained firms because of changes in average employees' earnings and borrowing after monetary policy shocks.

[5] In our empirical specifications we control for differential state-unemployment effects across firm sizes to capture differences in firms' productivity and their response to state unemployment.

employment of heterogeneous firms is that of Bahaj, Foulis, Pinter, and Surico (2022). In their analysis they use yearly firm-level data in the United Kingdom to emphasize housing collateral constraints and to verify the existence of the financial accelerator channel that propels younger firms' employment to respond more to monetary policy shocks than older firms'. Similar results are found by Yu (2021) who also emphasizes housing collateral constraints using U.S. data.[6] Our work is the first empirical study on the effects of monetary policy on the employment of large and small firms in the U.S. Moreover, our empirical analysis emphasizes sign asymmetry of the monetary policy shocks, employment flows, and the effects on employees' earnings, all of which have not been previously studied in the related literature.

Our sign asymmetry result (result ii) is related to a large literature that finds variation in the response of aggregate variables like output and prices, to monetary contractions versus expansions, starting with Cover (1992) and more recently in Tenreyro and Thwaites (2016) and Angrist, Jordà, and Kuersteiner (2018). Our contribution here is to distinguish the effects of monetary easings from those of tightenings on small and large firms and show that without that distinction we would erroneously conclude that small firms respond more than large ones to monetary policy shocks. In addition, the direction distinction uncovers differences in the timing of the response of the labor market to monetary policy shocks, being slower in monetary expansions versus contractions.[7]

A related recent literature studies employment concentration (e.g., Hopenhayn, Neira, and Singhania, 2022 and Karahan, Pugsley, and Şahin, 2022 examine start-up deficit; Hartman-Glaser, Lustig, and Xiaolan, 2019, Autor, Dorn, Katz, Patterson, and Van Reenen, 2020, and Kehrig and Vincent, 2021 study employment concentration and the declining labor share).[8] Focusing on the labor market and firms' size, our findings imply that monetary policy reduces employment concentration in large firms, and thus does not contribute to the recent trends observed in the data as shown in Figure A.2.1.

Our paper also relates to recent literature that examines the effects of monetary policy

[6]See also Madeira and Salazar (2023) for the analysis of Chile.

[7]It is likely that the delayed employment response to an expansionary shock seen in our analysis reflects jobless recoveries, a feature of the aggregate data documented in a large literature (e.g. Groshen and Potter, 2003; Schreft and Singh, 2003; Berger, 2018; Jaimovich and Siu, 2020).

[8]While not related to employment, there is research on how market power affects monetary policy (e.g., Duval, Furceri, Lee, and Tavares, 2021; Ferrando, McAdam, Petroulakis, and Vives, 2021).

on labor flows, like the work of Braun, De Bock, and DiCecio (2007), White (2018) and Graves, Huckfeldt, and Swanson (2022). We show and document in result (iii) that flows provide important information about the effect of monetary policy on decisions that form labor market outcomes. We further contribute to this line of research by identifying flow responses across various firm size categories, along with the aggregate effects. Moreover, we show distinct labor market flow responses depending on the direction of the monetary policy shock, an aspect that has not been explored before in this literature.

The paper is organized as follows. Section 2 describes the data and empirical methodology. Section 3 presents the empirical results and discusses the policy implications of our findings. Section 4.1 introduces additional empirical results that through a model, presented in Section 4.2, rationalize our main empirical findings. Finally, Section 5 concludes.

2 Data and methodology

In this section, we describe the data and discuss the methodology employed in our analysis.

2.1 Data

We use the QWI panel dataset, which is publicly available and is derived from the Longitudinal Employer Household Dynamics (LEHD) program of the U.S. Census Bureau. The data includes all private, state, and local government (but not federal) employers that are covered by unemployment insurance in the U.S., aggregated by state, industry, and firm size.

The QWI provides quarterly information on employment, employment dynamics, and employees' earnings, together with information on firm characteristics, such as size, location, and industry classification. The source data are unique job-level data that links employers and employees. A single employer may have one or many establishments where the establishment is a physical place of work. QWI data are then aggregated from job level to establishments. For public release, it is further aggregated and therefore the cross-sectional dimension of our panel is specified by the triplet "state-industry-size." The state and industry information refers to the characteristics of the establishment while the firm size is defined at the national level.[9]

In the QWI states started reporting data at different points in time which makes the dataset unbalanced. For example, in 1990 only four states were in the sample. Data on additional states were gradually included and by 2004 the dataset covers forty-nine states (all U.S. states apart from Massachusetts and Washington, D.C.). Given the highly unbalanced nature of the panel, we exclude states that become part of the sample after 1995:1.[10] Our sample, therefore, consists of 17 states, including the largest two states, i.e., California and Texas, and covers the period 1995:1-2019:2. We exclude Agriculture, Forestry, Fishing and Hunting, and Public Administration, as is usual in employment studies, as well as Finance and Insurance, and Real Estate (FIRE), and Rental and Leasing, as is usual in monetary policy studies. The QWI reports five firm size categories; size one has 0-19 employees, size two has 20-49, size three has 50-249, size four has 250-499, and size five has more than 500 employees. Our sample consists of a total of $131,301$ observations ($N \times T$) with $1,360$ unique state-industry-size observations.

In our analysis, we focus on the behavior of employment, hiring, and the average earnings of newly hired employees. In the QWI dataset, these variables are *Emp*, *HirA*, and *EarnHirNS*, respectively. Their exact definitions are available in Appendix A. We consider hiring in our analysis, as it measures inflows to employment and it implies a mutual agreement between firms and employees for the match to occur. It allows us to also understand the role of monetary policy in creating new labor market matches. Separations, on the other hand, can be voluntary (retirement, quits, new job) and involuntary (layoffs, firing), and since the two types of separations cannot be separately identified in the data, we do not consider separations in our analysis. The third variable, the average earnings of new hires, allows us to measure changes in the relevant labor costs, not driven by previous wage contracts and negotiations. The data are seasonally adjusted using X-12-ARIMA method by the U.S. Census Bureau.

Table 1 presents summary statistics of the labor market variables. As seen from the table, small and large firms have distinctly different growth rates (median) for all the

[9] The fact that the firm size is defined at the national level in our dataset is a desirable characteristic given that we use firm size as a proxy for financing constraints in the model.

[10] The fact that the announcement of the Federal Funds rate target becomes official after this period has contributed to making the cutoff decision.

Table 1: Summary statistics of labor market variables

Variables (growth rates, in percent)		All firms	Small (size 1) firms	Large (size 5) firms
Employment	mean	1.26	0.81	2.03
	median	1.66	0.90	2.02
	st. dev.	5.24	10.28	10.43
Hiring	mean	−0.02	−0.86	1.11
	median	1.47	−0.17	2.60
	st. dev.	17.37	19.08	27.71
Earning of new hires	mean	3.28	2.89	3.27
	median	3.37	2.91	3.30
	st. dev.	11.55	21.18	17.36

Notes: The table reports the mean, median, and standard deviation (st. dev.) of the annual growth rates of employment, hiring, and the earnings of new hires in all firms, small firms, and large firms from 1995:1-2019:2 in our sample.

variables considered in our empirical analysis, and these differences are significantly different.[11] Moreover, in the case of hiring, what is also striking is that while hiring growth has increased in large firms, it has decreased in small firms.

Our analysis exploits the differences across firms' sizes while controlling for industry and geography.[12] Figures A.3.1 and A.3.2 in Appendix A.3 plot the distribution of employment and new hires for small and large firms across industries and states. While the distribution is not uniform, the figures illustrate that small and large firms are not specific to any industry and/or geographic location. Comparing the aggregate employment in our sample with the total private employment from the Federal Reserve Economic Data (FRED) in Figure 1, we see that the trends in our sample are closely related to the trends in the aggregate. This is despite the smaller coverage of our data as we exclude some states and industries.

For the monetary policy shocks, we use the federal funds rate factor series constructed by Swanson (2021), based on the state-of-the-art high-frequency futures market identification approach first developed by Kuttner (2001) and relevantly decomposed to capture different aspects of monetary policy.[13] Those decompositions are important. For example,

[11]These differences are statistically significant at the 1% level.

[12]In a related paper, Singh, Suda, and Zervou (2022) examine whether the effects of monetary policy shocks on the labor market variables vary across sectors. They find large differences across the manufacturing and construction relative to the service sector.

[13]The monetary policy shocks are constructed using the three principal components of the asset price responses to each announcement of the Federal Reserve's Federal Open Market Committee (FOMC) within

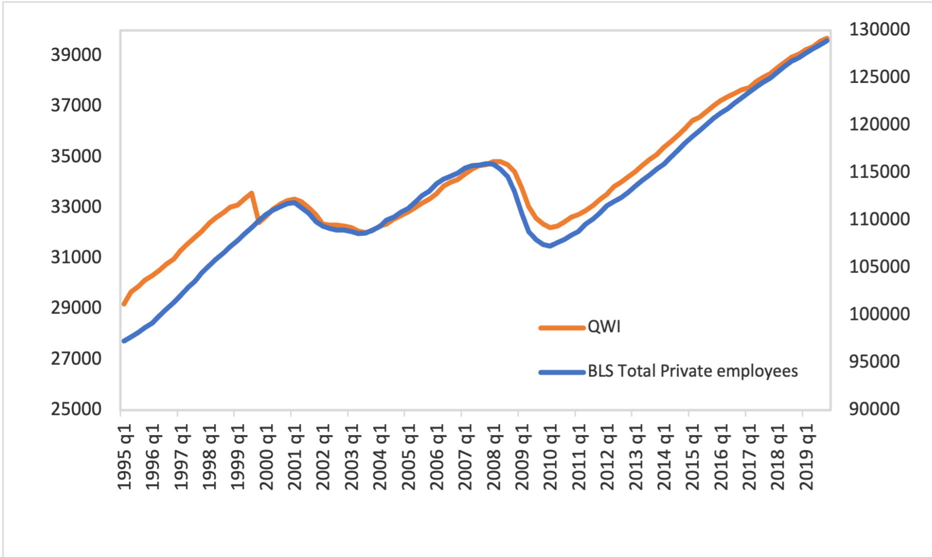

Figure 1: Employment from QWI

Notes: The figure plots employment from our QWI sample on the left vertical axis (orange line) against total private employment data (USPRIV) from FRED (blue line) on the right vertical axis, source Current Employment Statistics (Establishment Survey).

Gürkaynak, Sack, and Swanson (2005) decompose monetary policy shocks into two factors, pointing out that at the time of an FOMC announcement, the public receives information not only about the current federal funds rate target but also, through the statement that follows such announcements, about the expected path of the economy; this component is present in the central bank communication even before the introduction of formal forward guidance. Swanson (2021) identifies three factors of monetary policy, adding to the short-run federal funds rate and forward guidance factors, the large-scale asset purchases factor present after the Great Recession, and finds that all three factors have very persistent effects. The latter factor is relevant only in the period after 2008, and therefore we do not focus on it given our larger sample; however, we control for it in our analysis. The second factor has an unclear interpretation, given that it also includes, besides the forward guidance effect, a possible information effect, as pointed out by Campbell, Evans, Fisher, and Justiniano (2012); in our analysis, we control for this factor as well.[14] We focus on

the 30-minute window. See Swanson (2021) for more details.

[14]The Fed information arises when economic participants believe that the Federal Reserve has superior information, and act on that information. Its effect has been analyzed by Romer and Romer (2000) and Nakamura and Steinsson (2018) among others. A recent and thorough investigation is conducted by Hoesch,

the short-run effect of changes on the federal funds target rate surprises, using Swanson (2021)'s federal funds rate (ffr) factor series, isolating the effect of the short-term movements in asset prices and producing results that are not impacted by forward guidance and information effects of monetary policy, which can affect the interpretation of our conclusions.[15] Moreover, we aggregate the series to construct quarterly measures, as is common in the literature. Table 2 reports the summary statistics of the ffr factor shocks. We find that these ffr factor shocks have the expected effects on the aggregate macroeconomic variables, i.e., an increase in the ffr factor shock decreases real GDP and employment growth, as seen in Figure B.1.1 in Appendix B.1.

There is a large empirical literature, e.g. Cover (1992), DeLong and Summers (1988), Lo and Piger (2005), which argues that the impact of monetary policy on the economy is not symmetric. The asymmetry analyzed in this literature is either based on sign (positive or negative) or size (large or small) of monetary policy shocks. We focus on the sign asymmetry of the ffr shocks. In our Q1-robustness, we also address asymmetric effects across quarters as considered in Olivei and Tenreyro (2007). Moreover, the literature that studies labor flows, like Elsby, Hobijn, Karahan, Koşar, and Şahin (2019), uncovers flow movements that could result in cyclical asymmetries of labor market stocks, further motivating our analysis of the asymmetric response of labor market variables to monetary policy shocks.

Table 2 reports the summary statistics of the ffr factor shocks, as well as the positive and negative ffr factor shocks. What is striking is that the standard deviation of the negative monetary policy shock is almost 4 times the positive one. This can also be seen in Figure 2, which plots these shocks. Since the positive and negative shocks have distinct characteristics, they are likely to impact the labor market variables differently. We address this in our empirical analysis by studying the effects of positive and negative shocks separately. Moreover, since the shocks have different standard deviations depending on their direction, we convert the units of the federal funds rate shocks of Swanson (2021)

Rossi, and Sekhposyan (2023).

[15]We have conducted robustness tests using the "target" factor of an extended series we construct based on Gürkaynak, Sack, and Swanson (2005)'s series. We have also done robustness using the Campbell, Evans, Fisher, and Justiniano (2012) data; we thank Alejandro Justiniano for providing his event-study shocks series for that paper, and the extended version of it. Given the close correlation of those shocks with ours, and the similarity in their construction, we do not present those robustness exercises, though are available upon request.

Table 2: Summary statistics of monetary policy shocks

	ffr factor shocks
Overall	
Mean	0.51
Standard deviation	12.28
Positive (rate increase)	
Mean	5.31
Standard deviation	4.53
Negative (rate decrease)	
Mean	-12.98
Standard deviation	16.44

Notes: The table reports the mean and standard deviation (in basis points) for the ffr factor shocks, positive and negative ffr factor shocks for the period 1995:1-2019:2.

from standard deviation to basis points.[16] We then use the information of the standard deviation of the positive and negative ffr shocks to interpret our results.

Appendix A provides additional details about the data used in our analysis.

2.2 Empirical framework

To measure the impact of ffr shocks on the labor market we employ the local projection method of Jordà, Schularick, and Taylor (2015) who extend Jordà (2005)'s approach, to a panel data setting.[17]

Equation (1) below, is our baseline empirical specification that considers sign asymmetry and size heterogeneity. In our analysis, the dependent variables are cumulative growth rates of employment, hiring, and earnings of new hires, that is $\Delta_h n_{gis,t+h} \equiv \log N_{gis,t+h} - \log N_{gis,t}$, which is the cumulative difference of the log labor market variable N in state g, industry i, firm-size s, h periods after the monetary policy shock in period t. We control for state-industry-size specific fixed effects, α^h_{gis}. The coefficients of interest are $\beta^h_{s,ffr+}$ and $\beta^h_{s,ffr-}$ interacted with firm size, where $\mathbb{I}_s$ is the indicator for size. The impulse response functions presented in Section 3 are constructed using these coefficients.

[16] Since Swanson (2021) was examining the overall effects of the three factors, this conversion was not necessary in his analysis. To convert the federal funds rate factor of Swanson (2021) to basis points, we multiply those shocks by 11.92.

[17] See Plagborg-Møller and Wolf (2021) for a comparison of the impulse response functions generated using local projections and Vector Autoregressions (VARs).

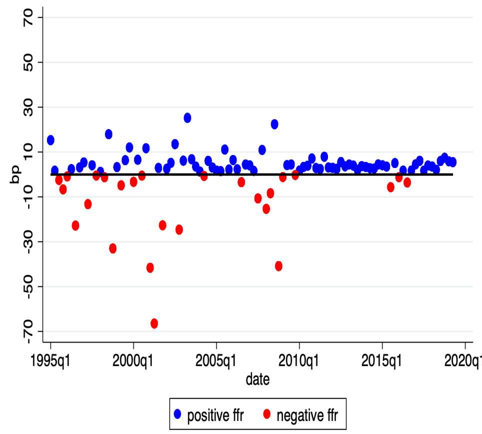

Figure 2: Positive and negative monetary policy shocks

Notes: The figure plots the positive (blue) and negative (red) ffr factor shocks in basis points.

$$\Delta_h n_{gis,t+h} = \alpha^h_{gis} + \beta^h_{s,ffr+}\epsilon^{ffr+}_t \mathbb{I}_s + \beta^h_{s,ffr-}\epsilon^{ffr-}_t \mathbb{I}_s + \Gamma^h Z_t + u^h_{gis,t+h} \tag{1}$$

The control variables in Z_t are one lag of the dependent variable, four lags of the federal funds rate, four lags of the state unemployment rate, and interactions of all three monetary policy factors with industry. In addition, we also control for the effects of the other two monetary policy factors, forward guidance and LSAP, by including in the set of controls the positive and negative effects of those two factors interacted with firm size. We also include four lags of the state unemployment rate interacted with firm size as control variables.

The reason we add state unemployment interacted with firm size in our set of controls, is because previous literature on firms' cyclical sensitivity (Moscarini and Postel-Vinay, 2012) has emphasized that large firms increase net job creation more than small firms at times when the unemployment rate is low, and decrease net job creation more than small firms when the unemployment rate is high. By including the interaction of state unemployment with firms' size as an explanatory variable, we capture the effect of monetary policy on the labor market variables after controlling for their fluctuations due to changes in state unemployment.[18] In fact, we find that state unemployment's effect on employment growth is consistent with the response of large firms being stronger than that of smaller firms. We

[18]We thank Giuseppe Moscarini for making this suggestion.

also find that in a specification that excludes monetary policy shocks, large firms increase employment growth more than small firms at times when the unemployment rate is low and vice versa, consistent with the results in Moscarini and Postel-Vinay (2012), see Figures B.9.1-B.9.2 in Appendix B.9.

Since we are using a panel dataset, observations might be cross-sectionally correlated (e.g., within a state) and serially correlated (across time). To control for those correlations we cluster standard errors based on state and time. Such clustering produces standard errors that are known to have wider bands compared with Driscoll and Kraay (1998) standard errors.

3 Empirical results

In this section, we present our empirical results where we examine the effects of monetary policy, using the monetary policy shocks constructed by Swanson (2021), on labor market variables of small and large firms. Note that while these shocks have a sharp interpretation and are not influenced by forward guidance or information effects, they are rather small. As a result, we analyze and interpret our findings using one standard deviation confidence bands following Coibion, Gorodnichenko, Kueng, and Silvia (2017), and Graves, Huckfeldt, and Swanson (2022), among others. We also report 1.65 standard deviation confidence intervals and the F-test results in Appendix B.2, for the null hypothesis that the impulse response is zero for each horizon, as in Coibion, Gorodnichenko, Kueng, and Silvia (2017).

Given the evidence presented in Table 2 on the differences across the negative and positive ffr factor shocks, we first examine separately the response of labor market variables to contractionary and expansionary ffr factor shocks in small and large firms in Section 3.1.[19] In Section 3.2, we present results without taking into account the sign distinction and show how those results could be misleading for policy evaluation. In Sections 3.3 and 3.4 we check the robustness of our findings. Finally, Section 3.5 discusses the implications of our empirical results.

[19] In Appendix B.3, we also present results for all firms, without differentiating firms based on their size.

3.1 Response of small and large firms

We study the response of the employment and hiring growth of small and large firms to positive and negative ffr factor monetary policy shocks using the estimates from equation (1). Our first set of results shed light on the transmission of monetary policy by examining the differential response of labor market variables to contractionary and expansionary ffr factor shocks in firms that differ in size.

Employment

Our empirical results in Figure 3 show that contractionary ffr factor shocks (top row) impact employment growth in small firms (middle columns) less relative to large firms (left columns), and expansionary ffr factor shocks (bottom row) impact small firms more relative to large firms. That is, small firms decrease employment growth less in response to a contractionary monetary policy shock and increase employment growth more in response to an expansionary monetary policy shock, relative to large firms. There is a delayed response to monetary expansions, with employment growth increasing only after the first five quarters of the shock. The difference in the timing of the responses to monetary expansions versus contractions will be a finding that sustains various specifications in our analysis and provides an additional reason for examining asymmetric responses of the labor market to monetary policy shocks.

The p-value for the null hypothesis that the impulse response is zero at each horizon for a contractionary shock is 0.168 for small firms and zero for large firms. The p-value for the null hypothesis that the impulse response is zero at each horizon for an expansionary shock is 0.001 for small firms and 0.918 for large firms. As such, the F-tests for the null hypothesis that the impulse responses are zero for each horizon show that the hypothesis is strongly rejected for large firms after contractionary monetary policy shocks, and for small firms after expansionary shocks.

The differences across large and small firms are calculated and depicted on the right panel of Figure 3. Note that on the graphs that depict differences in responses between large and small firms, the line below zero after a positive/contractionary ffr factor shock means that large firms tighten more than small firms; similarly, for a negative/expansionary ffr factor shock, having the line below zero means that large firms expand less than small firms. The top right panel of Figure 3 depicts the strong and significant difference in the response of large versus small firms after monetary contractions. The bottom right panel shows that with a delay of five quarters, a monetary policy loosening increases employment growth in small firms more than in large ones.

Even though the p-values are large in some instances, we still want to understand the differences in the responses of large and small firms. Given that the standard deviation of the positive ffr factor shock differs from that of a negative ffr factor shock, we adjust the responses appropriately to interpret the magnitude of the impulse response functions. With such adjustment, our results imply that a one standard deviation positive ffr factor shock decreases the employment growth of large firms by about 0.82% (0.18×4.53), and of small firms by 0.27% (0.06×4.53) over 8 quarters, two years after the shock; that is, large firms respond three times more than small firms after monetary contractions. Note that in this calculation and the ones that follow, the first number (here 0.18 and 0.06) are the cumulative changes in the eighth quarter in the relevant labor market variable, while the second number (here 4.53) is the standard deviation of the ffr shocks in basis points as reported in Table 2. A standard deviation negative shock increases employment growth of large firms by 0.66% (0.04×16.44), and of small firms by 0.99% (0.06×16.99) in the eighth quarter; that is, small firms respond one and half times more than large firms after monetary expansions.[20]

Our results suggest that after taking into account the ffr factor shock sign and firm size asymmetries, small firms drop employment growth less compared to large firms in response to a monetary contraction; they increase employment growth more than large firms after a monetary expansion.

Hiring

We analyze the response of hiring growth and find that our conclusions of impulse (contractionary versus expansionary shock) and response (small versus large firms) asymmetry

[20]The magnitude of our aggregate across firm size and shock sign results, presented in Appendix B.3, is economically important and in line with the results presented in the literature. We do not have a direct comparison of the results with size and sign heterogeneity in related literature.

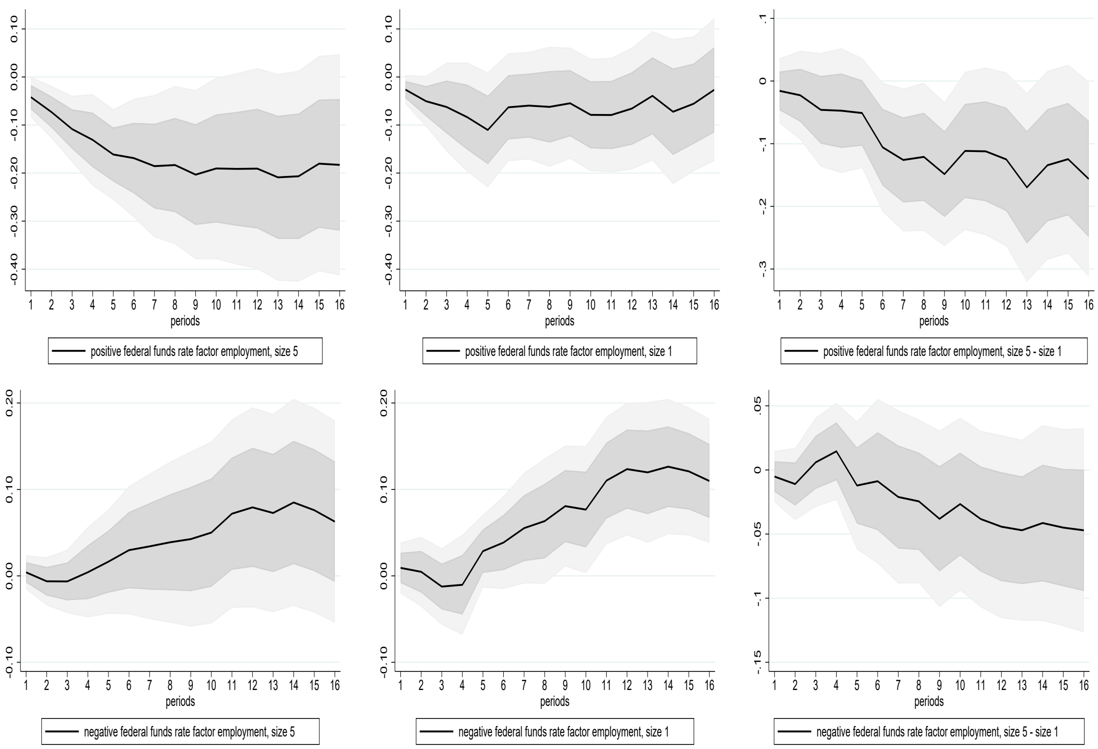

Figure 3: Response of employment growth in small and large firms to a positive and negative ffr factor shock

Notes: The top row plots the impulse response functions for employment growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response functions for employment growth to a negative (expansionary) ffr factor shock large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of employment growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

for employment also hold for hiring. The response of hiring growth is stronger than employment growth, and as such important to consider.

Figure 4 presents the response of large (left column) and small firms (middle column), and the difference in the responses of the two (right column), considering the direction of the shock. A monetary policy tightening (top row) decreases hiring growth, and it does so more for large firms relative to small ones. The difference in responses of large and small firms, shown in the right column, is always significant.

The p-value for the null hypothesis that the impulse response is zero at each horizon after a contractionary shock is 0.477 for small firms, and 0.019 for large firms, showing that a monetary contraction significantly affects large firms. In addition, the p-value for the null hypothesis that the impulse response is zero at each horizon after an expansionary shock is 0.063 for small firms and 0.908 for large firms, showing that small firms are the ones that benefit most during monetary expansions. As also for employment, we find for hiring growth too, that the F-tests for the null hypothesis that the impulse responses are zero for each horizon show that the hypothesis is strongly rejected for large firms after contractionary monetary policy shocks and for small firms after expansionary ones.

As before, taking into account the differences in standard deviations of positive and negative shocks as seen in Table 2, we find that a standard deviation positive shock decreases the hiring growth of large firms by 1.45% (0.32×4.53) and of small firms by 0.41% (0.09×4.53) after eight quarters. Hence the fall in hiring growth in large firms is three times larger than that of small firms. For a standard deviation negative shock, hiring growth in small firms increases by 3.29% (0.2×16.44), which is four times more that of the large firms, which increases by 0.82% (0.05×16.44) in the eighth quarter.

Taken together, our empirical results suggest that in fact, large firms are more responsive to a contractionary ffr factor shock while small firms are more responsive to an expansionary shock. Our results also show that compared to employment, hiring growth responds stronger to monetary policy ffr factor shocks. Therefore, looking at the effect of monetary policy on employment growth alone is not fully informative of the effect of monetary policy on the labor market; this is uncovered through the effects of monetary policy shocks on employment flows like hiring growth.

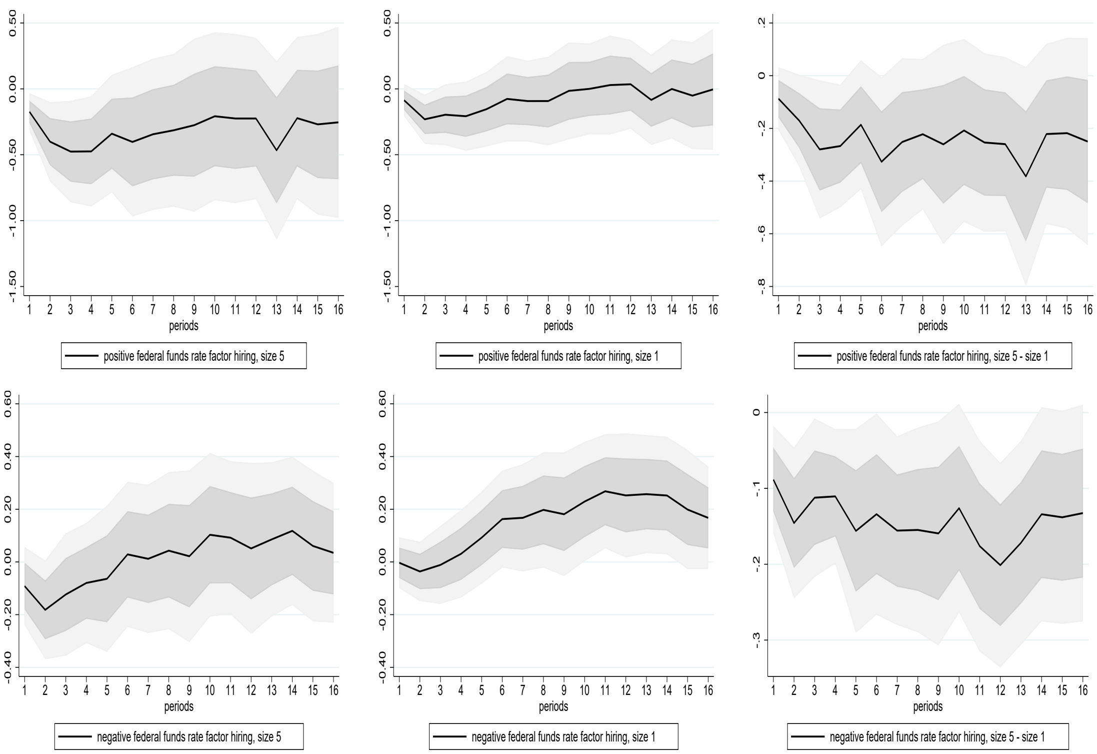

Figure 4: Response of hiring growth in small and large firms to a positive and negative ffr factor shock

The top row plots the impulse response functions for hiring growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response functions for hiring growth to a negative (expansionary) ffr factor shock large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of hiring growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

3.2 Response of small and large firms without sign distinction

In this subsection, we study the response of small and large firms to a ffr factor monetary policy shock, estimating a specification similar to equation (1) but without taking into account the sign distinction of the ffr shocks. The objective of this analysis is to highlight the importance of the direction of monetary policy shocks in analyzing their effects on the labor market of small and large firms.

Figure 5 presents the results. Without considering direction asymmetries, the top row of Figure 5 indicates small firms are more responsive to an increase in the ffr shock compared to large firms, in terms of employment growth. After eight quarters, small firms decrease employment growth by 0.49% following a one standard deviation ffr factor shock (this is 0.04×12.28, where 0.04 is the change in the response and 12.28 is the standard deviation of the ffr factor shock, as shown in Table 2) while for large firms the change is not significantly different from zero. The p-value for the null hypothesis that the impulse response is zero at each horizon is zero for small firms and 0.20 for large firms.

Similarly, the bottom row of Figure 5 shows that the hiring growth of small firms drops after an increase in ffr factor shock, while that of large firms does not respond much. The cumulative difference across firm size, shown in the right panel, is significant. After eight quarters, small firms decrease hiring growth by 2.09% (0.17×12.28) and for large firms, the change is not significantly different from zero.

As such, ignoring sign asymmetries, our conclusion would then be that small firms react more than large firms to monetary policy shocks. Similar conclusions have been reached in the literature, starting with the seminal work of Gertler and Gilchrist (1994), who examined the effects of monetary policy shocks on sales and inventories. These results have been the basis of the financial accelerator mechanism of Bernanke, Gertler, and Gilchrist (1999), the evidence of which is vast in the investment literature. However, our results in the previous Section 3.1 lay bare the fallacy of evaluating the effects of monetary policy in the labor market, without taking into account the sign distinction; that is, the intuition that we gain from studying the effects of monetary policy on investment, do not fully extend to the labor

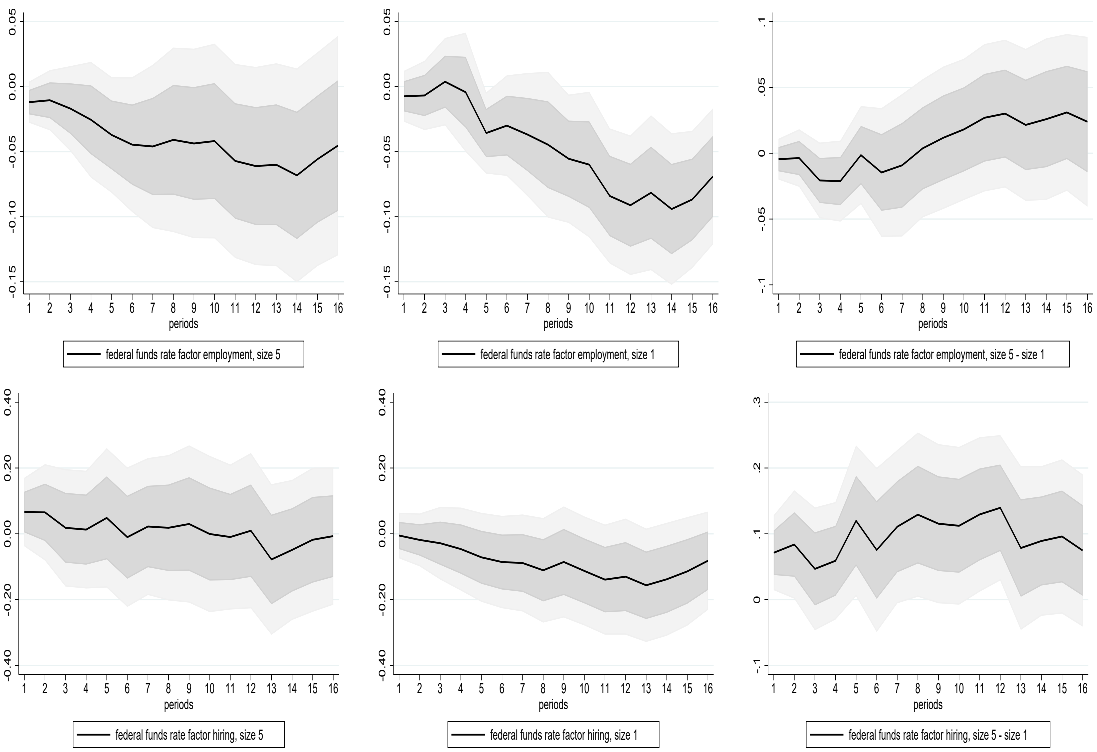

Figure 5: Response of employment and hiring growth of small and large firms to a ffr factor shock

Notes: The top row plots the impulse response functions of employment growth to an increase in ffr factor shock for large (size 5—left column) and small (size 1—middle panel) firms, and the difference in the response in large and small firms (right panel). The bottom row shows the equivalent effects for hiring growth. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

market. We find that in evaluating the effects of monetary expansions separately from that of contractions, it is indeed that small firms react more than large ones to expansionary shocks while large firms react more than small ones to contractionary shocks.

3.3 Monetary policy shocks in first quarter

In this section, we present results that account for the possibility that the relative response of small versus large firms is impacted by what Moscarini and Postel-Vinay (2012) describe as reclassification bias. The reclassification bias might arise because over time, and in response to economic conditions, firms could change size and be re-classified. The QWI dataset reports five firm size categories: size one has 0-19 employees, size two has 20-49, size three has 50-249, size four has 250-499, and size five has more than 500 employees. If for example, a firm with 19 employees grows, then it is reclassified in the bin with firms that have 20 or more employees; thus, studying the effects of an event on small firms' bin, we are only studying the firms that are currently in the bin and not the ones that have changed bins. To tackle this issue we utilize the fact that firms' size is determined once per year, in the first quarter, and firms stay in the same size bin for the rest of the calendar year. Therefore, in our Q1-robustness exercise presented here, we examine the effects of monetary policy shocks that occur only in the first quarter of each calendar year and focus on the *3-period* IRFs. This allows us to accurately measure and compare responses of firms that differ in size accounting for the reclassification bias in the QWI dataset.[21] Note that the 16-period impulse response function is presented so that we can compare the Q1-robustness results with our benchmark results. The summary statistics for the positive and negative ffr factor shocks occurring in the first quarter of each year are reported in Appendix A.4.

Focusing on the responses in the first three quarters, the top rows of Figures 6 and 7 show that large firms (left columns) decrease employment and hiring growth more than small firms (middle columns) after a contractionary ffr factor shock. The top right columns

[21] Haltiwanger, Jarmin, and Miranda (2013) highlight the importance of firm age in understanding the transmission of shocks to heterogeneous firms, and Casiraghi, McGregor, and Palazzo (2020) stress that the observed change in the fraction of old versus young firms might affect the strength of the monetary propagation mechanism. In order to use firms' age in the QWI, we would need the firms' initial age distribution and use a statistical model for the firms' evolution in various age categories. Given that we utilize the feature that firms stay in the same size bin for 4 quarters, we consider size as an attractive characteristic of the QWI dataset, and the Q1-robustness as one of our contributions.

on the two graphs show that the drop is sharper for large firms than for small firms and the difference in the response is statistically significant for all the first three quarters for employment, and at least for one of the first three quarters, for hiring. Overall, our conclusions regarding a monetary policy tightening are robust to the Q1-robustness exercise (that focuses only on the first three quarters after the shock); that is, employment and hiring growth of large firms drop more than that of small firms after a monetary tightening, and this result is not an artifact of reclassification bias.

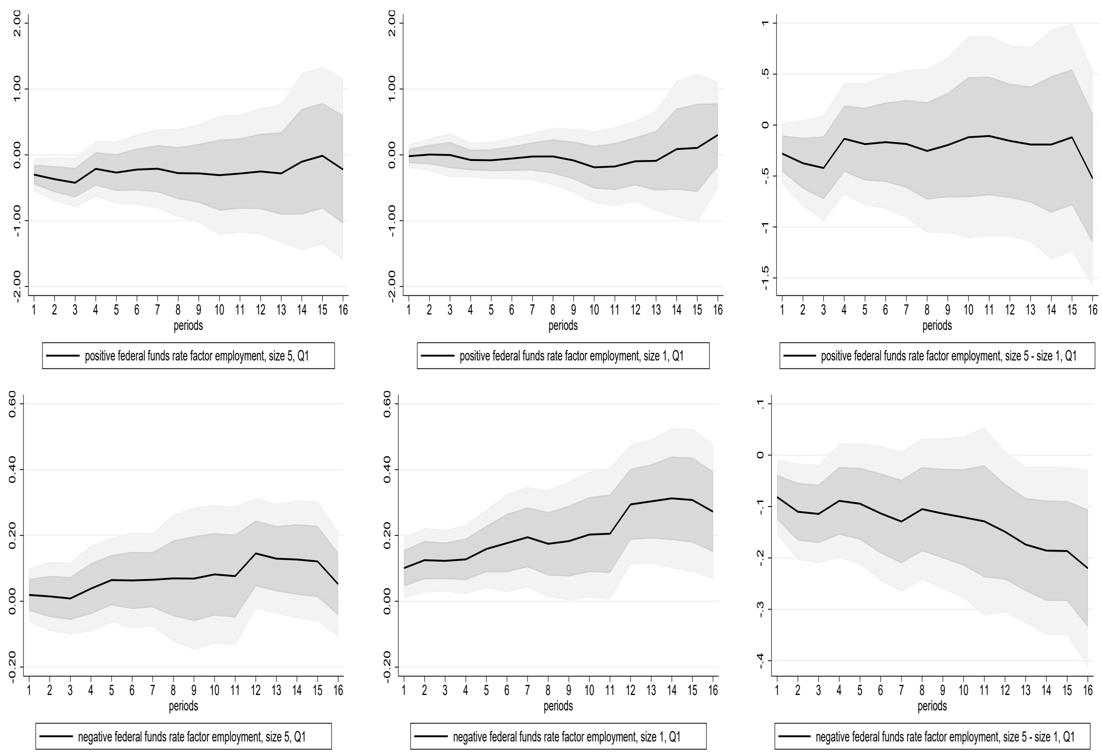

Figure 6: Response of employment growth in small and large firms to a positive and negative ffr factor shock; Q1-robustness

Notes: The top row plots the impulse response functions for employment growth to a positive (contractionary) ffr factor shock in Q1 for large (size 5—left column) and small (size 1—middle column) firms while the bottom row the impulse response functions for employment growth to a negative (expansionary) ffr factor shock in Q1 for large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of employment growth in large and small firms to a positive (contractionary) ffr factor shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock in Q1. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

On the bottom row of Figures 6 and 7, we see that the employment and hiring growth

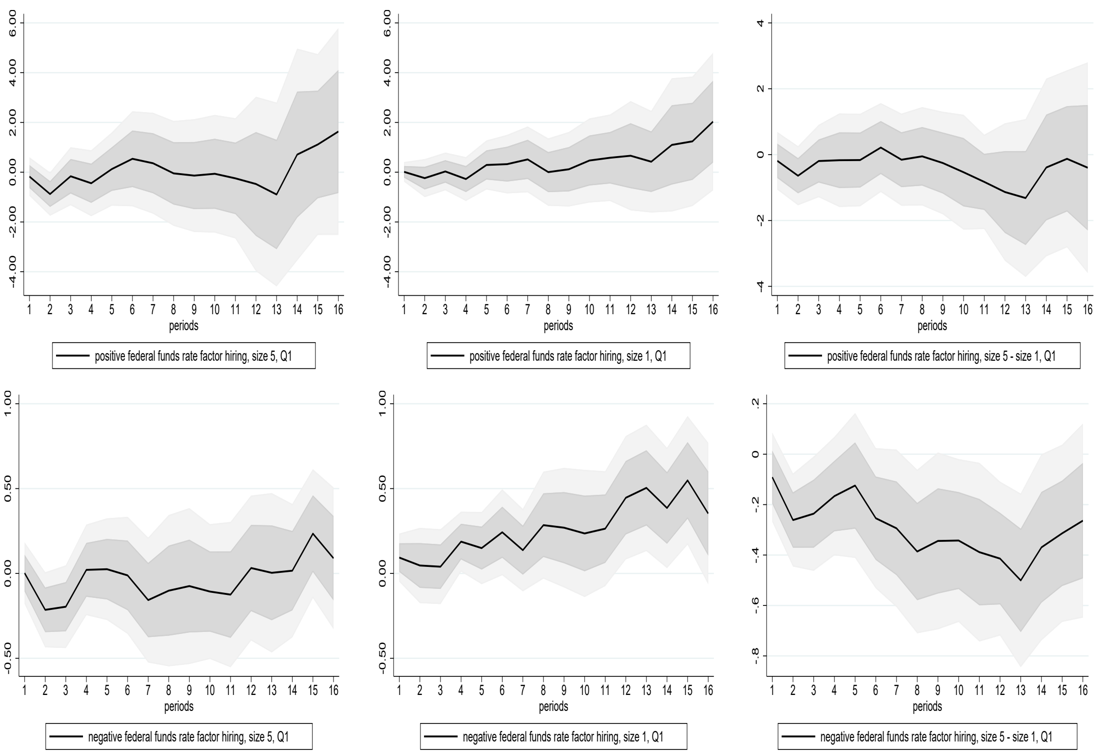

Figure 7: Response of hiring growth in small and large firms to a positive and negative target shock; Q1-robustness

The top row plots the impulse response functions for hiring growth to a positive (contractionary) target shock in Q1 for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response functions for hiring growth to a negative (expansionary) target shock in Q1 for large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of hiring growth in large and small firms to a positive (contractionary) ffr factor shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock in Q1. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

of small firms (middle columns) increases during the first three quarters after a monetary expansion; the response is significant for employment. However, the employment and hiring growth of large firms (left columns) doesn't change or decrease. The difference in the response across size categories is significant for both small and large firms during the first three quarters. We note that for an expansionary policy shock, the Q1-robustness analysis is less applicable. This is because the expansionary shocks are slower in affecting the labor market, as seen both in the responses of firms of different sizes in Figures 3 and 4, and in the response of total employment and hiring growth in Figures B.3.1 and B.3.2 in Appendix B.3. Although the Q1-robustness exercise, which is only valid for the first three quarters after the shock occurs, is harder to reconcile with the expansionary shock, the results from this exercise support our main findings of Section 3.1.

3.4 Additional robustness

Apart from the Q1-robustness exercise presented above, we also consider the following robustness exercises. First, our results remain robust after excluding the Great Recession period, suggesting that our empirical facts are not driven by that specific event. In Appendix B.4, we present the results for the sample period that excludes $2008Q1-2009Q4$.

In addition, we perform a robustness exercise where we redefine small firms in our data, where small firms are those with 1-49 employees, instead of those with 1-19 employees that we use in our main analysis. While this broader definition controls for vast changes in the extensive margin that very small firms might experience, it still allows us to consider interpretations based on financing constraints that differ across firms' sizes. Appendix B.5 shows that our main conclusions are robust to this redefinition of small firms.

Finally, our empirical results are also robust to multiple variations of the empirical specification, like clustering variations, and the exclusion/inclusion of lagged controls, the usage of the extended Gürkaynak, Sack, and Swanson (2005) target monetary policy shock or the extended Campbell, Evans, Fisher, and Justiniano (2012) one, instead of the one we use here, and terminating the sample before the Great Recession starts. In addition, all results presented in the Results Appendix B are robust to the Q-1 robustness exercise.[22]

[22]These additional results are available upon request.

3.5 Implications of our empirical results

In this subsection, we summarize our three main empirical results so far and discuss the implications for the policy mandate of maximum employment. Our first empirical result suggests that the aggregate employment response to monetary policy depends on the size of employers. Specifically, result (i) establishes that after a monetary tightening, large firms reduce employment and hiring growth more than small firms, while small firms expand more after a monetary easing. Given that employment is directed towards larger firms over time (Figure A.2.1), our result (i) then suggests that monetary tightening is likely to have a larger impact over time, as it affects larger firms, while monetary easing becomes less effective over time, as it affects smaller firms.[23] For this reason, the size composition, or otherwise, employment concentration, is an important metric for policy to track when assessing its effectiveness in achieving full employment.

Meanwhile, monetary policy actions impact employment concentration by in fact counteracting the increased employment concentration observed in the data. Therefore, in addition to aggregate effects, monetary policy affects the distribution of employment across firms of different sizes. Relatedly, a monetary expansion followed by an equally strong monetary tightening is non-neutral for the distribution of employees across firms.

Our second result suggests that the direction of the shock is important in understanding the effects of monetary policy on the labor market. Specifically, result (ii) establishes that without taking the shock sign asymmetry into account we would conclude that small firms react more than large ones to monetary policy shocks. We uncover that small firms do not in general react more to monetary policy shocks relative to large ones, yet they do so after monetary expansions; large firms react more after monetary contractions. These findings suggest that policies aiming to boost employment in small firms during times of monetary contractions might be less essential.

Our result (ii) suggests that taking into account the direction of the shock is important for an additional reason. We find that monetary expansions are realized in the labor market with a lag, a finding that becomes apparent only when we examine separately the impact

[23] Formally, the response of employment growth to interest rate changes $\frac{\partial \log N}{\partial i}$ depends on the fraction employed in small (N^C) and large firms (N^U), as well as the response of those firms to the interest rate, $\frac{\partial \log N^C}{\partial i}$, $\frac{\partial \log N^U}{\partial i}$. That is, $\frac{\partial \log N}{\partial i} = \frac{N^C}{N^C+N^U}\frac{\partial \log N^C}{\partial i} + \frac{N^U}{N^C+N^U}\frac{\partial \log N^U}{\partial i}$.

of positive and negative shocks. In turn, the difference in the timing of the responses after loosening versus tightening blurs the effect of monetary policy shocks on labor market variables when averaged out. We also note that exploiting the variation across firm size allows us, beyond the exploration of interesting questions, to estimate with confidence the sign asymmetries. The length of the sample of monetary announcements alone might not be adequate for making conclusions when using only time variation and splitting the data into positive and negative shocks. The information we unveil is important for policy design aiming to affect the labor market in a timely manner; our results suggest that this is easier done when attempting to cool down employment rather than when trying to boost it.

Finally, our result (iii) demonstrates that the effects of monetary policy are less pronounced for employment while they are more apparent for hiring. This result establishes the importance of labor market flows in evaluating and designing monetary policies that aim to impact employment; flows offer a more accurate account of the effects of monetary policy on the labor market than aggregate employment alone.

4 Accounting for Asymmetries

Our main findings indicate that there are asymmetric responses of employment and hiring growth to monetary contractions and expansions in small and large firms. In this section, we offer an explanation to account for these differences.

In Section 4.1 we investigate how firms' labor costs in small and large firms respond to changes in monetary policy. The QWI dataset provides information on the average earnings paid to newly hired employees enabling us to measure changes in labor costs that are not influenced by prior wage negotiations. Then, in Section 4.2, we build a theoretical model of firms' employment decisions to account for our empirical results. Given that wages are often financed with working capital (as also argued in e.g., Mendoza, 2010, Arellano, Bai, and Kehoe, 2019 and Bahaj, Foulis, Pinter, and Surico, 2022) and hence, can be impacted by monetary policy actions, we include both working capital constraints and financing frictions in the model. We proxy financially constrained firms in the model with small firms in the data and financially unconstrained firms in the model with large firms in the data. This assumption has been used previously in the literature, e.g. by Gertler and Gilchrist (1994), based on earlier findings, e.g. of Fazzari, Hubbard, and Petersen (1988), that small firms face tighter financing constraints. We show in the model, that the asymmetric response of earnings as found in the data, can account for the asymmetric responses observed in the employment and hiring growth of small and large firms, following contractionary and expansionary monetary policy shocks.

4.1 Earnings of new hires

One advantage of using the QWI is that together with employment and hiring information it provides employees' earnings in a unified dataset. Importantly it includes information on the earnings of new hires. In the case of new hires, negotiations regarding earnings and number of new hires occur concurrently and we measure firms' responses to the monetary policy shocks. As such, our results are not influenced by the uneven staggering of wage contract renegotiations, which typically occur with individuals who are already employed.

Figure 8 shows the growth of the average nominal earnings of new hires in large and small firms after monetary contractions (top row) and expansions (bottom row). In the left and middle panels of the top row, we see that while the average earnings growth remains largely unchanged in the large firms after a monetary policy tightening (positive ffr factor shock), it decreases in case of small firms. In the bottom row of Figure 8 we see that the average earnings growth decreases after a monetary expansion (negative ffr factor shock) for both types of firms, and it does so more for small firms. We call this the employee's earnings effect. The p-value for the null hypothesis that the impulse response is zero at each horizon is 0.761 for small firms and 0.858 for the large ones after a monetary contraction; those p-values are zero for both small and large firms, after a monetary expansion.

The difference between the response of earnings in large and small firms is statistically significant, where the drop in the average earnings growth of new hires is larger in small firms compared to large firms both for monetary contractions and expansions, as seen in the right column of Figure 8. In terms of magnitude, a one standard deviation positive shock decreases the average earnings growth of small firms by 0.27% (0.06×4.53) and of large firms by about 0.09% (0.02×4.53) in the eighth quarter. A standard deviation negative shock decreases the average earnings growth of small firms by about 1.48% (0.09×16.44)

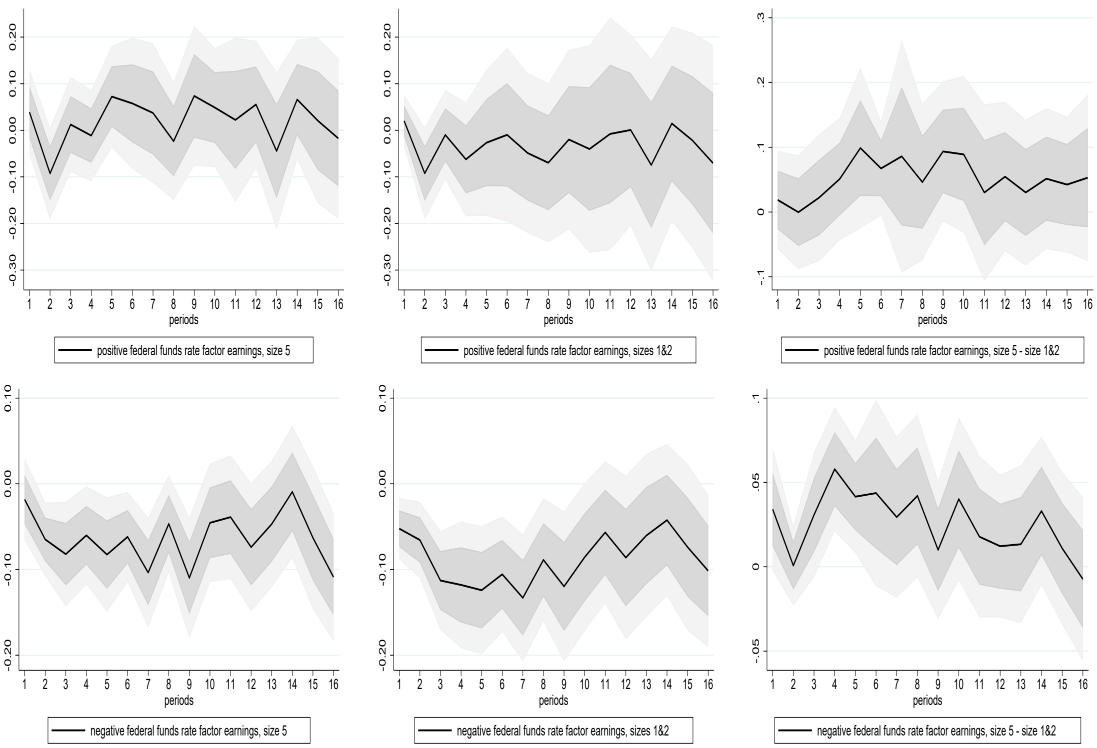

Figure 8: Response of average nominal earnings growth in small and large firms to a positive and negative ffr factor shock

Notes: The top row plots the impulse response functions for average nominal earnings growth to a positive (contractionary) ffr factor shock for large (size 5–left column) and small (sizes 1 and 2 combined—middle column) firms while the bottom row plots the impulse response functions for average nominal earnings growth to a negative (expansionary) ffr factor shock large (size 5—left column) and small (sizes 1 and 2 combined—middle column) firms. The top right panel plots the difference in the response of average nominal earnings growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

and of large firms by about 0.82% (0.05×16.44). That is, after a negative ffr factor shock the decrease of new hires earnings paid by small firms is almost twice as large as the decrease of earnings paid by large firms. This difference is both economically and statistically significant.

When comparing our findings on earnings with previous literature, we note that there is limited research on the effects of monetary policy on average earnings and wages. Notably, our results diverge from those of earlier studies like Christiano, Eichenbaum, and Evans (2005) that identify monetary policy shocks using the recursiveness assumption for the 1965:3-1995:3 sample period. They find the effects of monetary policy shocks on real wage are weak. We use a later sample period and our monetary policy shocks are identified using high-frequency data. Ramey (2016) provides an excellent summary of how results differ based on different ways of identifying monetary policy shocks. In addition, these differences could potentially be attributed to composition effects, as discussed in Gertler, Huckfeldt, and Trigari (2020) and Hazell and Taska (2020). These composition effects might explain the empirical asymmetries we observe in the response of average earnings of new hires after monetary expansions versus contractions. For instance, if a monetary expansion encourages the hiring of low-wage workers, this could decrease the average earnings paid by firms. Thus, our results do not necessarily contradict the conventional intuition regarding the response of wages.

Additionally, we show in Appendix B.6 that these findings of the responses of average earnings for newly hired employees are robust to the Q1-robustness, exclusion of the Great Recession period, and redefinition of small firms. In Appendix B.7, we examine the impact of monetary policy shocks on the average earnings of new hires, without considering the sign distinction of the shock. We find that an increase in the ffr shock leads to an increase in average earnings growth and it increases more for small firms; again highlighting the misleading conclusions one might reach if the sign of the monetary policy shock is not taken into account. Also, considering all firms, and not separately analyzing small and large firms, we find that both contractionary and expansionary ffr shocks lead to a decrease in the growth of earnings, consistent with our overall findings in Figure 8.

We report results for nominal average earnings, instead of average real earnings, because the monetary policy shocks often induce a well-known price puzzle, as lately documented by Ramey (2016). Using our ffr factor shocks we show in Appendix B.1 that there is an initial price increase but overall little evidence of a price puzzle. In Appendix B.8 we report the results for real earnings that are qualitatively the same as those for nominal earnings.

4.2 Model

This section presents a theoretical model demonstrating how the *employees' earnings effect* operates to rationalize our empirical results. Our starting point is the partial equilibrium heterogeneous firms employment-focused model of Bahaj, Foulis, Pinter, and Surico (2022), based on Ottonello and Winberry (2020) and Bernanke, Gertler, and Gilchrist (1999) channels of monetary transmission. The models of Ottonello and Winberry (2020) for investment and of Bahaj, Foulis, Pinter, and Surico (2022) for employment feature two opposing channels of monetary transmission: (i) the convex marginal cost channel and (ii) the financial accelerator channel. We incorporate a third channel, the *employees' earning* channel, motivated by our empirical findings about asymmetric earnings response to monetary policy shock presented in Section 4.1.

In the model, monetary policy affects the firms' labor choice through a working capital constraint. If a firm needs to borrow to finance its wage bill, an increase in the interest rate decreases its labor demand, holding all else constant. Many papers have introduced working capital constraints to emphasize the transmission mechanism where shocks impact employment demand through financing constraints (e.g., Mendoza, 2010 for productivity shocks, Arellano, Bai, and Kehoe, 2019 for uncertainty shocks; Bahaj, Foulis, Pinter, and Surico, 2022 for monetary shocks). Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas-Sanchez (2017) provide empirical support showing that external financing is important for firms. The working capital constraint has been traditionally thought of as a cash-in-advance constraint in production, as introduced by Fuerst (1992). However, Schwartzman (2014) interprets this constraint as a time-to-produce constraint through which firms use and pay for the labor input before the output is supplied. This interpretation allows for wider applicability of the working capital constraints.

Set-up. Firm j produces good Y^j using labor input N^j according to the Cobb-Douglas production function

$$Y_t^j = A_t^j (N_t^j)^\alpha,$$

where $\alpha \leq 1$ and A_t^j with $\mathrm{E}_t(A_t^j) = 1$ is the idiosyncratic stochastic productivity that is realized at the end of the period. The final good is homogeneous across firms and each firm sells its output at the price P_t. Each firm enters the period with the firm-specific amounts of liquid resources D_t^j and illiquid resources L^j. Let Q_t be the price of the illiquid resource. Assume that the liquid resource can be used to finance the operations of the firm, which faces working capital constraints, but the illiquid resource cannot be used for that purpose. While Bahaj, Foulis, Pinter, and Surico (2022) consider land as an illiquid resource, we allow for a broader interpretation, including firms' land and physical capital, but also intangible capital, such as payback reputation or trust in repaying the loan. In our empirical exercise, we use firms' size as a proxy for L^j, and this is what differentiates firms' type.

Firms borrow B_t^j at the beginning of the period in order to pay their labor input, while their output is sold at the end of the period. They borrow $B_t^j = \max\{W_t^j N_t^j - D_t^j, 0\}$, where W_t^j is a firm-specific nominal wage. We examine firm-specific wages in order to allow for a different response across firm sizes. Also, the wage paid by each firm is the same for all employees, and thus in the model, firm-level wage and average employee earnings are equivalent.[24] We assume that firms face working capital constraints and need to borrow externally if their liquid resources D_t^j are insufficient to pay their labor input. We also assume that firms do not distribute dividends and that firms cannot raise funds by issuing new equity.

If a firm needs to borrow, it pays the gross interest rate equal to the short-term nominal interest rate i_t plus additional spread, $\lambda(B_t^j, Q_t L^j) \equiv \lambda_t^j \geq 0$, which depends on both B_t^j and the value of the collateral, $Q_t L^j$. The spread is assumed to increase with borrowing, $\frac{\partial \lambda_t^j}{\partial B_t^j} = \lambda_1^j \geq 0$ at an increasing rate, $\lambda_{11}^j \geq 0$. It is also assumed to decrease with the value of illiquid resources, $\lambda_2^j \leq 0$. However, the rate at which the spread increases with the firm's borrowing is decreasing with the value of the firm's illiquid assets, that is $\lambda_{12}^j \leq 0$.

[24] We show in footnote 28 that in the presence of composition effects, we could use average employees' earnings instead of wages. We present wage changes in the main text for notation convenience.

In addition, we assume that $\frac{\partial Q}{\partial i} < 0$, i.e., the price of the illiquid resource decreases with the interest rate.

The next period liquid resources of firm j can be written as

$$D_{t+1}^{j} = P_t Y_t^j - (1+i_t)(W_t^j N_t^j - D_t^j) - \lambda_t^j \max\{W_t^j N_t^j - D_t^j, 0\}. \quad (2)$$

In this economy, the aggregate state is given by $S_t = \{P_t, i_t, Q_t\}$ and $\{W_t^j\}$. This is a partial equilibrium model where the wage is exogenous. However, when the monetary authority changes the nominal interest rate i_t, it impacts the aggregate state vector and the wage. We feed the response of earnings to monetary shocks as found in the data, to explore the implications of the model for employment.

The value of the firm depends on the liquid resources. The firm's problem is to choose the labor input to maximize its expected value subject to equation (2), that is

$$\max_{N_t^j} V(D_t^j; S_t) = \frac{1}{1+i_t} \mathrm{E}_t [V(D_{t+1}^j; S_{t+1})] \quad (3)$$

where we assume that the firm does not default.[25] Substituting in the above equation the firm's next period cash, we can re-write the optimization problem as:

$$\max_{N_t^j} V(D_t^j; S_t) = \frac{1}{1+i_t} \mathrm{E}_t \left[V(P_t A_t^j (N_t^j)^\alpha - (1+i_t)(W_t^j N_t^j - D_t^j) - \lambda_t^j \max\{W_t^j N_t^j - D_t^j, 0\}; S_{t+1})\right] \quad (4)$$

with the following transversality condition $\lim_{s\to\infty} \prod_{k=0}^{s} (1+i_{t+k})^{-1} D_{t+k}^j \geq 0$.

We denote the indicator function for $W_t^j N_t^j > D_t^j$ as $\mathbb{1}_{(B_t^j > 0)}$. The first order condition for firm j is as follows

$$\mathrm{E}_t[V'(D_{t+1}^j; S_{t+1})] \left[P_t A_t^j \alpha (N_t^j)^{\alpha-1} - (1+i_t) W_t^j - \mathbb{1}_{(B_t^j>0)} \left(\lambda_t^j W_t^j + (W_t^j N_t^j - D_t^j) \lambda_1^j \frac{\partial B_t^j}{\partial N_t^j} \right) \right] = 0. \quad (5)$$

Simplifying equation (5), suppressing time subscripts and substituting in $\frac{\partial B^j}{\partial N^j} = W^j$ we

[25] Here we think of L^j as an illiquid asset; alternatively, we assume that the firm, even if it has to finance all labor employed by borrowing, having an upper bound of spread $\bar{\lambda}$, it still finds it suboptimal to liquidate its illiquid asset, i.e., there is an N^j such that $(N_t^j)^a - (1+i_t+\bar{\lambda})(W_t^j N_t^j) > i_t Q_t L^j$.

have:

$$\alpha P(N^j)^{\alpha-1} = \left[1 + i + \mathbb{1}_{(B^j>0)}\left(\lambda^j + (W^j N^j - D^j)\lambda_1^j\right)\right] W^j.$$

Defining the expected value of the marginal product of labor as $MPN^j \equiv P\alpha(N^j)^{\alpha-1}$ and taking logs of the first-order condition, we get the following equation:

$$\log MPN^j = \log\left((1+i) + \mathbb{1}_{(B^j>0)}\left[\lambda^j + (W_t^j N^j - D^j)\lambda_1^i\right]\right) + \log W^j.$$

Taking a first-order Taylor expansion of $i + \mathbb{1}_{(B^j>0)}\left(\lambda^j + (W^j N^j - D^j)\lambda_1^j\right)$ around zero and defining the value of the marginal product of labor as $MPN^j \equiv P\alpha(N^j)^{\alpha-1}$ we derive the following expression:[26]

$$\log(MPN^j) - \log W^j - i = \mathbb{1}_{(B^j>0)}\left(\lambda^j + (W^j N^j - D^j)\lambda_1^j\right). \quad (6)$$

Define

$$MB^j \equiv \log(MPN^j) - \log W^j - i = \log P + \log\alpha + (\alpha-1)\log N^j - \log W^j - i$$

as the marginal benefit from hiring an additional worker. Similarly, we define the marginal spread on the borrowing cost to finance the wage of the marginal worker as

$$MS^j \equiv \mathbb{1}_{(B^j>0)}\left(\lambda^j + (W^j N^j - D^j)\lambda_1^j\right).$$

For all firms, we have that $MB^j - MS^j = 0$, with $MS^j = 0$ for firms that do not need to borrow, i.e. $B^j = 0$,.

To see the impact of changes in the nominal interest rate on employment, we use the implicit function theorem on equation (6). The resulting equation is given below:

$$\frac{dN^j}{di} = -\frac{\frac{\partial MB^j}{\partial i} - \frac{\partial MS^j}{\partial i}}{\frac{\partial MB^j}{\partial N^j} - \frac{\partial MS^j}{\partial N^j}}.$$

[26] As usually, approximating $\log(1+i+x)$ around $i+x=0$, gives $\log(1+i+x) \simeq i+x$. We use $=$ in place of the formal $\simeq$ for what follows.

Since

$$\frac{\partial MB^j}{\partial N^j} = \frac{\partial MPN^j}{\partial N^j} = \frac{\alpha - 1}{N^j}$$

and, for $B_j > 0$,

$$\frac{\partial MS^j}{\partial N^j} = \frac{\partial \lambda^j}{\partial N^j} + W^j \lambda_1^j + \left(W^j N^j - D^j\right) \frac{\partial \lambda_1^j}{\partial N^j} = \left(2\lambda_1^j + \lambda_{11}^j \left(W^j N^j - D^j\right)\right) W^j$$

we can transform this equation to be

$$\frac{dN^j}{di} = \frac{\frac{\partial MB^j}{\partial i} - \frac{\partial MS^j}{\partial i}}{\frac{1-\alpha}{N^j} - \mathbb{1}_{(B^j>0)} \left(2\lambda_1^j + \lambda_{11}^j (W^j N^j - D^j)\right) W^j}. \tag{7}$$

Note that because of our assumptions regarding the spread, the denominator in equation (7) is positive, and assumed strictly positive for the implicit function theorem to hold. In addition, in the case of firms that borrow the higher the amount of illiquid asset L^j, the lower the denominator. This is because a firm with more illiquid assets has a lower cost of hiring the extra worker because it pays a lower spread for borrowing than a firm with a less illiquid asset.[27] This is the effect analyzed by Ottonello and Winberry (2020) and the reason why firms with higher illiquid assets respond more to a change in the nominal interest rate (and in general).

We now focus on the numerator of equation (6). It depends on the responses of the net marginal benefit, MB^j, and of the marginal spread, MS^j, to nominal interest rate changes. This is where we incorporate the employees' earnings effect, which introduces a new channel for firms' differential response to monetary policy shocks.

We first analyze a monetary contraction and assume that the decrease in earnings of new hires is homogeneous across firms of different sizes. This case demonstrates that even if the earnings response is the same for all firms, the earnings channel introduces differences in the amount of hiring among them. The differences in hiring get further amplified when the earnings paid by smaller firms decrease more compared to large ones, as found in our empirical work in Section 4.1. We then consider monetary expansion and incorporate this asymmetry in the response of earnings for large and small firms.

[27]This is beacuse $\frac{\partial\left(\frac{1-\alpha}{N^j} + 2\lambda_1^j W^j + \lambda_{11}^j (W^j N^j - D^j) W^j\right)}{\partial L^j} = 2W^j \lambda_{12}^j Q \leq 0$ given that $\lambda_{12}^j \leq 0$.

First, consider the effect of interest rate increase i on the net marginal benefit MB^j:

$$\frac{\partial MB^j}{\partial i} = \frac{\partial \left(\log P + \log \alpha + (\alpha - 1)\log N^j - \log W^j - i\right)}{\partial i} = \frac{1}{P}\frac{\partial P}{\partial i} - \frac{1}{W^j}\frac{\partial W^j}{\partial i} - 1.$$

In addition, the effect of the interest rate on the marginal spread MS^j is:

$$\frac{\partial MS^j}{\partial i} = \frac{\partial Q}{\partial i} L^j(\lambda_2^j + (W^j N^j - D^j)\lambda_{12}^j) + \frac{\partial W^j}{\partial i} N^j (2\lambda_1^j + \lambda_{11}^j (W^j N^j - D^j)).$$

In the homogeneous earnings response case an interest rate hike reduces employee's earnings to the same extent across the j firms, i.e., we can drop the j superscript from the wage growth expression $\frac{1}{W^j}\frac{\partial W^j}{\partial i}$. In addition, the price level may also change in response to changes in the nominal interest rate i. Then, $\frac{\partial MB^j}{\partial i} = \frac{1}{P}\frac{\partial P}{\partial i} - \frac{1}{W}\frac{\partial W}{\partial i} - 1$, where we see that we can drop the j superscript from $\frac{\partial MB}{\partial i}$ since this effect is also homogeneous across firms. Note that, if there is no price puzzle or stickiness, we expect $\frac{\partial P}{\partial i} < 0$. However, we do not need to restrict the response of the price level, which given the empirical evidence in the literature, could increase, decrease, or stay constant. For our purposes, it suffices to make the less restrictive assumption that $\frac{\partial MB}{\partial i} \leq 0$, so monetary policy tightening lowers the net marginal benefit from employment. Finally, substituting in equation (7) the response of the marginal spread to changes in interest rate, we get:

$$\frac{\partial N^j}{\partial i} = -\frac{\frac{\partial MB}{\partial i} - \left[\frac{\partial Q}{\partial i} L^j(\lambda_2^j + (W^j N^j - D^j)\lambda_{12}^j) + \frac{\partial W^j}{\partial i} N^j (2\lambda_1^j + \lambda_{11}^j (W^j N^j - D^j))\right]}{\frac{\alpha - 1}{N^j} - 2\lambda_1^j W^j - \lambda_{11}^j (W^j N^j - D^j) W^j}. \tag{8}$$

In equation (8), the heterogeneous response of firms via the effect of interest rate on the marginal spread MS^j (i.e., the second term of the numerator which is inside the square brackets), can be analyzed in two parts. The first part captures the effect through the value of the illiquid asset, Q. Given that $\frac{\partial Q}{\partial i} < 0$ and $\lambda_2, \lambda_{12} \leq 0$, this first part is positive. That is, an increase in the interest rate decreases the value of the illiquid asset, and increases the marginal spread, decreasing input demand. This is the financial accelerator effect that traditionally has been used for understanding the response of investment to monetary policy (e.g., Bernanke, Gertler, and Gilchrist, 1999), or recently for studying the response of labor demand to monetary policy (as in Bahaj, Foulis, Pinter, and Surico, 2022). The second part of the term in the square bracket is novel in our work. This term summarizes the employees' earnings effect found on our empirical analysis, suggesting that $\frac{\partial W^j}{\partial i} < 0$.[28] This term was assumed to be zero in Bahaj, Foulis, Pinter, and Surico (2022) and Ottonello and Winberry (2020). Given that $\lambda_{11} > 0$ and for $\frac{\partial W^j}{\partial i} < 0$, this term is negative, decreasing the spread that firms need to pay to finance employment after a decrease in employees' earnings. The intuition is that as a monetary tightening decreases earnings, it decreases the total borrowing by a firm and hence lowers the marginal spread. This force tends to increase employment after a monetary tightening.

How does employment change in constrained and unconstrained firms in response to a change in monetary policy? We let $j = U$ be the *unconstrained* firm that we assume does not pay spread for the relevant employment levels hired, and hence $\lambda^U = 0$ and $MS^U = 0$. The *constrained* firm is denoted by $j = C$, where $B^C > 0$, pays spread $\lambda^C > 0$ and $MS^C > 0$. We denote $\Lambda^j \equiv -\frac{1}{\frac{\alpha-1}{N^j} - 2\lambda_1^j W^j - \lambda_{11}^j (W^j N^j - D^j) W^j}$. For unconstrained firms we have $\Lambda^U = -\frac{1}{\frac{\alpha-1}{N^U}}$, with $\Lambda^U \geq \Lambda^C$. Then we can write the difference between the interest rate effect on the employment of constrained versus unconstrained firms as:

$$\frac{\partial N^C}{\partial i} - \frac{\partial N^U}{\partial i} = (\Lambda^C - \Lambda^U)\frac{\partial MB}{\partial i} - \Lambda^C \left[\frac{\partial Q}{\partial i} L^C [\lambda_2^C + (W^C N^C - D^C)\lambda_{12}^C]\right] - \Lambda^C \left[\frac{\partial W^C}{\partial i} N^C [2\lambda_1^C + \lambda_{11}^C (W^C N^C - D^C)]\right]. \tag{9}$$

We analyze how monetary policy shocks impact constrained versus unconstrained firms differently, using equation (9). Given that $\Lambda^C - \Lambda^U < 0$, unconstrained firms are expected to respond more through the first term; this is the channel emphasized by Ottonello and Winberry (2020) where constrained firms scale down less than unconstrained ones after an interest rate increase.[29] This is because when decreasing labor input, the constrained firms which are the ones that pay spread, need to borrow less and pay a lower spread. As a result,

[28] To address possible composition effects note that in $\frac{\partial MS}{\partial i}$, we can split the earnings effect ($\frac{\partial W}{\partial i} N$) into the sum of the non-observed in our data change of the individual kth worker wage ($\frac{\partial W^k}{\partial i}$) and the observed in our data change in average earnings AE for the rest of the k-1 employees ($\frac{\partial AE}{\partial i} N^{k-1}$, where N^{k-1} denotes the number of the k-1 workers). From our data analysis, we know that $\frac{\partial AE}{\partial i} < 0$; as such, the response of the average earnings is important for the earnings channel, which is still valid in the presence of composition effects.

[29] Note that $0 < \Lambda^C < \Lambda^U$ and $\frac{\partial MB}{\partial i} < 0$, so $(\Lambda^C - \Lambda^U)\frac{\partial MB}{\partial i} > 0$ and the first term of equation (9) implies that $-\frac{\partial N^C}{\partial i} < -\frac{\partial N^U}{\partial i}$, i.e., unconstrained firms contract more after an interest rate hike.

constrained firms do not decrease the labor input as much as unconstrained firms do. This effect is depicted by the steeper slope of the MS^C curve (with respect to N) versus the MS^U curve in Figure 9. The second term in equation (9) is the financial accelerator effect; given our assumptions, this term suggests that constrained firms tend to react more to the change of the interest rate. These two opposing forces have been examined in Ottonello and Winberry (2020) for investment and in Bahaj, Foulis, Pinter, and Surico (2022) for employment. These two opposing channels suggest that if the accelerator effect is strong, then constrained firms respond more than unconstrained firms to monetary policy shocks; if the accelerator effect is weak, then unconstrained firms respond more than constrained firms to monetary policy shocks.

The third term in equation (9) is our contribution to the existing literature and suggests that unconstrained firms tend to react more to monetary policy shocks compared to constrained ones due to the employees' earnings effect. This is because, in the case of a monetary tightening accompanied by lower earnings paid to employees, constrained firms need to borrow less to finance employment, pay a lower spread and thus scale down less than the unconstrained firms. The existence of this third channel allows the overall effect of monetary policy on unconstrained firms to be stronger than that on constrained firms, even in the presence of a strong accelerator channel, relative to the previous literature.

Graphically these 3 effects are depicted in Figures 9-11. In all figures, the vertical axes measure the net marginal benefit MB and the marginal spread MS, and the horizontal axes measure employment N. The downward sloping MB curve is the same for all firms in this first version with homogeneous changes in employees' earnings among firms. The convex MS curves differ for the two types of firms, constrained (steeper/blue) and unconstrained (flatter/black). For the unconstrained firms, the MS curve is flat for the levels of employment considered, although it is not for the constrained firms.

Figure 9 shows the response of the two types of firms to a monetary contraction, ignoring the effect of the financial accelerator and the earnings effect, therefore capturing only the first term in equation (9). As noted earlier, because the constrained firms have to pay a spread while the unconstrained firms do not have to, unconstrained firms are more responsive and scale down more than constrained firms. The financial accelerator effect is

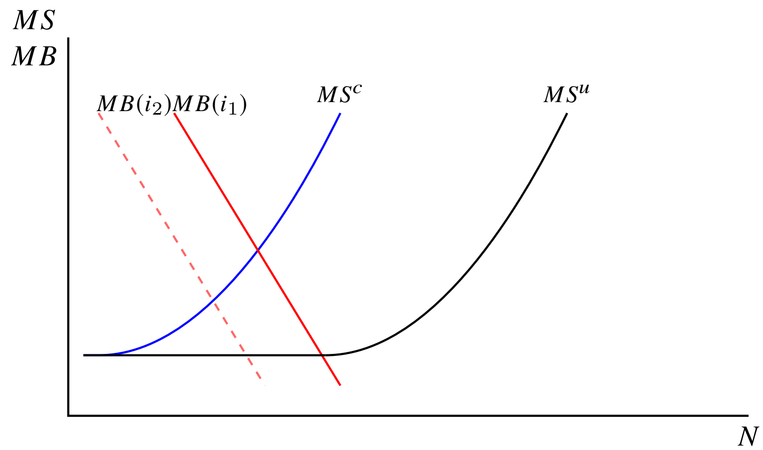

Figure 9: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. Model without taking into account the accelerator effect and the change in spread due to change in employees' earnings.

incorporated in Figure 10. This effect steepens and shifts inwards the MS curves (shifting from solid blue to dashed blue for the constrained firms and from solid black to dashed black for the unconstrained firms); we depict a strong accelerator effect, which results in constrained firms scaling down more than the unconstrained ones, as in Bahaj, Foulis, Pinter, and Surico (2022).

In Figure 11 we add the employees' earnings effect, depicting all three effects combined. The earnings effect makes the marginal spread MS curve flatter than what it was in Figure 10, shifting from dashed blue to yellow for the constrained firms and from dashed black to green for the unconstrained firms. In this case, unconstrained firms respond more than constrained ones to monetary policy shocks, even in the presence of a strong accelerator effect. This is because the new effect we identify, coming from the response of employees' earnings, suggests that constrained firms tend to react less. This picture is consistent with the empirical results we show in Section 3, where small firms decrease hiring and employment growth less than large firms after a monetary policy tightening that decreases average earnings growth similarly across firms of both size classes; those differences intensify if the earnings drop of small firms is deeper than that of the large firms.

We now show how the above model can incorporate heterogeneous earnings responses among constrained and unconstrained firms. We do this exposition for monetary expan-

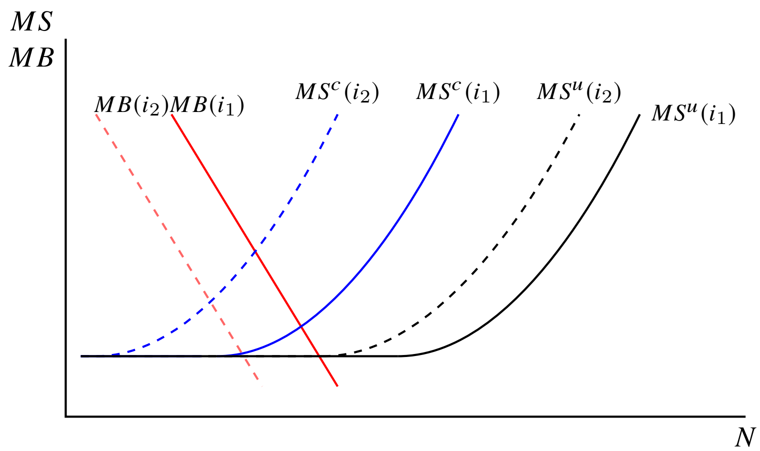

Figure 10: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. The financial accelerator effect moves the MS curve of constrained firms to blue dashed and of unconstrained to black dashed curves. Model without taking into account the change in spread due to change in employees' earnings.

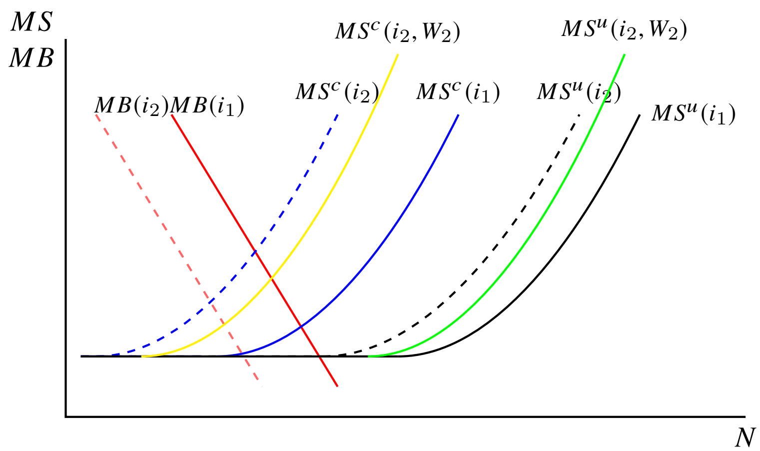

Figure 11: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. The financial accelerator effect moves the MS curve of constrained firms to blue dashed and of unconstrained to black dashed curves. Taking into account the employees' earnings effect moves those curves to yellow for constrained and to green for unconstrained firms. Model with homogeneous changes in earnings growth.

sions, as it is obvious and discussed above for monetary tightening. Specifically, in our empirical results, we found that both large and small firms decrease average earnings growth after a monetary expansion and that small firms do so more than large firms. If this is so, we cannot simplify and drop the j superscript in the MB^J function as we did before, and equation (8) now becomes:

$$\frac{\partial N^j}{\partial i} = -\frac{\frac{\partial MB^j}{\partial i} - \left[\frac{\partial Q}{\partial i} L^j(\lambda_2^j + (W^j N^j - D^j)\lambda_{12}^j) + \frac{\partial W^j}{\partial i} N^j(2\lambda_1^j + \lambda_{11}^j(W^j N^j - D^j))\right]}{\frac{\alpha-1}{N^j} - 2\lambda_1^j W^j - \lambda_{11}^j(W^j N^j - D^j)W^j}. \quad (10)$$

The equation that determines the relative magnitude of responses of constrained versus unconstrained firms now is:

$$\begin{aligned}\frac{\partial N^C}{\partial i} - \frac{\partial N^U}{\partial i} = &\left(\Lambda^C \frac{\partial MB^C}{\partial i} - \Lambda^U \frac{\partial MB^U}{\partial i}\right) - \Lambda^C \left[\frac{\partial Q}{\partial i} L^C [\lambda_2^C + (W^C N^C - D^C)\lambda_{12}^C]\right] \\ &- \Lambda^C \left[\frac{\partial W^C}{\partial i} N^C [2\lambda_1^C + \lambda_{11}^C (W^C N^C - D^C)]\right].\end{aligned} \quad (11)$$

The second and third terms of equation (11) are the same as those in equation (9). That is, the financial accelerator and earnings channels (second and third term, respectively) affect the relative response of large versus small firms as before, through the cost of external financing. However, given that there is a decrease in employees' earnings, those two channels are now in agreement. The financial accelerator effect suggests that the constrained firms would be affected more than the unconstrained ones because the price of the illiquid asset would ease their borrowing costs. Similarly, the earnings channel suggests that having to finance lower employees' earnings, the constrained firms borrow less, and the spread decreases.

Moreover, the first term of equation (11) is now different than that of equation (9). Focusing on this first term, we have, as before, $0 < \Lambda^C < \Lambda^U$; however, the heterogeneous changes in the employees' average earnings now activate a differential response on firms' net marginal benefit, given that we now have that $0 > \frac{\partial MB^U}{\partial i} > \frac{\partial MB^C}{\partial i}$. That is, the earnings growth paid to employees by small firms drops more than that of large firms, and thus the

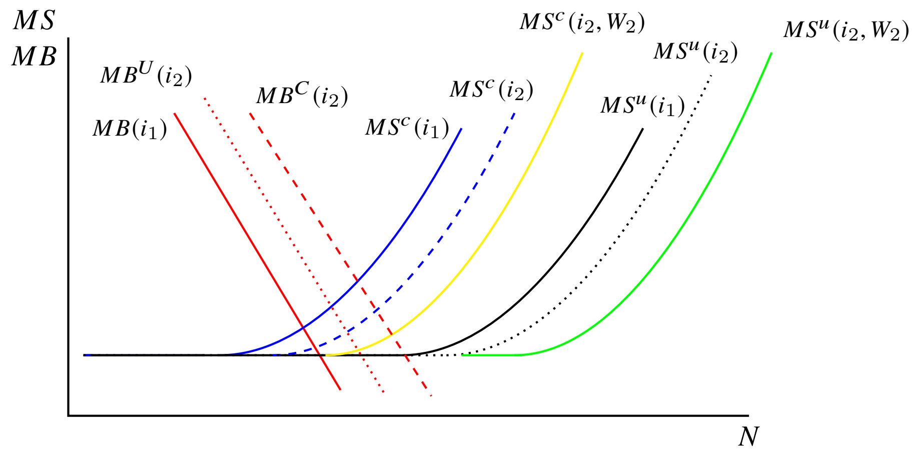

Figure 12: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary expansion $i_2 < i_1$, the MB curve moves from red solid to red dashed line for constrained firms, and to red dotted for unconstrained firms. The financial accelerator effect moves the MS curve of constrained firms to blue dashed and of unconstrained to black dotted curves. Taking into account the earnings effect moves those curves further, to yellow for constrained and to green for unconstrained firms. The model with heterogeneous changes in earnings growth.

net marginal benefit of expanding increases more for small firms relative to large firms.[30]

Incorporating our finding that the average employees' earnings decrease during monetary expansions, and the drop for the small firms is found to be deeper than that of the larger firms, the graphical representation is different than before. First, it involves two different MB curves, with the net marginal benefit of the constrained firms, MB^C, responding more than that of the unconstrained firms, MB^U, as shown in Figure 12. Given the different movements of the MB curve for the two types of firms, and also depending on the slope of the MS curves, the first part of the equation (11) leads to constrained firms increasing employment more than unconstrained firms after monetary expansions, as found on our empirical evidence.

In addition, given that the financial accelerator and earnings effect are now in agreement, they imply that small firms respond more than large firms after a monetary expansion. In conclusion, in the case of monetary expansion with heterogeneous earnings response, the theoretical implications of the model are even clearer, suggesting that constrained firms increase employment more than large firms, consistent with the result (i) spelled out in Section 4.1.

[30] As $|\frac{1}{W^U}\frac{\partial W^U}{\partial i}| < |\frac{1}{W^C}\frac{\partial W^C}{\partial i}|$ so $|\frac{\partial MB^U}{\partial i}| < |\frac{\partial MB^C}{\partial i}|$ and $0 > \frac{\partial MB^U}{\partial i} > \frac{\partial MB^C}{\partial i}$.

5 Conclusion

This paper revisits the classic question of how monetary policy affects small and large firms differently. Unlike previous studies that focused on investment, we examine the less-explored labor market, and we uncover novel results. Specifically, we explore the effects of monetary policy on key labor market variables and document how those effects differ based on the direction of the monetary policy shock (positive versus negative) and the size of the firm (small versus large). To investigate these aspects, we use the QWI dataset, which provides information about employment flow margins and employees' earnings in a unified setting. Additionally, the dataset covers a broad range of small and large firms in the US on a quarterly basis, making it the ideal publicly available dataset for answering those research questions.

Our findings indicate that small firms are less affected by a monetary contraction in terms of hiring compared to large firms. We suggest that this is because the decrease in average earnings growth that occurs with an unexpected monetary policy tightening leads to lower spreads paid by small firms. This, in turn, influences their decision not to downsize. On the other hand, when there is a monetary expansion and average earnings growth decreases, the decrease in spreads provides a channel through which small firms can hire more employees relative to large firms. This channel supports our empirical finding that after monetary expansions, small firms experience higher employment and hiring growth compared to large firms.

Although our dataset allows us to uncover useful information about the impact of monetary policy on labor market variables, it has limitations. It lacks information about the financial standing of the firms involved, which we can only proxy for using the reported firm size information. Furthermore, our information on average earnings does not allow us to explore possible composition effects; these are interesting questions that we hope to study further in future works. Despite these limitations, our study represents a significant step forward in understanding the effects of monetary policy on the labor market. Our findings provide valuable insights for policymakers seeking to achieve Congress' mandate of full employment.

References

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

Angrist, J. D., Ò. Jordà, and G. M. Kuersteiner (2018). Semiparametric estimates of monetary policy effects: String theory revisited. *Journal of Business & Economic Statistics 36*(3), 371–387.

Arellano, C., Y. Bai, and P. J. Kehoe (2019). Financial frictions and fluctuations in volatility. *Journal of Political Economy 127*(5), 2049–2103.

Autor, D., D. Dorn, L. F. Katz, C. Patterson, and J. Van Reenen (2020). The fall of the labor share and the rise of superstar firms. *The Quarterly Journal of Economics 135*(2), 645–709.

Bahaj, S., A. Foulis, G. Pinter, and P. Surico (2022). Employment and the collateral channel of monetary policy. *Journal of Monetary Economics 131*, 26–44.

Berger, D. (2018). Countercyclical restructuring and jobless recoveries. Manuscript.

Bernanke, B. S., M. L. Gertler, and S. Gilchrist (1999). *The financial accelerator in a quantitative business cycle framework, in J. B. Taylor & M. Woodford (Ed.), Handbook of Macroeconomics, 1341-1393*, Volume 1. Elsevier.

Braun, H., R. De Bock, and R. DiCecio (2007). Supply shocks, demand shocks, and labor market fluctuations. *FRB of St. Louis Working Paper No*.

Campbell, J., C. Evans, J. Fisher, and A. Justiniano (2012). Macroeconomic effects of federal reserve forward guidance. *Brookings Papers on Economic Activity*, 1–80.

Casiraghi, M., T. McGregor, and B. Palazzo (2020). Young firms and monetary policy transmission. *Available at SSRN 3732896*.

Census (2020). United States Bureau of the Census, Quarterly Workforce Indicators Release R. *Cornell University, Labor Dynamics Institute [distributor], Ithaca, NY, USA*.

Chari, V. V., L. J. Christiano, and P. J. Kehoe (2013). The Gertler-Gilchrist evidence on small and large firm sales. Manuscript.

Chodorow-Reich, G. (2014). 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.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy 113*(1), 1–45.

Cloyne, J., C. Ferreira, M. Froemel, and P. Surico (2021). Monetary policy, corporate finance and investment. *Journal of the European Economic Association, forthcoming*.

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

Cover, J. (1992). Asymmetric effects of positive and negative money-supply shocks. *Quarterly Journal of Economics 107*(4), 1261–1282.

Crouzet, N. and N. R. Mehrotra (2020). Small and large firms over the business cycle. *American Economic Review 110*(11), 3549–3601.

Davis, S. J. and J. Haltiwanger (1999). On the driving forces behind cyclical movements in employment and job reallocation. *American Economic Review 89*(5), 1234–1258.

DeLong, J. B. and L. Summers (1988). How does macroeconomic policy affect output? *Brookings Papers on Economic Activity 1988*(2), 433–494.

Driscoll, J. C. and A. C. Kraay (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of Economics and Statistics 80*(4), 549–560.

Duval, M. R. A., D. Furceri, R. Lee, and M. M. Tavares (2021). *Market power and monetary policy transmission*. International Monetary Fund.

Elsby, M., B. Hobijn, F. Karahan, G. Koşar, and A. Şahin (2019). Flow origins of labor force participation fluctuations. In *AEA Papers and Proceedings*, Volume 109, pp. 461–64.

Fazzari, S., G. Hubbard, and B. Petersen (1988). Financing constraints and corporate investment. *Brookings Papers on Economic Activity, Economic Studies Program 19*(1), 141–206.

Ferrando, A., P. McAdam, F. Petroulakis, and X. Vives (2021). Product market structure and monetary policy: Evidence from the euro area.

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

Fuerst, T. S. (1992). Liquidity, loanable funds, and real activity. *Journal of Monetary Economics 29*(1), 3–24.

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

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

Gnewuch, M. and D. Zhang (2022). Monetary policy, firm heterogeneity, and the distribution of investment rates. *Firm Heterogeneity, and the Distribution of Investment Rates (December 20, 2022)*.

Gopinath, G., Ş. Kalemli-Özcan, L. Karabarbounis, and C. Villegas-Sanchez (2017). Capital allocation and productivity in South Europe. *The Quarterly Journal of Economics 132*(4), 1915–1967.

Graves, S., C. Huckfeldt, and E. Swanson (2022). The labor demand and labor supply channels of monetary policy. Unpublished Manuscript, University of California Irvine.

Groshen, E. L. and S. Potter (2003). Has structural change contributed to a jobless recovery? *Available at SSRN 683258*.

Gürkaynak, R. S., B. Sack, and E. T. Swanson (2005). Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking 1*(1), 55–93.

Haltiwanger, J., R. Jarmin, and J. Miranda (2013). Who creates jobs? Small vs. large vs. young. *Review of Economics and Statistics 95*(2), 347–361.

Hartman-Glaser, B., H. Lustig, and M. Z. Xiaolan (2019). Capital share dynamics when firms insure workers. *The Journal of Finance 74*(4), 1707–1751.

Hazell, J. and B. Taska (2020). Downward rigidity in the wage for new hires. *Available at SSRN 3728939*.

Hoesch, L., B. Rossi, and T. Sekhposyan (2023). Has the information channel of monetary policy disappeared? Revisiting the empirical evidence. *American Economic Journal: Macroeconomics 15*(3), 355–387.

Hopenhayn, H., J. Neira, and R. Singhania (2022). From population growth to firm demographics: Implications for concentration, entrepreneurship and the labor share. *Econometrica 90*(4), 1879–1914.

Howes, C. (2021). Financial constraints, sectoral heterogeneity, and the cyclicality of investment. *Federal Reserve Bank of Kansas City Working Paper* (21-06).

Jaimovich, N. and H. E. Siu (2020). Job polarization and jobless recoveries. *Review of Economics and Statistics 102*(1), 129–147.

Jeenas, P. (2019). Firm balance sheet liquidity, monetary policy shocks, and investment dynamics. Manuscript.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review 95*(1), 161–182.

Jordà, Ò., M. Schularick, and A. M. Taylor (2015). Betting the house. *Journal of International Economics 96*, S2–S18.

Karahan, F., B. Pugsley, and A. Şahin (2022). Demographic origins of the startup deficit. *National Bureau of Economic Research*.

Kehrig, M. and N. Vincent (2021). The micro-level anatomy of the labor share decline. *The Quarterly Journal of Economics 136*(2), 1031–1087.

Kroner, N. (2021). Firm-level uncertainty and the transmission of forward guidance to investment. *Available at SSRN 3931591*.

Kudlyak, M. and J. Sanchez (2017). Revisiting Gertler-Gilchrist evidence on the behavior of small and large firms. *Journal of Economic Dynamics and Control 77*, 48–69.

Kuttner, K. N. (2001). Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of Monetary Economics 47*(3), 523–544.

Lo, M. C. and J. Piger (2005). Is the response of output to monetary policy asymmetric? Evidence from a regime-switching coefficients model. *Journal of Money, Credit and Banking 37*, 865–886.

Madeira, C. and L. Salazar (2023). The impact of monetary policy on a labor market with heterogeneous workers: The case of chile. *Latin American Journal of Central Banking 4*(2), 100092.

Manea, C. (2020). Monetary policy with financially-constrained and unconstrained firms. *Essays in Monetary Economics, PhD Thesis, Universitat Pompeu Fabra*.

Martellini, P., G. Menzio, and L. Visschers (2021). Revisiting the hypothesis of high discounts and high unemployment. *The Economic Journal 131*(637), 2203–2232.

Mendoza, E. G. (2010). Sudden stops, financial crises, and leverage. *American Economic Review 100*(5), 1941–66.

Moscarini, G. and F. Postel-Vinay (2012). The contribution of large and small employers to job creation in times of high and low unemployment. *American Economic Review 102*(6), 2509–2539.

Moscarini, G. and F. Postel-Vinay (2013). Stochastic search equilibrium. *Review of Economic Studies 80*(4), 1545–1581.

Nakamura, E. and J. Steinsson (2018). High frequency identification of monetary non-neutrality: The information effect. *Quarterly Journal of Economics 133*(3), 1283–1330.

Olivei, G. and S. Tenreyro (2007). The timing of monetary policy shocks. *American Economic Review 97*(3), 636–663.

Ottonello, P. and T. Winberry (2020). Financial heterogeneity and the investment channel of monetary policy. *Econometrica 88*(6), 2473–2502.

Plagborg-Møller, M. and C. K. Wolf (2021). Local projections and vars estimate the same impulse responses. *Econometrica 89*(2), 955–980.

Ramey, V. A. (2016). Macroeconomic shocks and their propagation. In Elsevier (Ed.), *Handbook of Macroeconomics*, Chapter 2, pp. 71–162.

Romer, C. D. and D. H. Romer (2000). Federal reserve information and the behavior of interest rates. *American Economic Review 90*(3), 429–457.

Schreft, S. L. and A. Singh (2003). A closer look at jobless recoveries. *Economic Review-Federal Reserve Bank of Kansas City 88*(2), 45–73.

Schwartzman, F. (2014). Time to produce and emerging market crises. *Journal of Monetary Economics 68*, 37–52.

Sharpe, S. A. (1994). Financial market imperfections, firm leverage, and the cyclicality of employment. *American Economic Review 84*(4), 1060–1074.

Singh, A., J. Suda, and A. Zervou (2022). Monetary policy, labour market, and sectoral heterogeneity. *AEA Papers and Proceedings 112*, 491–495.

Swanson, E. T. (2021). Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. *Journal of Monetary Economics 118*, 32–53.

Tenreyro, S. and G. Thwaites (2016). Pushing on a string: US monetary policy is less powerful in recessions. *American Economic Journal: Macroeconomics 8*(4), 43–74.

White, N. (2018). Gross worker flows, job loss, and monetary policy. Manuscript.

Yu, L. (2021). Monetary policy and firm heterogeneity. Manuscript.

Zervou, A. (2014). Firms' finance, cyclical sensitivity, and the role of monetary policy.

A Data appendix

A.1 Further information on the QWI

The QWI dataset includes quarterly, state-level information on total employment and employment dynamics (employment, hires, separations, earnings) including also employer or establishment information, like firm size and NAICS Sectors.[31] All private (i.e., not Federal) employers that are covered by unemployment insurance in the U.S. are included.[32]

The QWI links together the following datasets: 1) Unemployment Insurance earnings data (UI) from where the employment and earnings data at the job level (a worker at an establishment) is taken. All employers that are covered by unemployment insurance submit quarterly earnings reports for all employees (around 96% of wage and salary civilian jobs in the U.S.) 2) Quarterly Census of Employment and Wages (QCEW) from where employer information such as industry, is taken. 3) Business Dynamics Statistics (BDS) from where firm age or size is obtained. This is reported on the employer/firm level (not on establishment). 4) Various sources provide information about the demographic characteristics of the worker, such as age, sex, race, ethnicity, education, and place of residence (e.g., the 2000 Census Social Security Administrative records, individual tax returns, etc).

The main definitions used to describe a job are as follows. An employer is a single account in a given state's unemployment reporting system, referred to as State Employer Identification Number (SEIN). State-based Employers may be linked across states to a national firm, via the Federal Employer Identification Number (EIN). An establishment is a physical place of work within an employer (SEINUNIT). A single employer may have one or many establishments. An employee is a single worker, identified by Social Security Number (SSN), encoded to Protected Identification Key (PIK). Job is the association of an individual PIK with an establishment (SEINUNIT) in a given year and quarter.

Our dependent variables from the QWI are employment-*Emp*, hires-*HirA*, and average monthly earnings of newly hired employees-*EarnHirNS*. The definitions of those variables

[31] An alternative data set that we could have used is the Quarterly Census of Employment and Wages. However, this data set does not include job creation/destruction, which is important in identifying the sources of employment changes.

[32] Examples of jobs that are not covered include federal employment, some agricultural jobs, railroad employment, self-employment, and other exceptions that vary from state to state.

are as follows. *Emp*: count of employees with positive earnings at t and $t-1$; *HirA*: count of workers having positive earnings at a specific employer in t but no earnings from that employer in $t-1$; *EarnHirNS*: average earnings of newly hired employees, who were hired for the full quarter.

We use the information on the employer size which is defined at the national level (not at the state level). A national firm may be larger or older than the part of that firm found in a state. Firm size refers to the national employment size of the firm on March 12th (Q1) of the previous year. For new firms, firm size is measured as the current year's March employment (or the employment in the first month of positive employment if born after March). There are five category bins of firm size ($0-19$, $20-49$, $50-249$, $250-499$ and 500+ Employees). We also use the information on the state of work, i.e., this characteristic is based on the job geography. Finally, we use the 2-digit industry code.

One of the drawbacks of the QWI dataset is that as a panel, is unbalanced across states. In 1990, when it was first introduced, only four states participated. Additional states joined through 2004, when forty-nine states are included (all U.S. states apart from Massachusetts and Washington, D.C.). Given the unbalanced panel, we exclude the states that become part of the sample after $1995:1$. That leaves us with 17 states (CA, CO, ID, IL, KS, LA, MD, MN, MO, MT, NC, OR, RI, TX, UT, WA, WI).

A.2 Employment shares in small and large firms

The top panel of Figure A.2.1 plots the share of large and small firms in total employment using the Bureau of Labor Statistics annual data from 1994-2021. The bottom panel plots the share of large and small firms in total employment in our sample using the QWI. From both figures, we see that the share of employment in large firms has been increasing over time, and that of small firms decreasing over time.

A.3 Distribution of employment and new hires

Figures A.3.1 and A.3.2 plot the distribution of employment and new hires in small and large firms across industries and states in our sample. These figures highlight that small and large firms are not particularly concentrated in a specific industry and/or a state and

Figure A.2.1: Employment concentration in large and small firms

Notes: The figure plots the fraction (in % points) of employment in large firms (more than 500 employees) and small firms (1-19 employees) in the U.S. The top row uses the Bureau of Labor Statistics annual data from 1994-2021 while the bottom row uses our QWI sample for the period 1995:1-2019:2.

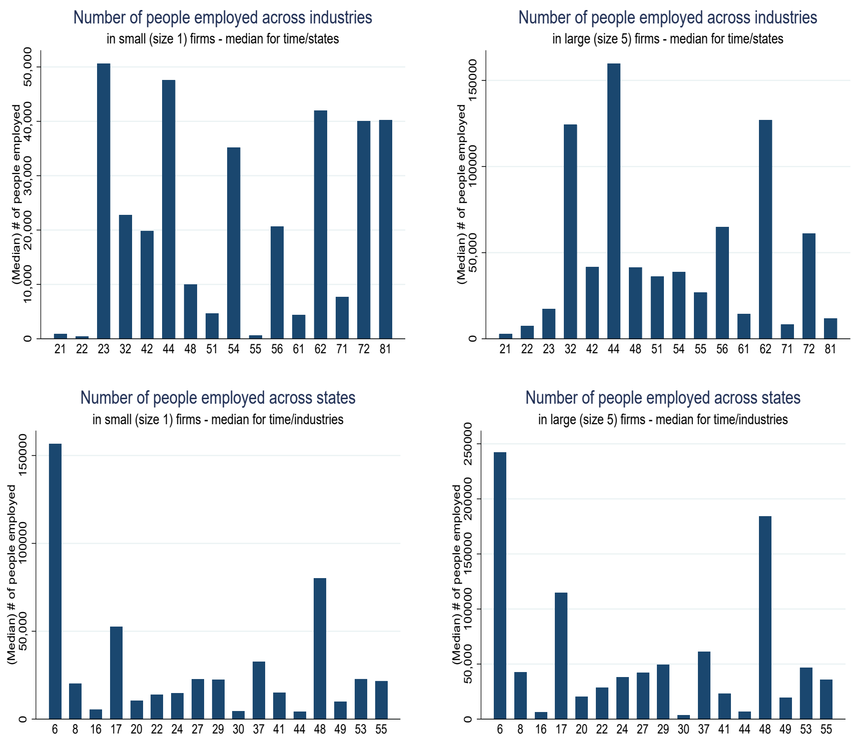

Figure A.3.1: Distribution of employment across industries and states in small and large firms

Notes: The figure plots the median number of people employed across industries (top panels) and across states (bottom panels) for small (size 1—left column) and large (size 5—right column) firms.

therefore the dataset is suitable for our analysis.

A.4 Q1 ffr factor shocks

Table A.1 reports the summary statistics for all ffr factor shocks and those that occur in quarter 1. It also reports the positive and negative ffr factor shocks occurring in all quarters and in the first quarter that are used in the Q1-robustness exercise of Section 3.3. From the last two columns, we can see that the negative (expansionary) ffr factor shocks that occur during the first quarter of our sample have a similar mean and standard deviation to those occurring in all quarters. The positive (contractionary) ffr factor shocks occurring during the first quarter of our sample, however, are on average 44% smaller and less than half the standard deviation than those occurring in all quarters.

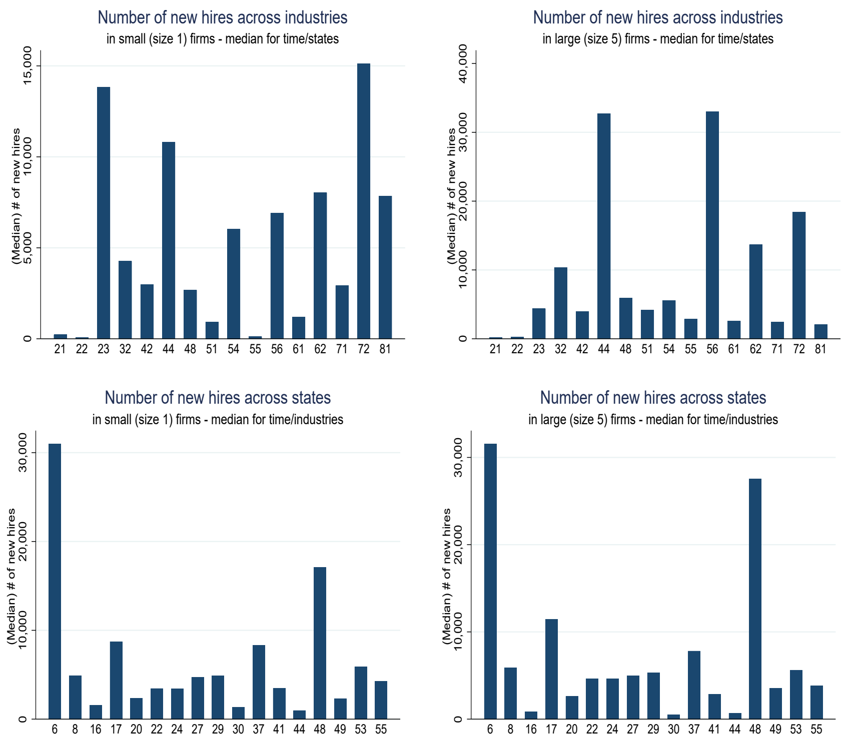

Figure A.3.2: Distribution of hiring across industries and states in small and large firms

Notes: The figure plots the median number of new hires across industries (top panels) and across states (bottom panel) for small (size 1—left column) and large (size 5—right column) firms.

B Results appendix

B.1 Aggregate data

We examine the effect of the ffr factor shocks on key aggregate variables such as real GDP (GDPC1, Real Gross Domestic Product, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate), employment (USPRIV, All Employees, Total Private, Thousands of Persons, Quarterly, Seasonally Adjusted), and the price level (CPIAUCSL, Consumer Price Index for All Urban Consumers, Quarterly, Seasonally Adjusted). The data are from the St. Louis FRED database, for the period 1995:1-2019:2. We estimate the following equation

$$\Delta_h n_{t+h} = \beta^h_{ffr}\epsilon^{ffr}_t + \Gamma^{h\prime} Z_t + u^h_{t+h} \tag{B.1}$$

Table A.1: Summary statistics for ffr factor shocks, all quarters (Qs) and Q1

	Qs	Q1	Qs (+)	Q1 (+)	Qs (-)	Q1 (-)
Mean	0.51	0.65	5.31	2.97	-12.98	-10.66
Standard deviation	12.28	9.99	4.53	1.66	16.44	14.81

Notes: The table reports the mean and standard deviation (in basis points) of the change in the ffr factor shock for the period 1995:1-2019:2, occurring in all quarters (Qs) and in the first quarter (Q1). It also reports the same statistic for positive and negative ffr factor shocks.

where Z includes the other two components of monetary policy, forward guidance and large-scale asset purchases (LSAPs), and current and three lags of the federal funds rate, and capacity utilization.

Figure B.1.1 shows that an increase in the ffr factor shock decreases real GDP and employment growth, and lowers the price level (although with an initial price-puzzle period). As such, the ffr factor shocks that we use in this paper, generate the expected effects on the aggregate variables.

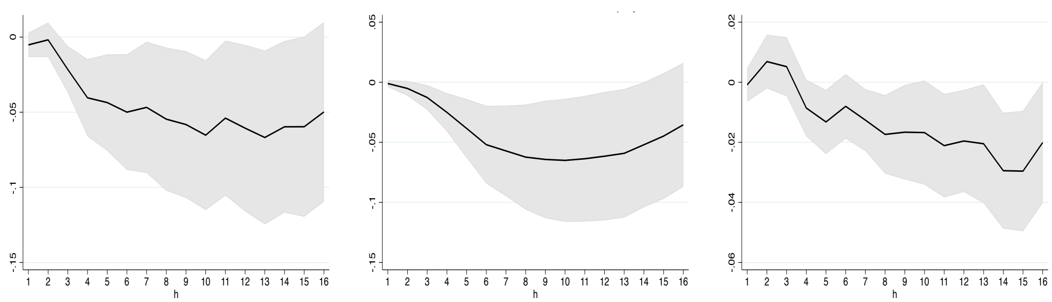

Figure B.1.1: Response of the growth rate of real GDP, aggregate employment and the price level to a ffr factor shock

Notes: The figure plots the response of the growth rate of real GDP (left column), aggregate employment (middle column) and the price level (right column), to an increase in the ffr factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The shaded area depicts 68% confidence bands.

B.2 Test for significance of our empirical results

We present a table with all p-values for the F-tests for the null hypothesis that the impulse responses are zero for each horizon, after positive/contractionary (ffr^{+}) and negative/expansionary (ffr^{-}) ffr shocks on the growth rate of new hires, employment, average nominal earnings, and average real earnings.

Table B.1: p-values for F-tests

	ffr^{+} small	ffr^{+} large	ffr^{-} small	ffr^{-} large
New hires	0.477	0.019	0.063	0.908
Employment	0.168	0.000	0.006	0.918
Earnings	0.761	0.857	0.000	0.000
Real earnings	0.471	0.000	0.942	0.001

Notes: The table reports the p-values for the F-tests for the null hypothesis that the impulse responses are zero for each horizon, after positive (ffr^{+}) and negative (ffr^{-}) ffr shocks on the growth rate of new hires, employment, average nominal earnings, and average real earnings for our sample.

B.3 Effects of monetary policy shocks on firms of all sizes

In this section we estimate the effects of the ffr factor shocks on the labor market of firms of all sizes, using the specifications below:

Baseline specification:

$$\Delta_h n_{gis,t+h} = \alpha^h_{gis} + \beta^h_{ffr}\epsilon^{ffr}_t + \Gamma^h Z_t + u^h_{gis,t+h} \tag{B.2}$$

Sign asymmetry:

$$\Delta_h n_{gis,t+h} = \alpha^h_{gis} + \beta^h_{ffr+}\epsilon^{ffr+}_t + \beta^h_{ffr-}\epsilon^{ffr-}_t + \Gamma^h Z_t + u^h_{gis,t+h} \tag{B.3}$$

The control variables in Z_t are one lag of the dependent variable, four lags of the federal funds rate, four lags of the state unemployment rate, and interactions of all three monetary policy factors with industry. In addition, we also control for the effects of the other two monetary policy factors, forward guidance and LSAP in the baseline specification, equation (B.2), and the positive and negative effects of these additional factors in the sign asymmetry specification, equation (B.3). Moreover, we include four lags of the state unemployment rate interacted with firm size as control variables. Our impulse response functions presented in the results below are constructed using the coefficients $\beta^h_{s,ffr}$ from corresponding regressions.

Using the estimates of equation (B.2), Figure B.3.1 plots the response of employment

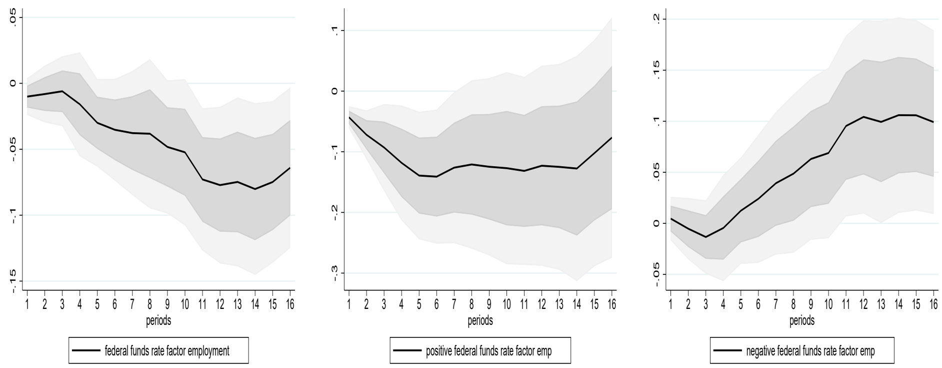

Figure B.3.1: Response of employment growth to a ffr factor shock

Notes: The figure plots the impulse response functions of employment growth to an increase in the ffr factor shock (left panel), positive (contractionary) ffr factor shock (middle panel) and the negative (expansionary) ffr factor shock (right panel). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands respectively.

which has the expected sign, although there is a delayed response. In terms of magnitude, our results are comparable with the existing literature studying employment responses to monetary policy shocks. For example, Bahaj, Foulis, Pinter, and Surico (2022) find that employment falls by 1% after two years as a result of a one standard deviation monetary policy shock.[33] Our empirical results suggest that a positive ffr factor shock decreases employment growth by about 0.54% in the eighth quarter, and over the same period, a standard deviation negative ffr factor shock increases employment growth by 0.82%.

Figure B.3.2 shows that tightening monetary policy decreases hiring growth. However, when looking at the response of hiring to positive and negative ffr factor monetary policy shocks separately (middle and right panels), we see that the contractionary and expansionary policy effects are stronger than what one would expect by examining the left panel where the hiring response is weak. There is again a delayed response to monetary expansions, with hiring growth increasing only after the first five quarters of the shock. In terms of magnitudes, a one standard deviation positive ffr factor shock decreases hiring growth by about 1.04% (0.23×4.53) over the period of 8 quarters, and over the same period a one standard deviation negative ffr factor shock increases hiring growth by 1.48% (0.09×16.44).

[33] Note that in Bahaj, Foulis, Pinter, and Surico (2022) monetary policy shocks are identified through a VAR and their results are for the U.K.

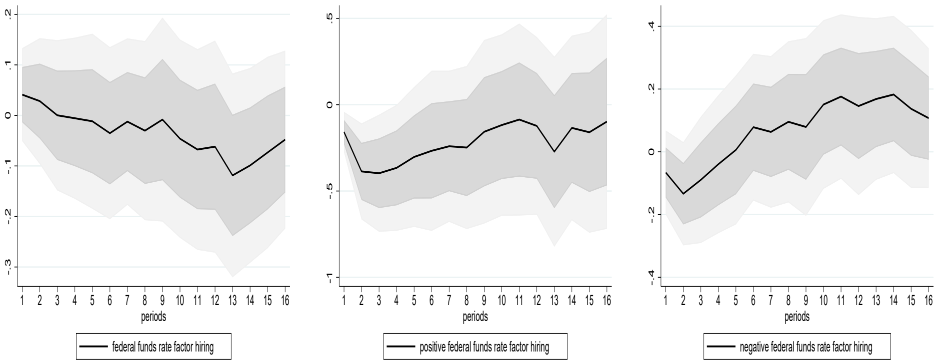

Figure B.3.2: Response of hiring growth to a ffr factor shock

Notes: The figure plots the impulse response functions of hiring growth to a ffr factor shock (left column), positive (contractionary) ffr factor shock (middle column) and the negative (expansionary) ffr factor shock (right column). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

Overall, when we consider sign asymmetries, we observe that a monetary contraction has expected adverse effects on the labor market. However, for monetary expansions, we often see responses that do not suggest, especially in the first periods after the shock hits, this intuition.[34] We note that the length of the sample might not be adequate for making conclusions when using only time variation and splitting the data into positive and negative shocks; exploiting the variation across firm size, as we do in the main text, allows us, beyond the exploration of interesting questions, to estimate with confidence the sign asymmetries.

B.4 Excluding the Great Recession

We plot figures where the sample period excludes the Great Recession; that is, we exclude the period $2008Q1 - 2009Q4$ and we use in our regressions the sample periods $1995Q1 - 2007Q4$ and $2010Q1 - 2019Q2$. Figures B.4.1 and B.4.2 show that, like Figures 3 and 4 in the main text, large firms respond more to a monetary contraction and small firms respond more to a monetary expansion for both employment and hiring growth.

[34] Martellini, Menzio, and Visschers (2021) explore a search theoretic model which after a decrease in the discount rate, the productivity level below which a firm-worker pair finds it optimal to exist increases, suggesting that fewer labor market matches survive. We do not take this modeling approach, but we note here that reasons that might affect the quality of the labor market matches, apart from the unemployment rate that we control for, might be operating after monetary policy shocks, driving the initial labor market response during monetary expansions.

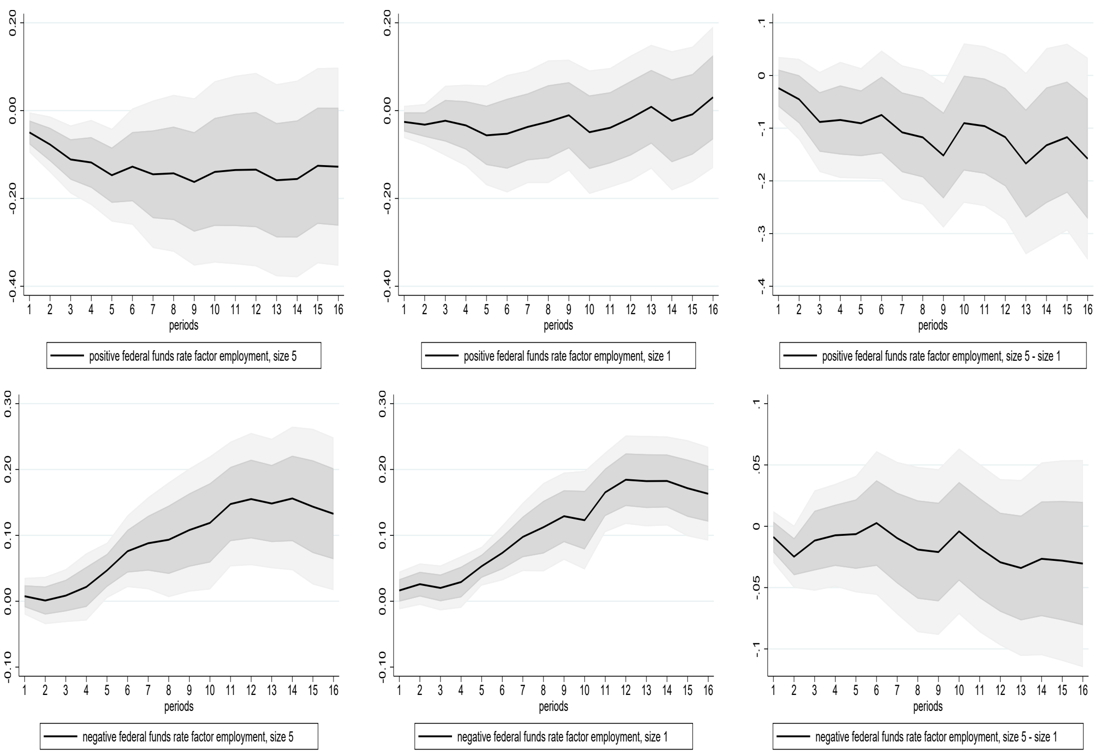

Figure B.4.1: Response of employment growth in small and large firms to a positive and negative ffr factor shock, without GR sample

Notes: The top row plots the impulse response functions for employment growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response functions for employment growth to a negative (expansionary) ffr factor shock for large (size 5—left column) and small (size 1-middle column) firms. The top right panel plots the difference in the response of employment growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The sample does not include the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

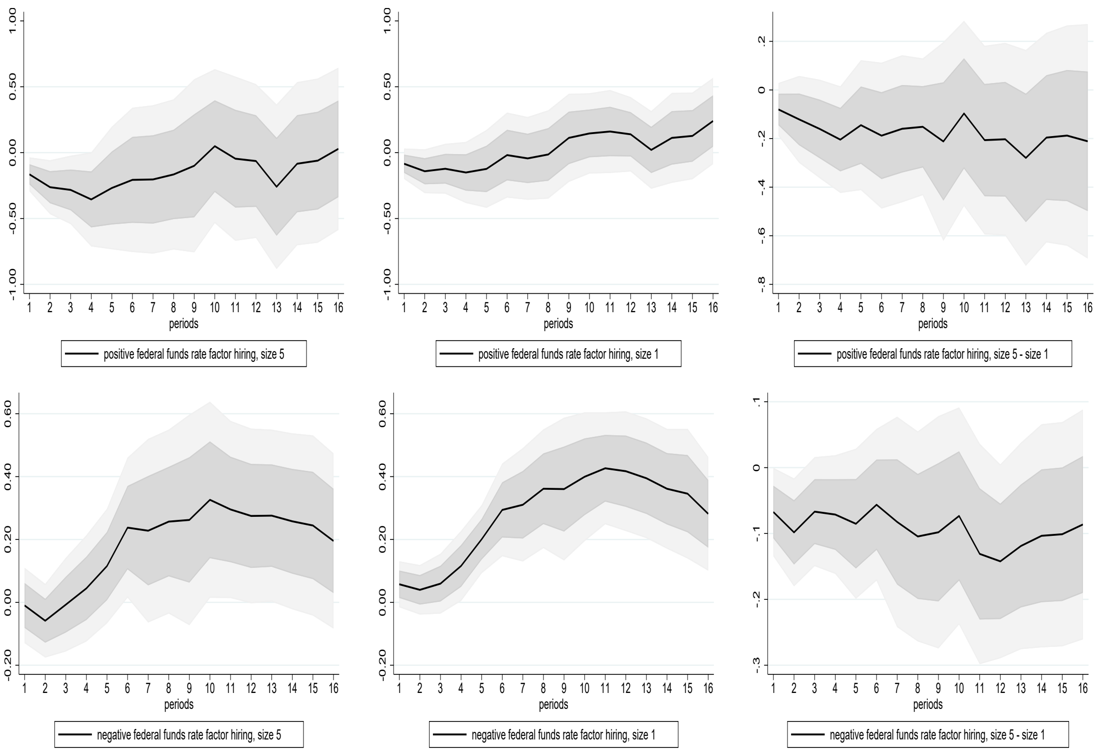

Figure B.4.2: Response of hiring growth in small and large firms to a positive and negative ffr factor shock, without GR sample

The top row plots the impulse response functions for hiring growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response functions for hiring growth to a negative (expansionary) ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of hiring growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The sample does not include the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

When only size differences are taken into account (and not sign asymmetries), we see in Figure B.4.3 that as in Figure 5 where the full sample is considered, small firms react more than large firms to ffr factor monetary policy shocks. This is a consequence of not considering sign asymmetries of ffr factor shocks, as emphasized in the main text for the whole sample, and shown also in Figures B.4.1 and B.4.2, above, for the sample excluding the Great Recession period.

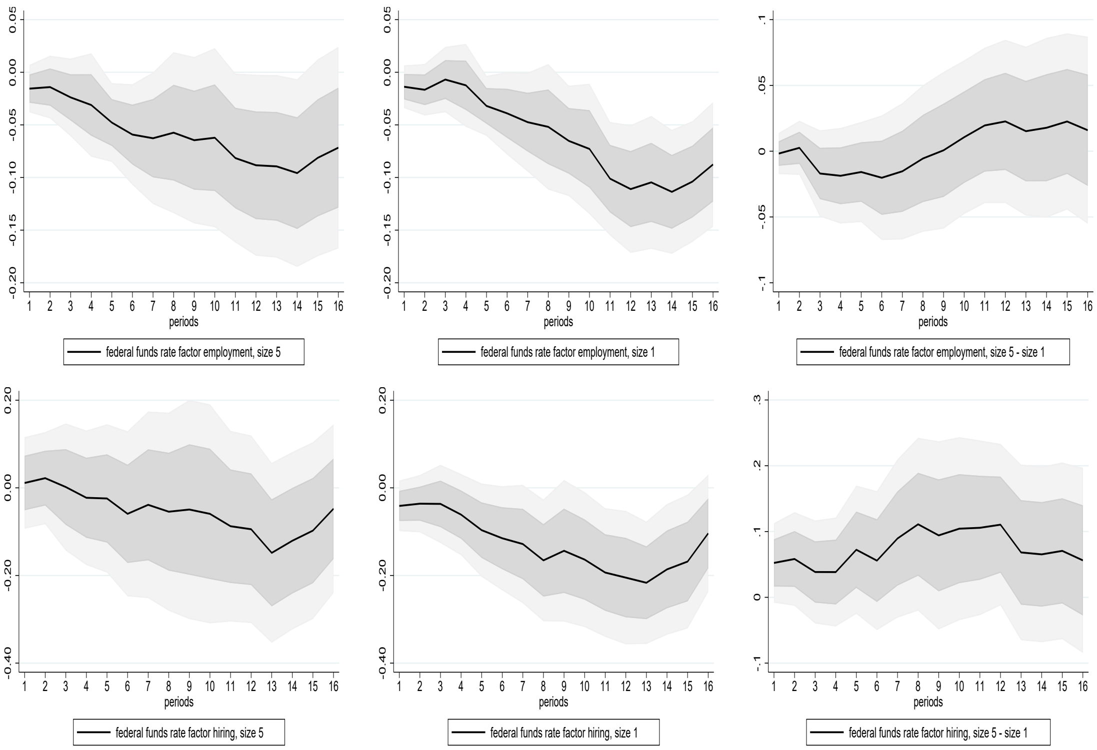

Figure B.4.3: Response of employment and hiring growth of small and large firms to an increase in ffr factor shock, without GR sample

Notes: The top row plots the impulse response functions of employment growth to a ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms, and the difference in the response in large and small firms (right panel). The bottom row plots the equivalent effects for hiring growth. The sample does not include the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

B.5 Redefining small firms

In this section, we present results when we consider a broader definition of small firms than in the main text. We do so as the extensive margin might be more active on very small firms, and we want to verify that our conclusions are not driven purely by that margin. In the figures B.5.1-B.5.2, small firms are defined as firms with a total number of employees of 1-49, instead of 1-19. Our conclusions are unchanged, i.e., employment and hiring growth falls more for large firms compared to small firms during monetary contractions, while employment and hiring growth expands more for small firms compared to large firms during monetary expansions. That is, our conclusions are robust to redefining small firms as larger as in the main text. In addition, when only size differences are taken into account, Figure B.5.3 shows that small firms react more than large firms to ffr factor monetary policy shocks.

B.6 Robustness of average earnings empirical result

In this subsection, we present robustness tests for the results in Section 4.1. Figure B.6.1 presents the Q1-robustness results. The top row shows that while average earnings growth decreases for small firms, it increases for large firms after a monetary contraction making the employee earnings effect even stronger for small firms. For an expansionary shock, bottom row, the results are consistent with our conclusions in Section 4.1.

A comment is in order given that we estimate the effect of monetary policy shocks on earnings during the first quarter, which might have a different impact on the economy compared to monetary policy shocks occurring at a different time in the year.[35] Earlier work by Olivei and Tenreyro (2007) estimated a quarter-dependent VAR and found that monetary policy shocks that occur in the first half of the year have stronger effects on hours and weaker effects on nominal wages than monetary policy shocks that occur in the second half of the year.[36] The Q1-robustness exercise that we implement refers to the number of

[35] As we discussed above, the response of the firms to ffr factor shocks that occur during any quarter, versus shocks occurring in the first quarter, is indeed different for monetary expansions (but not for monetary contractions).

[36] The interpretation that the authors give emphasizes that at periods when wage contracts are renegotiated, during the third and fourth quarters, nominal wages and prices react to monetary policy shocks, and monetary policy is neutral in terms of effects on real variables. On the contrary, during periods when wage contracts are not adjusting, during the first and second quarters, nominal wages and prices do not react to

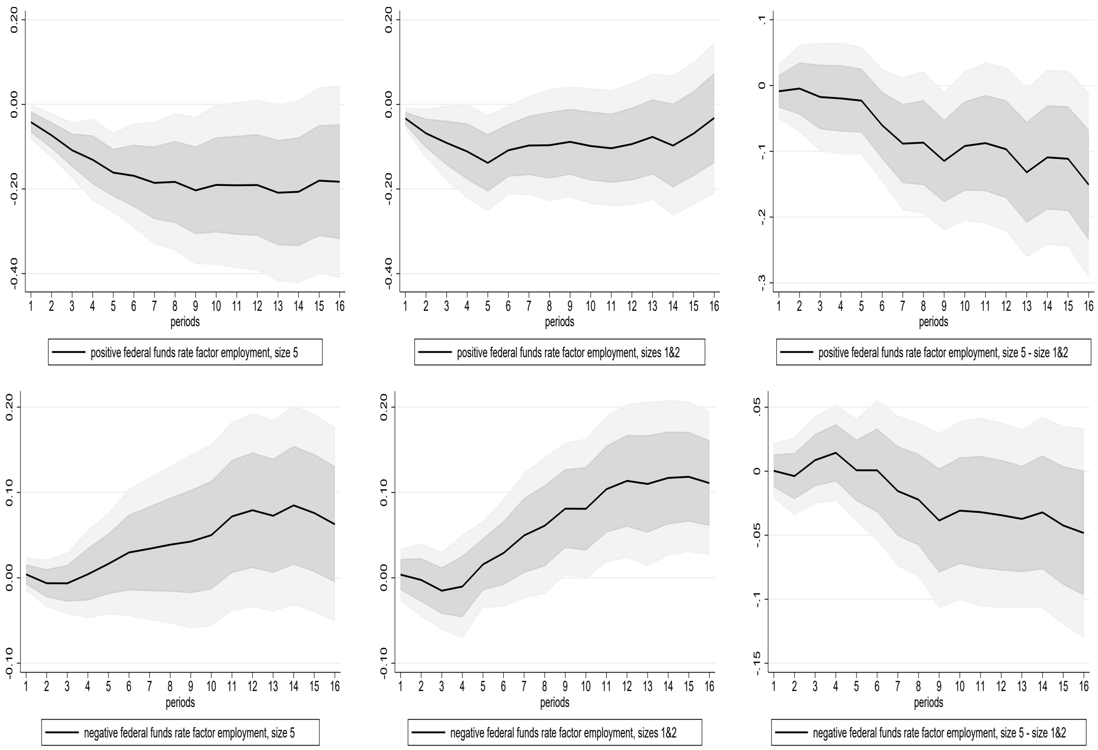

Figure B.5.1: Response of employment growth in small (size 1 and 2 combined) and large firms to a positive and negative ffr factor shock

Notes: The top row plots the impulse response functions for employment growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (sizes 1 and 2 combined—middle column) firms while the bottom row plots the impulse response functions for employment growth to a negative (expansionary) ffr factor shock large (size 5—left column) and small (sizes 1 and 2 combined—middle column) firms. The top right panel plots the difference in the response of employment growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The dark and light-shaded areas depict respectively the 68% and 90% confidence bands. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

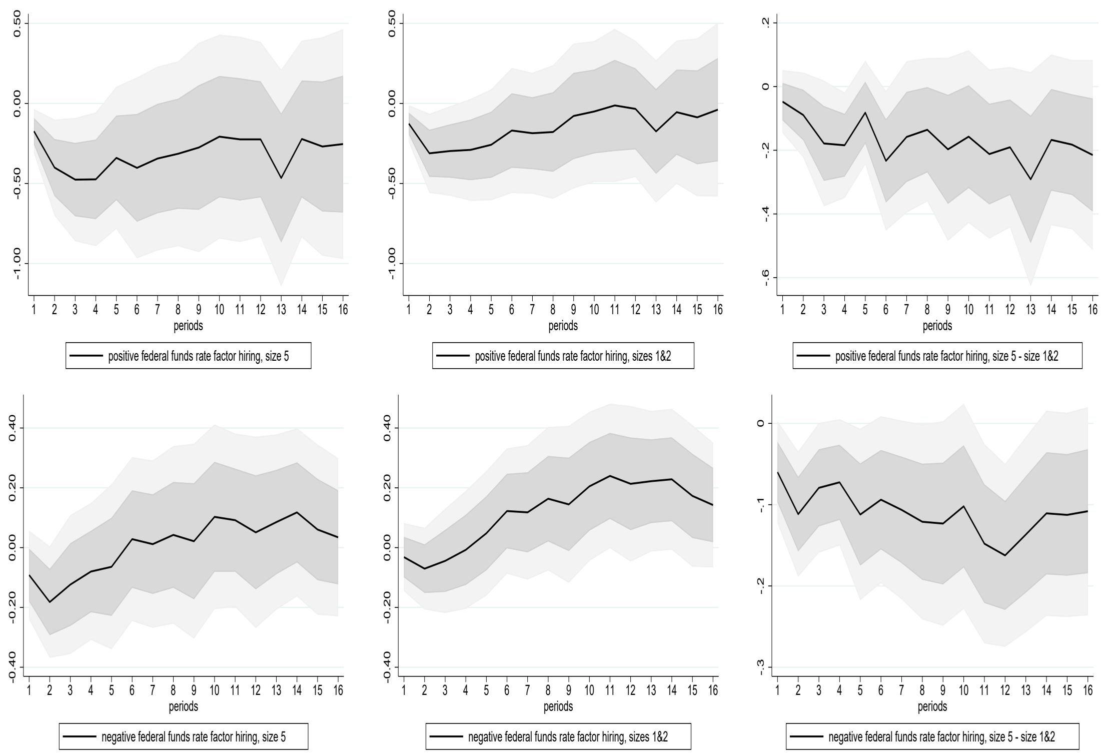

Figure B.5.2: Response of hiring growth in small (size 1 and 2 combined) and large firms to a positive and negative ffr factor shock

The top row plots the impulse response functions for hiring growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (size 1 and 2 combined—middle column) firms while the bottom row plots the impulse response functions for hiring growth to a negative (expansionary) ffr factor shock large (size 5—left column) and small (size 1 and 2 combined—middle column) firms. The top right panel plots the difference in the response of hiring growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

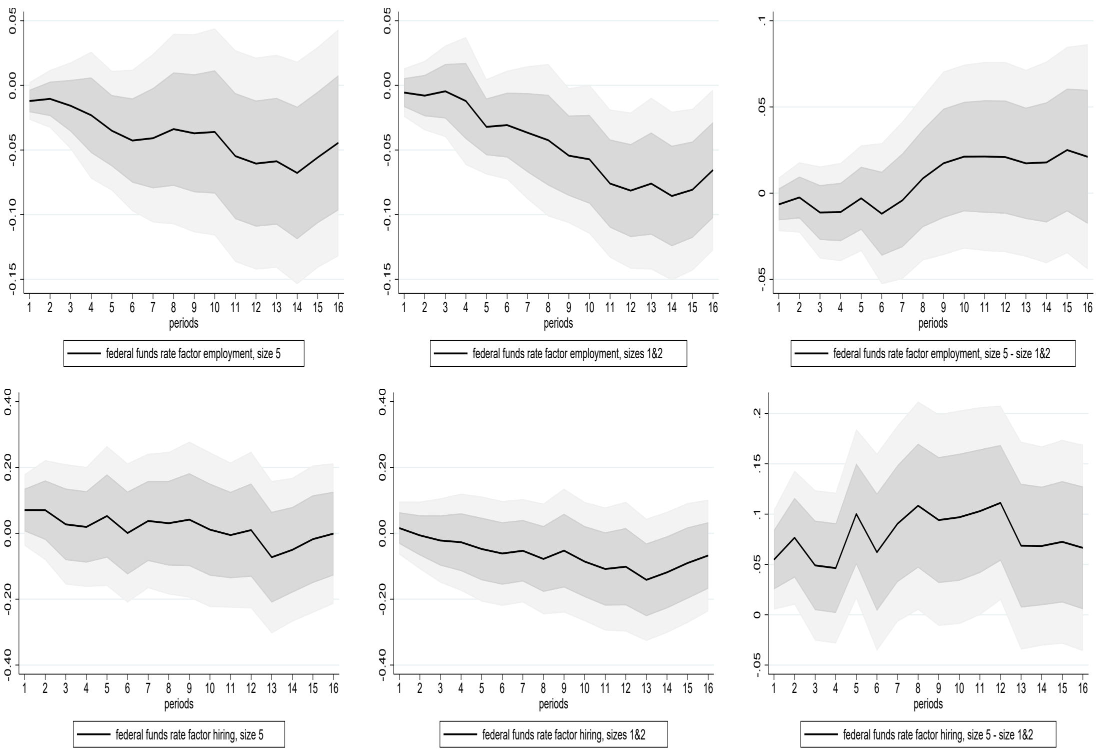

Figure B.5.3: Response of employment and hiring growth of small (size 1 and 2 combined) and large firms to an increase in ffr factor shock, without GR sample

Notes: The top row plots the impulse response functions of employment growth to a ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms, and the difference in the response in large and small firms (right column). The bottom row plots the equivalent effects for hiring growth. The sample does not include the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

hires and the average earnings of those new hires, and not to the total workers employed and their earnings. Given that the negotiations of earnings and hours happen simultaneously for hires and their earnings, our results are not imputed by the uneven staggering of wage contract re-negotiations, that take place with the already employed individuals.

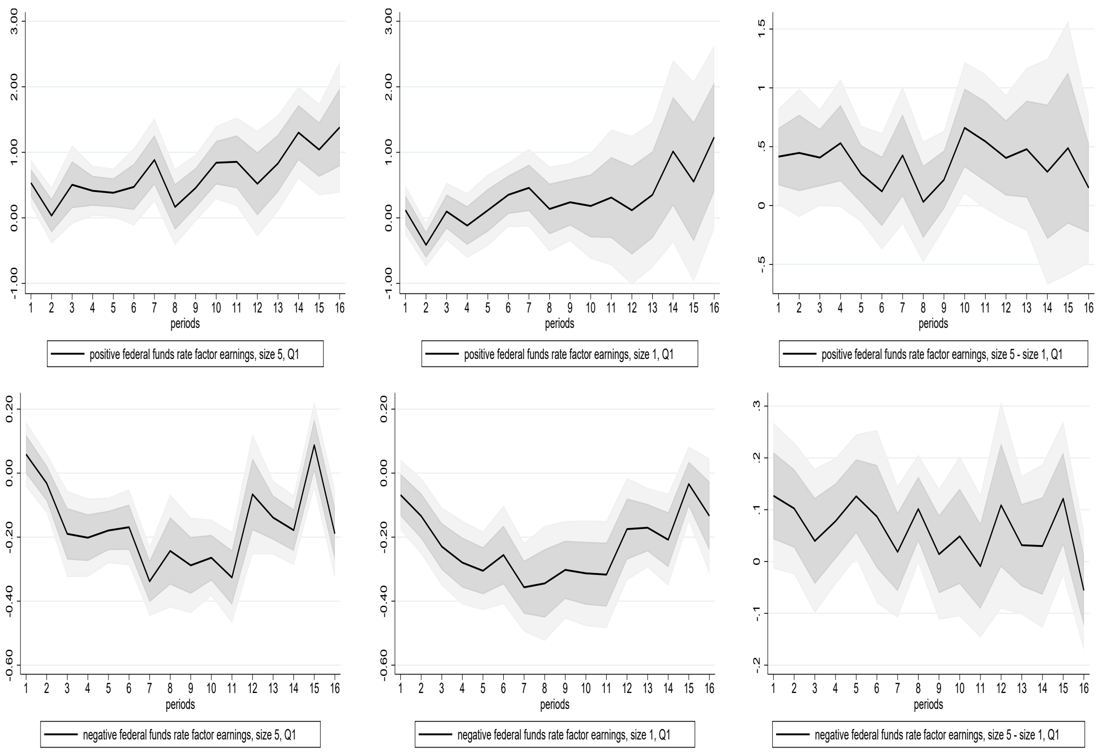

Figure B.6.1: Response of nominal average earnings growth of new hires growth in small and large firms to a ffr factor shock; Q1-robustness

Notes: The top row plots the impulse response functions for average nominal earnings growth to a positive (contractionary) ffr factor shock in Q1 for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response functions for average nominal earnings growth to a negative (expansionary) ffr factor shock in Q1 for large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of average nominal earnings growth in large and small firms to a positive (contractionary) ffr factor shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock in Q1. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

Similarly, excluding the Great Recession period, Figure B.6.2, and redefining small firms, Figure B.6.3, shows that average earnings growth of both types of firms decreases

monetary policy shocks, and monetary policy affects real variables.

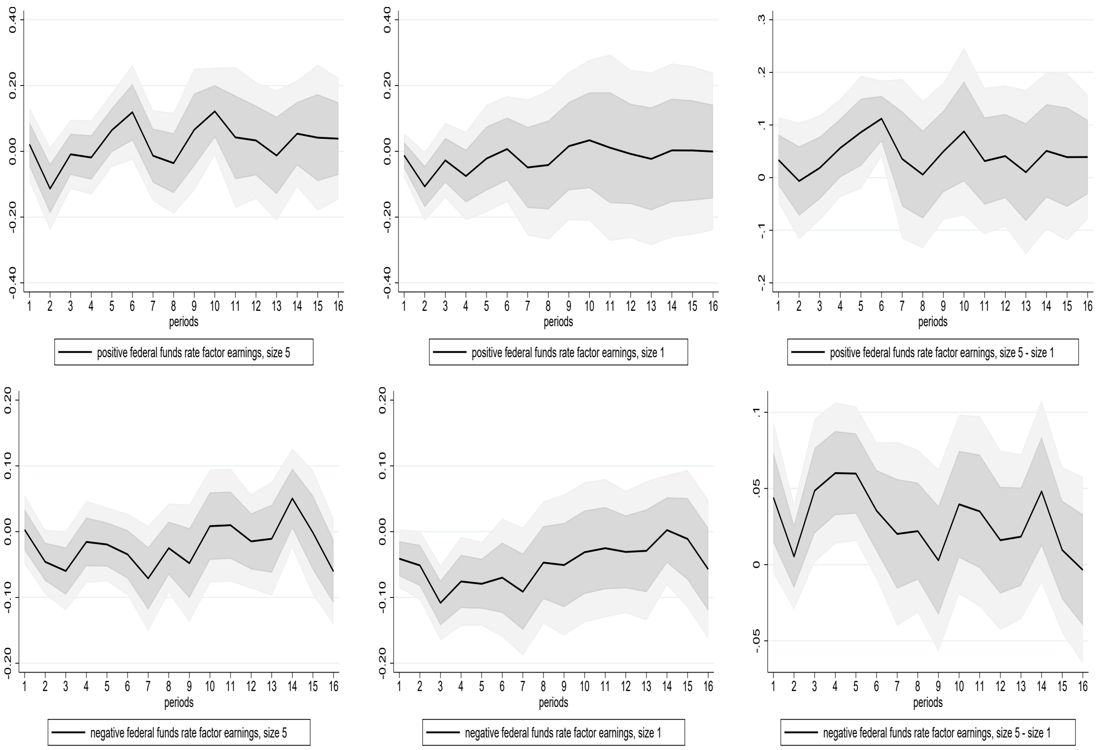

Figure B.6.2: Response of average nominal earnings growth in small and large firms to a positive and negative ffr factor shock, without GR sample

Notes: The top row plots the impulse response functions for average nominal earnings growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (size 1-middle column) firms while the bottom row plots the impulse response functions for average nominal earnings growth to a negative (expansionary) ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of average nominal earnings growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The sample does not include the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

after monetary contractions and after monetary expansions. The difference in the response is stronger for small firms versus large firms, which makes the earnings channel stronger than in the benchmark, homogeneous case.

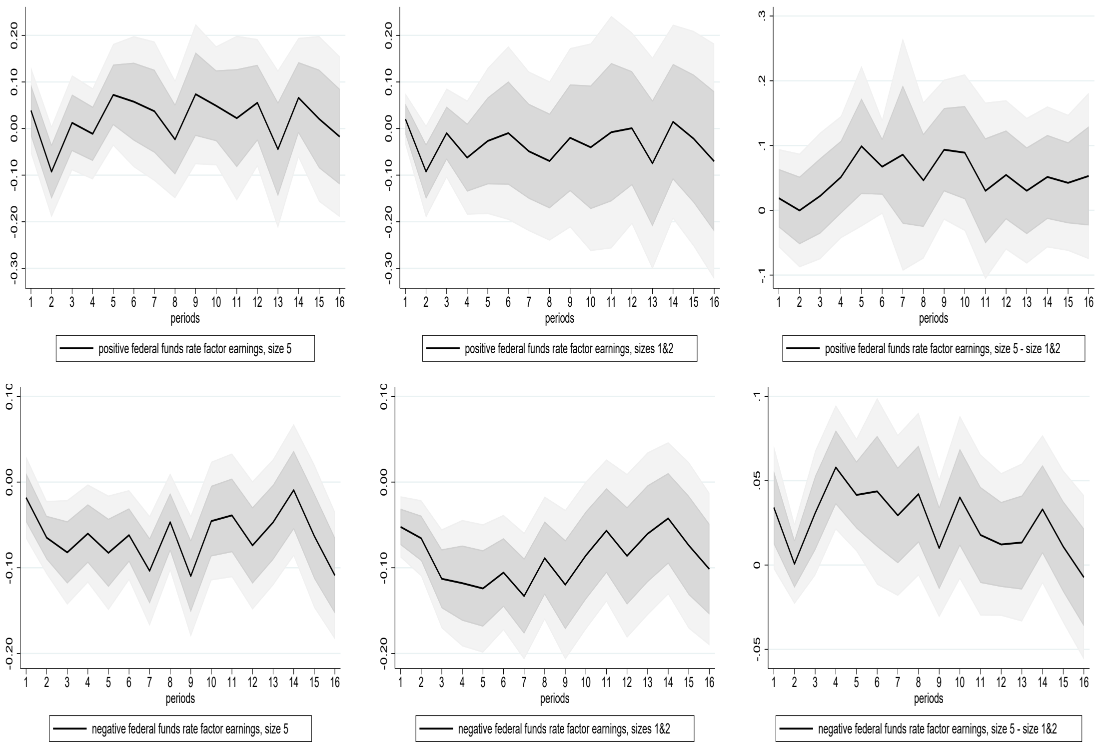

Figure B.6.3: Response of average nominal earnings growth in small (size 1 and 2 combined) and large firms to a positive and negative ffr factor shock

Notes: The top row plots the impulse response functions for average nominal earnings growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (sizes 1 and 2 combined—middle column) firms while the bottom row plots the impulse response functions for average nominal earnings growth to a negative (expansionary) ffr factor shock large (size 5—left column) and small (sizes 1 and 2 combined—middle column) firms. The top right panel plots the difference in the response of average nominal earnings growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The dark and light-shaded areas depict respectively the 68% and 90% confidence bands. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

B.7 Additional results for average earnings

In this subsection, we examine how the results for the growth rate of earnings change when we do not take into account the sign distinction of the monetary policy shock and consider all firms, instead of considering small and large firms separately.

Figure B.7.1 shows how the average nominal earnings growth of new hires in small and large firms responds to an increase in ffr factor shock when the sign of that shock is not taken into account. An increase in the ffr factor shock leads to increases in the earnings paid in all firms, and it does so more in small firms. The p-value for the null hypothesis that the impulse response is zero at each horizon is zero for both small and large firms, implying significant effects of monetary policy on the average earnings of new hires.

We also explore how the ffr factor shocks affect the growth of nominal earnings of new hires for all firms. In the left panel of Figure B.7.2 we see that an increase in the ffr shock increases nominal earnings. However, the middle and the right panels show that after both expansionary and contractionary ffr factor shocks, the growth of earnings of new hires decreases, pointing at expansionary monetary policy as the source of the behavior of average earnings.

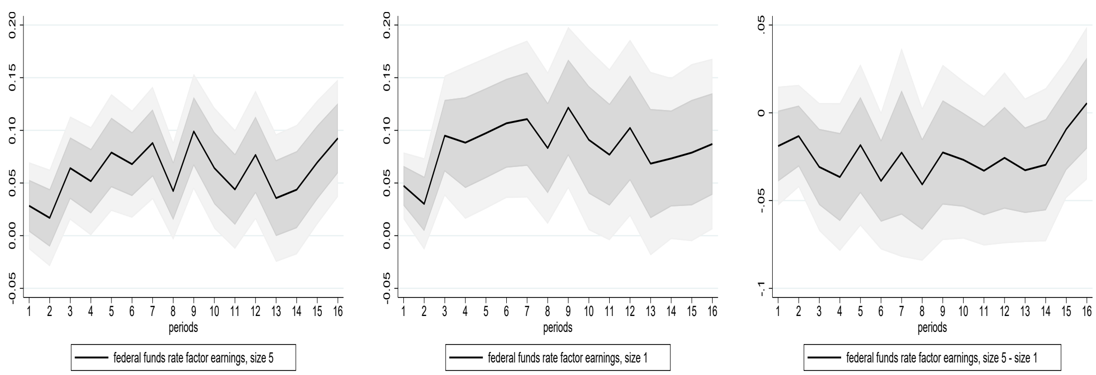

Figure B.7.1: Response of average nominal earnings growth of new hires of small and large firms to a ffr factor shock

Notes: The top row plots the impulse response functions of average nominal earnings growth of new hires to a ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms, and the difference in the response in large and small firms (right column), to a ffr factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

B.8 Average real earnings

In the main text, we report the response of the growth rate of nominal earnings to a ffr shock. Here we report results for the average real earnings of new hires, converted into

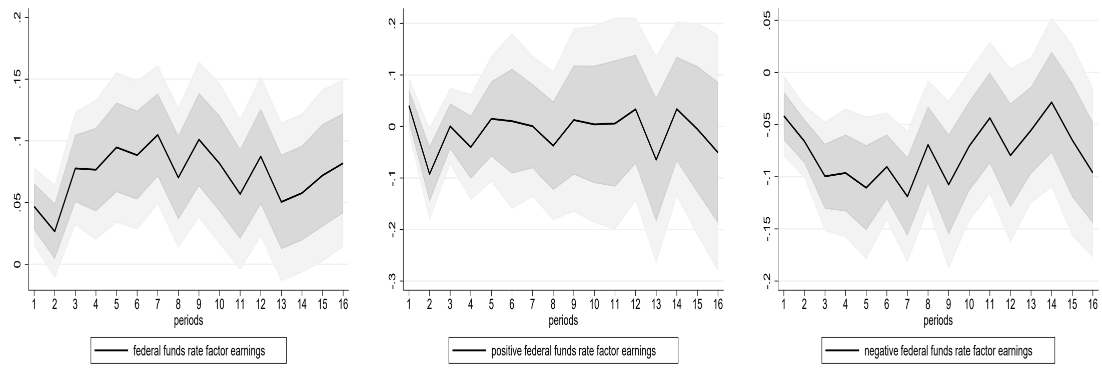

Figure B.7.2: Response of average nominal earnings growth to a ffr factor shock

Notes: The figure plots the impulse response functions of average nominal earnings growth of new hires to a ffr factor shock (left column), positive (contractionary) ffr factor shock (middle column) and the negative (expansionary) ffr factor shock (right column). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

real using the Consumer Price Index (CPI); the response of the price level is reported in Appendix B.1. Our overall conclusions for the average nominal earnings response remain when we examine the real earnings response, although the response of real earnings is at times milder than that of nominal earnings.

Figure B.8.1 show that, as for nominal earnings, the growth of real earnings falls for both large and small firms after both monetary contractions and expansions; the difference is deeper for small firms versus large firms.

In addition, Figure B.8.2 shows that when the sign asymmetry is not taken into account, an increase in the ffr factor shock leads to increases in the average real earnings paid in all firms, and it does so more in small firms.

Figure B.8.3 shows the response of the growth of real earnings of new hires for all firms. Like the nominal earnings in Figure B.7.2, the left panel shows that when the sign is not taken into account, an increase in the ffr shock policy shock increases real earnings. However, the middle and right panels show that after both expansionary and contractionary ffr factor shocks, the growth of earnings of new hires decreases, pointing to monetary expansions as the source of this behavior.

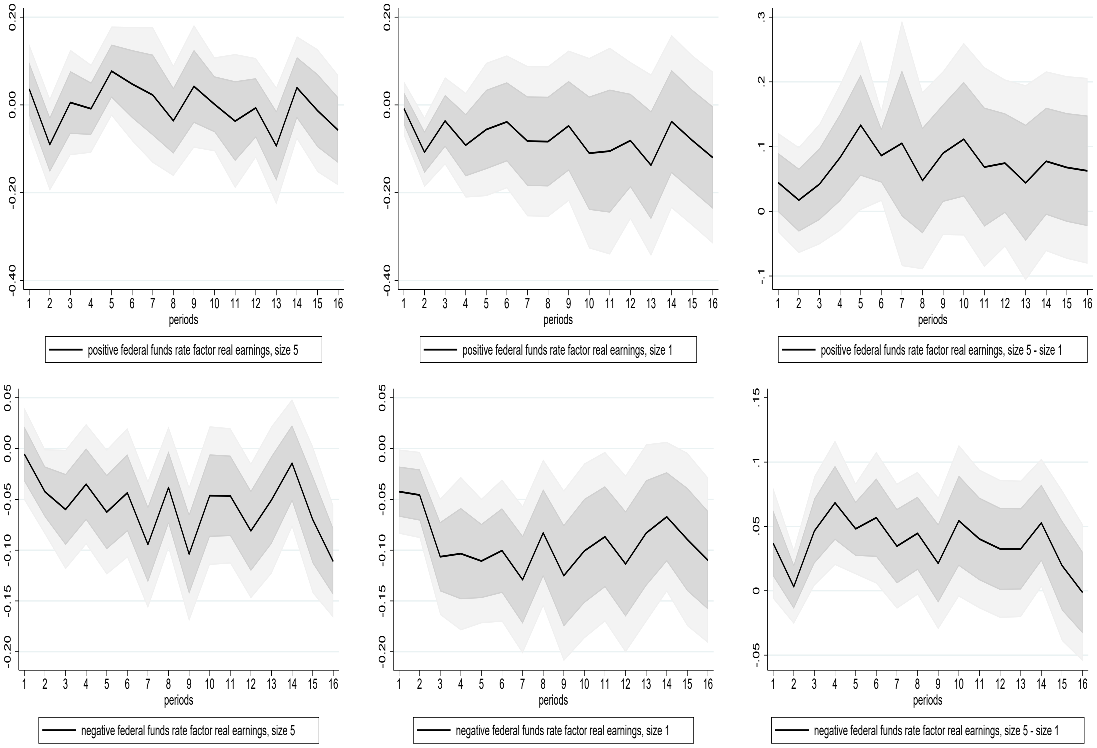

Figure B.8.1: Response of average real earnings growth in small and large firms to a positive and negative ffr factor shock

Notes: The top row plots the impulse response function for average real earnings growth to a positive (contractionary) ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response function for average real earnings growth to a negative (expansionary) ffr factor shock for large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of average real earnings growth in large and small firms to a positive (contractionary) ffr factor shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) ffr factor shock. The sample does not include the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict respectively the 68% and 90% confidence bands.

B.9 State unemployment

In this subsection, we show how the employment growth of large and small firms responds to state unemployment changes. Figure B.9.1 shows the response of employment growth of large (left panel) and small (middle panel) firms using the estimates from equation (1). The figure shows that the employment growth of small firms decreases, while that of large firms decreases even more, after an increase in the state unemployment rate. The difference between large and small firms, shown in the top right panel, is statistically significant,

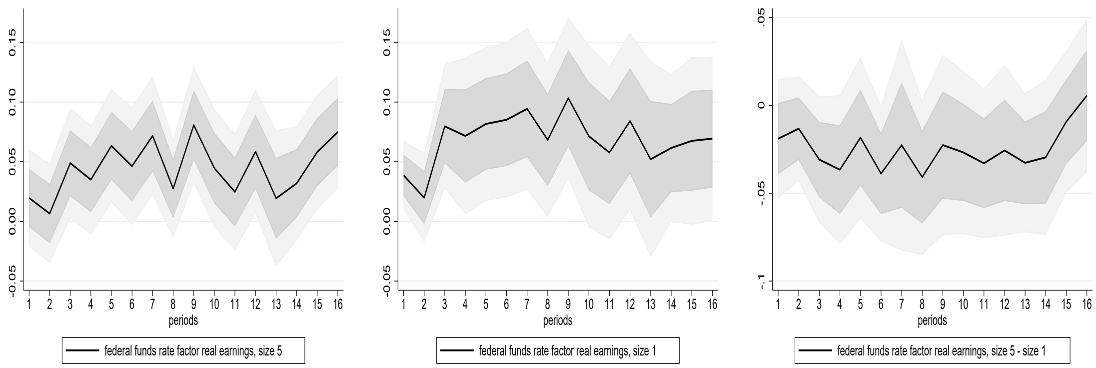

Figure B.8.2: Response of real earnings of new hires growth in small and large firms to a ffr factor shock

Notes: The left panel plots the impulse response function for real earnings of new hires growth to a ffr factor shock for large firms, and the middle panel for small firms. The left panel plots the difference in the response between large and small firms. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands respectively.

consistent with the theory of Moscarini and Postel-Vinay (2013).

We also examine whether these results hold when we exclude monetary policy shocks such that our analysis is similar to that of Moscarini and Postel-Vinay (2012).[37] From Figure B.9.2 we see that the results of Moscarini and Postel-Vinay (2012) survive; that is, the employment growth of large firms responds more to state unemployment changes than that of small firms.

[37]Specifically, the regression is the same as specification (1), but we exclude all the monetary policy shocks and their lags and their interaction with size or industry.

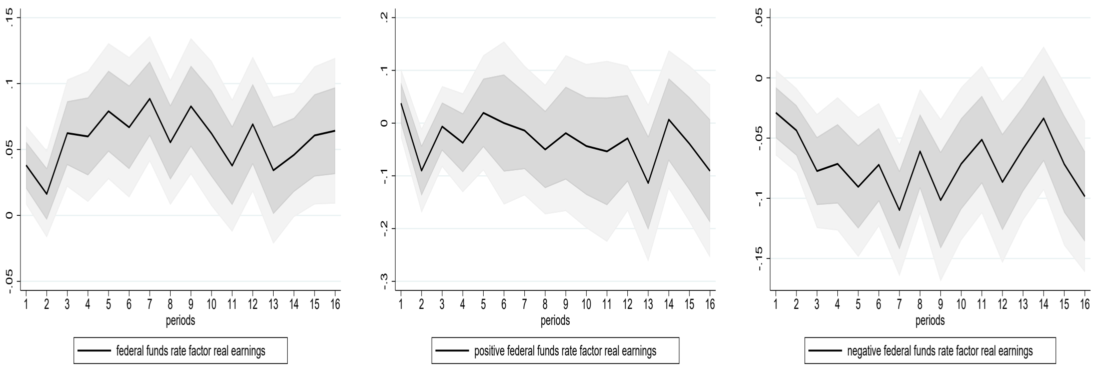

Figure B.8.3: Response of average real earnings growth to a ffr factor shock

Notes: The figure plots the impulse response functions of average real earnings growth of new hires to a ffr factor shock (left panel), positive (contractionary) ffr factor shock (middle panel) and the negative (expansionary) ffr factor shock (right panel). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands respectively.

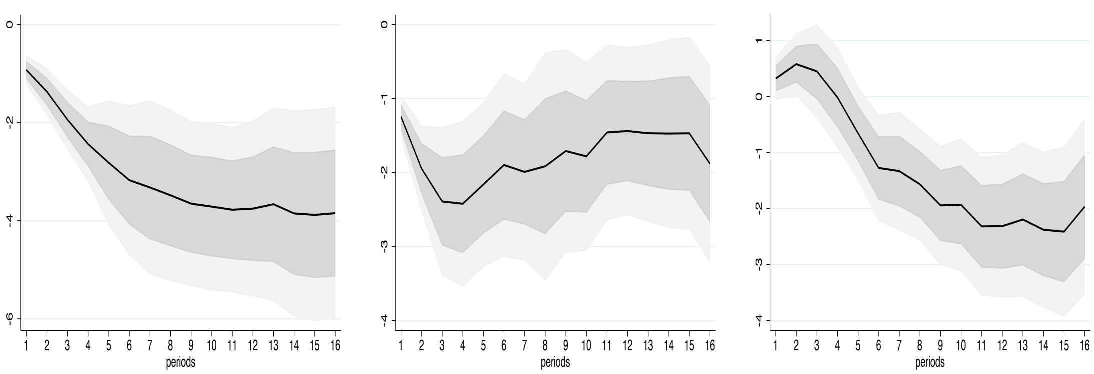

Figure B.9.1: Response of employment growth to state unemployment

Notes: The figure plots the response of employment growth to an increase in state unemployment in large (size 5—left column) and small (size 1—middle column) firms and the difference between them (right column). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.

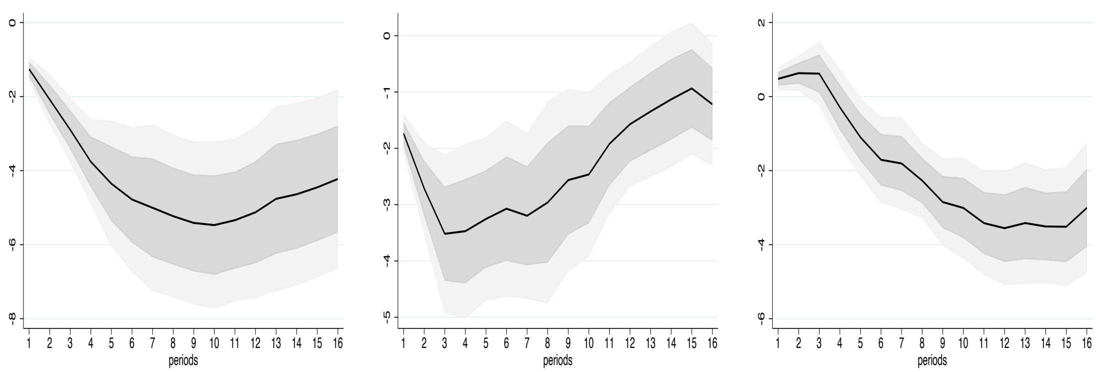

Figure B.9.2: Response of employment growth to state unemployment in the specification without monetary policy shocks (MPV style)

Notes: The figure plots the response of employment growth to an increase in state unemployment in large (size 5—left column) and small (size 1—middle column) firms and the difference between them (right column) when monetary policy shocks are not included in the regression. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a one basis point shock. The dark and light-shaded areas depict the 68% and 90% confidence bands, respectively.