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

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

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Abstract

We study the heterogeneous effects of monetary policy on the labor market of large and small firms in the United States. We uncover the following facts: (i) Expansionary monetary policy boosts employment and hiring growth in small firms more than in large firms; however, a monetary contraction shrinks small firms' employment and hiring growth less than in large firms. As a result, monetary policy has a countervailing effect on the employment concentration in large firms. (ii) There is an asymmetry in the effects of monetary contractions versus expansions with respect to firms' employment and hiring growth. Not accounting for such asymmetry leads to the fallacious conclusion that small firms respond more than large firms to monetary policy shocks. This asymmetry also reveals that contractionary monetary policy shocks have immediate effects on the labor market while the effects of expansionary shocks are slower to manifest. (iii) The response of employment is weaker than that of hiring, highlighting the importance of using labor market flows. (iv) The growth of earnings of new hires decreases similarly across large and small firms in contractions but reacts more for small firms in expansions. We use a heterogeneous firms model with a working capital constraint, an upward-sloping marginal cost curve, and a financial accelerator effect. We augment this model with the *wage effect* summarized in fact (iv) and demonstrate how the additional wage effect can explain the differential response of the hiring and employment growth of small and large firms of fact (i).

JEL classification: $D22$, $E24$, $E52$, $J23$, $L25$

Keywords: Heterogeneous firms, financing constraints, labor market, monetary policy

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[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 Austin; zervoua@gmail.com.

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1 Introduction

The Federal Reserve is operating under a mandate from Congress that includes promoting "effectively the goals of maximum employment ....". Underlying this mandate is the premise that monetary policy affects employment. This paper examines the effects of monetary policy shocks on the hiring, employment, and earnings of new hires across U.S. firms that differ in size. We provide new empirical evidence showing that monetary policy effects depend on the size of the firm and the direction of the monetary policy shock.

Studying the effect of monetary policy on the employment dynamics of small and large firms is important for a number of reasons. First, recent literature finds weak evidence of monetary policy influence on aggregate variables (see Ramey, 2016). By exploring more disaggregated data and worker flows in heterogeneous firms we re-examine the effects of monetary policy on the labor market and we find them strong; the earlier found weak affects are due to aggregation. Second, studying the effects of monetary policy on heterogeneous firms is central to emphasizing the channels of monetary policy transmission. This approach has been widely adopted by the related literature which 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 an upward trend in the share of workers employed in large firms (firms with more than 500 employees), and a downward trend in the share of workers employed in small firms (firms with less than 20 employees) in the U.S. as seen in Figure 1.[1] The relative employment by firm size has been in the forefront of policy discussions, frequently resulting in policy enactment.[2] 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; Haltiwanger, Jarmin, and Miranda, 2013, Chodorow-Reich,

[1] The trend is similar when we calculate the share of workers in large and small firms using our dataset, the Quarterly Workforce Indicators, shown in Figure A.2.1 in the Data Appendix A.2.

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

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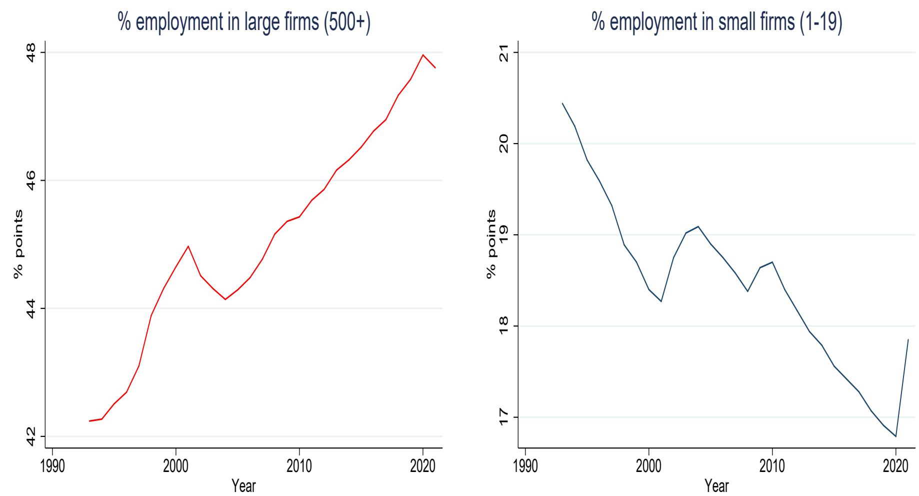

Figure 1: Employment concentration in large and small firms

Notes: The figure plots the time series of the fraction (in % points) of employment in large (more than 500 employees) and small firms (1-19 employees) in the U.S., using the Bureau of Labor Statistics annual data from 1994-2021.

2014), although there is less research on the relative employment response of small versus large firms to monetary policy shocks. Our paper highlights that both the sign of monetary policy shocks and the size of firms affected by those shocks, are important dimensions to consider when examining how monetary policy impacts the U.S. labor market.

We uncover the following novel facts. (i) A surprise monetary contraction decreases hiring and employment growth in all firms, but it does so more for larger firms. On the contrary, a surprise monetary expansion increases the hiring and employment growth of all firms, but it does so more for smaller firms. This striking heterogeneity in the response reveals that monetary policy mitigates the recent data trends of employment concentration in large U.S. firms as shown in Figure 1. (ii) There is a direction asymmetry in the effects of monetary policy on the labor market. Ignoring this asymmetry leads to the misleading conclusion that small firms respond more than large firms to monetary policy shocks in terms of employment and hiring growth. In addition, exploring this 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

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flows in understanding the effects of monetary policy on the labor market. (iv) Monetary policy also affects average employees' earnings. A surprise monetary contraction decreases the growth in earnings of new hires and the magnitude of the drop is similar across small and large firms. In addition, a surprise monetary expansion decreases the growth in earnings of new hires too, and the decline is more pronounced for small firms compared to large firms. That is, monetary policy introduces variations in employees' earnings, affecting the firms' cost of hiring.

Given that financing constraints impact the transmission of monetary policy, we use a model of heterogeneous firms that features a working capital constraint and a spread that small firms pay for financing their labor input. Our model emphasizes how wage changes can affect the firms' employment decisions differently across size categories, introducing a *wage effect* channel of heterogeneous responses. We use the model to show how the additional wage effect can interpret our first empirical result that the hiring and employment of small firms respond more in expansions, although that of large firms responds more in contractions.

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. In our model, there are three channels through which the employment response to a monetary policy shock of financially constrained firms might differ from that of unconstrained firms. The first channel relies on the financial accelerator mechanism (Bernanke, Gertler, and Gilchrist, 1999) which in the presence of working capital constraints causes the employment of constrained firms to react more to a monetary policy shock compared to unconstrained firms. The second channel involves the upward-sloping marginal cost curve, where the curve is flatter for unconstrained firms compared to constrained firms (Ottonello and Winberry, 2020). Due to the lower cost of borrowing, unconstrained firms are able to borrow more and hire workers at a lower cost than constrained firms, making unconstrained firms more responsive compared to constrained firms. These two opposing mechanisms through which monetary policy affects investment (Ottonello and Winberry, 2020) and employment (Bahaj, Foulis, Pinter, and Surico, 2022) have been previously emphasized in the literature.

Our theoretical contribution is the introduction of a third channel through which the

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response of employment to a monetary policy shock could be different across large and small firms. Given our empirical results on the response of earnings of new hires to a monetary policy shock (fact iv), we incorporate in the theoretical model the additional *wage effect* channel. To understand the role of this channel, consider a homogeneous decrease in wages following a monetary contraction resulting in both constrained and unconstrained firms needing to borrow less to finance employment. Although the decrease in wages is homogeneous across firms, the responses of employment and hiring are not, as constrained firms pay a spread on the amount that they borrow. The new wage effect channel suggests that hiring and employment in constrained firms tend to decrease less following monetary policy contractions, as seen in our empirical findings (fact i). After monetary expansions, our empirical work finds heterogeneous wage effects across small and large firms, with a decline that is deeper for small firms versus large firms. Incorporating this heterogeneity, the additional wage effect channel implies lower costs for financing employment in small firms, and leads to our empirical finding that small firms respond more than large ones to expansionary monetary policy shocks (fact i).

In our empirical analysis, we use the publicly available Quarterly Workforce Indicators (QWI) dataset from the Census (2020) and employ the local projections method to compute impulse responses of labor market variables to high-frequency monetary policy shocks. The QWI dataset includes all private (non-federal) employers that are covered by unemployment insurance in the U.S., aggregated by state, industry, and firm size. Apart from data on employment, the dataset includes information on hiring and earnings of new hires, helping us examine aspects of the labor market that are potentially masked when analyzing employment alone.[3,4]

To identify the monetary policy shocks we use high-frequency Federal Funds futures contracts data. The Federal Funds rate target announcements are also accompanied by

[3]Aggregate employment features worker flows that exhibit cyclical behavior. For example, Krusell, Mukoyama, Rogerson, and Şahin (2017) find procyclical behavior for transitions from unemployment to nonparticipation even when the participation rate is procyclical. In order to examine these flows and their responses to changes in policy, we use data on hiring.

[4]Coibion (2012) finds that monetary policy shocks can account for a large share of unemployment rate fluctuations, motivating further the study of the effect of monetary policy on labor variables. Braun, De Bock, and DiCecio (2007) find that labor market flows like the job finding rate, can account for the observed changes in the stock variables after monetary policy shocks. By examining additional flows, White (2018) finds that monetary policy impacts job loss which in turn determines how employment and unemployment respond to monetary policy shocks.

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statements containing information about the central bank's beliefs about the future course of the economy and information about its future actions. To disentangle the two pieces of information, we use data from Campbell, Evans, Fisher, Justiniano, Calomiris, and Woodford (2012), who apply Gürkaynak, Sack, and Swanson (2005)'s methodology to more recent years, and identify "target" monetary policy shocks separately from "path" shocks. In our analysis, we use the target shocks, which correlate with short-term movements in asset prices, and are immune to the forward guidance and information effects of monetary policy.[5] We estimate the effects of the target monetary policy shocks on employment variables using Jordà, Schularick, and Taylor (2015)'s panel application of Jordà (2005)'s local projection method. In our analysis, we examine the response of labor market variables to both contractionary (positive) and expansionary (negative) target monetary policy shocks and we take into account that these responses could be different for small and large firms.

Our empirical results are robust to variations in the definition of small firms, the exclusion of the Great Recession period from the sample, and the control of the reclassification bias. In our empirical analysis, reclassification bias might arise because given constant size cutoffs in the QWI data, firms could change size bins and be re-classified over time and as economic conditions evolve. Thus, when studying the dynamic monetary policy effects on firms of a certain size, it is possible that the size of some firms changes over the response period.[6] To tackle this issue we utilize the fact that size is reported once per year, during the first quarter, and firms stay in the same size bin for the rest of the calendar year.[7] Therefore, we examine the effects of monetary policy shocks that occur only in the first quarter of each calendar year and focus on the 3-periods IRFs. This novel exercise allows us to accurately measure and compare responses of firms that differ in size, accounting for the reclassification bias in the QWI dataset; we call this exercise Q1-robustness.[8]

[5]Gürkaynak, Sack, and Swanson (2005) discuss the forward guidance effect and Romer and Romer (2000) and Nakamura and Steinsson (2018) describe the information effect.

[6]For a detailed discussion of the reclassification bias see Moscarini and Postel-Vinay (2012).

[7]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. If for example, a firm with 19 employees expands, 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.

[8]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

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Related literature.

The empirical analysis in our paper relates to an older but recently revived literature that explores the sensitivity of heterogeneous firms to macroeconomic shocks over the cycle. A strand of this literature has focused on the effects of monetary policy on the investment and sales of heterogeneous firms, like the work of 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) among others. Another strand has examined employment responses to other variables, but not with respect to monetary policy shocks, like the work of Sharpe (1994), Davis and Haltiwanger (1999), Moscarini and Postel-Vinay (2012), Fort, Haltiwanger, Jarmin, and Miranda (2013), Haltiwanger, Jarmin, and Miranda (2013). Our paper stands at the intersection of these two strands of the literature by examining the effects of monetary policy on employment among heterogeneous firms.

The first strand of the literature mentioned above explores the monetary transmission mechanism. Gertler and Gilchrist (1994), based on earlier findings that small firms face tighter financing constraints (e.g. Fazzari, Hubbard, and Petersen, 1988), show in their paper that after tight money episodes, sales and inventories of small (in terms of assets) firms are more responsive than those of larger firms; their work emphasizes the credit channel and the financial accelerator mechanism of Bernanke, Gertler, and Gilchrist (1999). We follow this literature by using size as a proxy of financing constraints in our model. Recent research by Jeenas (2019), Cloyne, Ferreira, Froemel, and Surico (2021) and Ottonello and Winberry (2020) explores the strength of the investment channel. Like those papers, we also explore the effects of monetary policy shocks on heterogeneous firms and emphasize the role of financing frictions; however, our focus is on the labor market.

The second strand of the literature that we contribute to explores the cyclicality of employment margins of heterogeneous firms. Focusing on size heterogeneity, as we do, 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

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.

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results are supported by theoretical work (Moscarini and Postel-Vinay, 2013) based on labor market frictions, where firms' size proxies for firms' productivity. Our work contributes to this literature by studying the differential response of employment dynamics of large and small firms to monetary policy shocks.[9] Additionally, we contribute to this literature through our Q1-robustness analysis which provides an alternative way of addressing the reclassification bias in the QWI dataset.

A related recent literature studies employment concentration (e.g., Hopenhayn, Neira, and Singhania, 2022 and Karahan, Pugsley, and Şahin, 2022 study the 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). Focusing on firms' size, our findings suggest 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 1.

The first paper to examine empirically the effects of monetary policy shocks on the employment of heterogeneous firms is that of Bahaj, Foulis, Pinter, and Surico (2022). In their seminal work, 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 that of older firms'. Similar results are found by Yu (2021), using U.S. data, who also emphasizes housing collateral constraints. 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 work emphasizes sign asymmetries of the monetary policy shocks, employment flows, and an additional transmission mechanism based on the wage effect, all of which have not been studied previously in the literature.

The paper is organized as follows. Section 2 describes the data and empirical methodology used in our analysis. Section 3 presents the empirical results. A model consistent with those results is described in Section 4. Finally, Section 5 concludes.

[9] 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.

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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 cross-sectional dimension of our panel is specified by the triplet "state-industry-size." In the QWI states started reporting data at different points in time which makes the dataset unbalanced. For example, in 1990 only four states are in the sample. Data on additional states are 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 1995:1-2014:1. We exclude Agriculture, Forestry, Fishing and Hunting, Public Administration, Finance and Insurance, and Real Estate (FIRE), and Rental and Leasing. 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 $115,310$ observations ($N \times T$) with $1,530$ unique state-industry-size observations.

In our analysis, we focus on the behavior of the number of hires, employment, and the average monthly earnings of newly hired employees. In the QWI dataset, these variables are *HirA*, *EmpEnd*, *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

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

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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 monthly earnings of newly hired employees, allows us to measure the current wage rate that is not related to previous wage contracts and negotiations. The data are seasonally adjusted using X-12-ARIMA method developed 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 variables considered in our empirical analysis, and these differences are significantly different for the employment and earnings of new hires.[11] In the case of hiring this difference is not only quantitative but also qualitative: in our sample, hiring growth has increased in large firms but decreased in small firms.

Our analysis exploits the differences across firms' sizes while controlling for industry and geography.[12] Figures A.4.1 and A.4.2 in Appendix A.4 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 2, 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 Kuttner (2001)'s type high-frequency federal funds futures contracts' data, with a short window. The monetary policy shock is the adjusted difference of the federal funds' futures rate shortly after to shortly before the rate announcement and captures new information. In particular, our baseline specification employs a 60-minute time window, starting 15 minutes before and ending 45 minutes after

[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 and find large differences across the durable the service sectors.

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Table 1: Summary statistics of labor market variables

Variables (growth rates, in percent)		All firms	Small (size 1) firms	Large (size 5) firms
Hiring	mean	−0.86	−1.32	0.09
	median	0.61	−0.78	1.48
	st. dev.	20.78	20.45	33.10
Employment	mean	1.08	0.68	1.86
	median	1.46	0.75	1.78
	st. dev.	6.05	11.15	12.05
Earning of new hires	mean	3.31	2.81	3.38
	median	3.32	2.79	3.42
	st. dev.	11.73	20.95	17.67

Notes: The table reports mean, median, and the standard deviation (st. dev.) of the annual growth rates of hiring, employment, and the earnings of new hires in all firms, small firms, and large firms from 1995:1-2014:1.

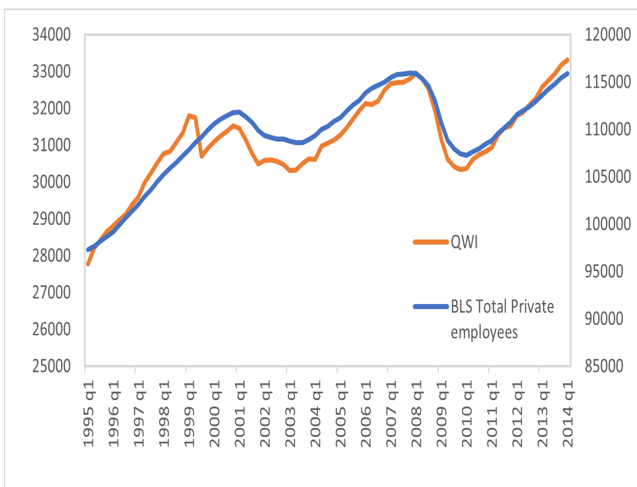

Figure 2: Employment from QWI

Notes: The figure plots employment from QWI 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).

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the announcement. Following Wong (2019) we construct a quarterly measure by adding the shocks that occur within a quarter.[13]

Gürkaynak, Sack, and Swanson (2005) point out that at the time of a policy 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 by the central bank future path of the economy.[14] In addition, economic participants might believe that the Federal Reserve has superior information, i.e., there is Fed information effect, as described by Romer and Romer (2000) and Nakamura and Steinsson (2018). For those reasons, we focus on the short-run effect of changes on the federal funds target rate surprises. Specifically, we use the "target" shocks of Campbell, Evans, Fisher, Justiniano, Calomiris, and Woodford (2012) data, who extend Gürkaynak, Sack, and Swanson (2005) and include later time period.[15] Figure B.1.1 in Appendix B.1 shows that the effects of the target shocks in aggregate macroeconomic variables have the expected effects, i.e., an increase in the target shock decreases real GDP and employment growth, and increases unemployment.

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 target monetary policy shocks. In our Q1-robustness exercise, 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 the study of the asymmetric response of labor market variables to monetary policy.

[13]We thank Arlene Wong for providing her monthly shocks series. Wong (2019) uses Gorodnichenko and Weber (2016) futures information for the period 1996-2007 and Gürkaynak, Sack, and Swanson (2005) for the period before 1994. The series includes scheduled and inter-meeting announcements. We exclude the information of the first trading day after September 11, 2001, because of the possible noise that the terrorist attack created.

[14]This component is present in the central bank communication even before the introduction of *forward guidance*.

[15]We thank Alejandro Justiniano for providing his event-study shocks series for that paper, and the extended version of it. We aggregated the series in order to construct quarterly measures.

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Table 2: Summary statistics of monetary policy shocks

	MP shocks	Target shocks
Overall		
Mean	-3.20	-0.67
Standard deviation	10.14	12.74
Positive (rate increase)		
Mean	1.02	3.53
Standard deviation	2.56	4.53
Negative (rate decrease)		
Mean	-4.22	-4.21
Standard deviation	9.37	10.57

Notes: The table reports mean and standard deviation (in basis points) of the high frequency monetary policy (MP) shocks for the period 1995:1-2014:1. It also reports the same statistics for target shocks, positive and negative target shocks.

Table 2 reports the summary statistics of the high frequency monetary policy (MP) shocks and target shocks, as well as the positive and negative MP shocks and target shocks. What is striking is that the standard deviation of the negative monetary policy shock is approximately 3 times larger than the positive shock; moreover, the standard deviation of the negative target shock is more than double relative to the positive one. This can also be seen from Figure 3, which plots these shocks. Given that 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. Appendix A provides additional details about the data used in our analysis.

2.2 Empirical framework

To measure the impact of high-frequency monetary policy shocks on the labor market we employ the local projection method of Jordà, Schularick, and Taylor (2015) who extend Jordà (2005) and introduce local projections impulse response to the panel data. In our analysis, the dependent variables are cumulative growth rates of hiring, employment, and earnings of new hires. The equations below specify our baseline empirical specification, equation (1), and specifications that considers sign asymmetry, equation (2) and sign asymmetry and size heterogeneity, equation (3).

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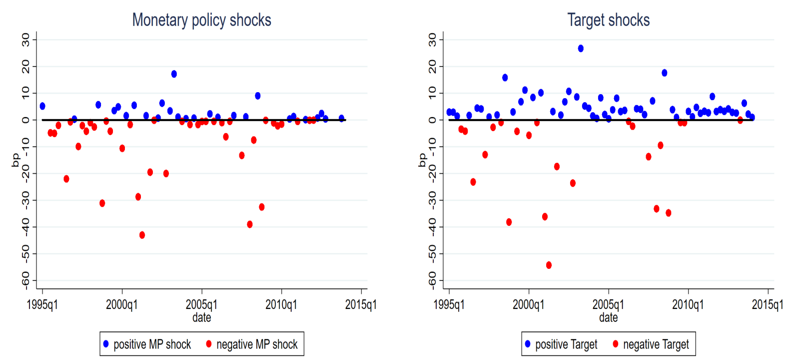

Figure 3: Positive and negative monetary policy shocks

Notes: The figure plots the positive (blue) and negative (red) high frequency monetary policy shocks (left panel) and target shocks (right panel).

Baseline specification:

$$\Delta_h n_{gis,t+h} = \alpha^h_{gis} + \beta^h_{Target}\epsilon^{Target}_t + \beta^h_{Path}\epsilon^{Path}_t + \delta^h_i \epsilon^{Target}_t \mathbb{I}_i + \Gamma^{h\prime} Z_t + u^h_{gis,t+h} \tag{1}$$

Sign asymmetry:

$$\begin{aligned}\Delta_h n_{gis,t+h} =& \alpha^h_{gis} + \beta^h_{Target+}\epsilon^{Target+}_t + \beta^h_{Target-}\epsilon^{Target-}_t \\ &+ \beta^h_{Path+}\epsilon^{Path+}_t + \beta^h_{Path-}\epsilon^{Path-}_t + \delta^h_{i+}\epsilon^{Target+}_t \mathbb{I}_i + \delta^h_{i-}\epsilon^{Target-}_t \mathbb{I}_i + \Gamma^{h\prime} Z_t + u^h_{gis,t+h}.\end{aligned} \tag{2}$$

Sign asymmetry and size heterogeneity:

$$\begin{aligned}\Delta_h n_{gis,t+h} =& \alpha^h_{gis} + \beta^h_{s,Target+}\epsilon^{Target+}_t \mathbb{I}_s + \beta^h_{s,Target-}\epsilon^{Target-}_t \mathbb{I}_s \\ &+ \beta^h_{s,Path+}\epsilon^{Path+}_t \mathbb{I}_s + \beta^h_{s,Path-}\epsilon^{Path-}_t \mathbb{I}_s + \delta^h_{i+}\epsilon^{Target+}_t \mathbb{I}_i + \delta^h_{i-}\epsilon^{Target-}_t \mathbb{I}_i + \Gamma^{h\prime} Z_t + u^h_{gis,t+h}\end{aligned} \tag{3}$$

In the above equations, $\Delta_h n_{gis,t+h} \equiv \log N_{gis,t+h} - \log N_{gis,t}$ 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. The coefficients of interest are β^h_{Target} in the baseline specification, $\beta^h_{s,Target+}$ and $\beta^h_{s,Target-}$ in the sign asymmetry specification and $\beta^h_{s,Target+}$ and $\beta^h_{s,Target-}$ interacted with firm size in the sign asymmetry and size heterogeneity specification, where $\mathbb{I}_s$ in equation (3) is a size-specific indicator variable.

In our specifications we control for state-industry-size specific fixed effects, α^h_{gis}. The

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differential effects of monetary policy across industries are captured by industry-shock interactions, $\epsilon_t^{Target}\mathbb{I}_i$, where $\mathbb{I}_i$ is the industry indicator. As control variables in Z_t we include the current federal funds rate and its four lags as well as contemporaneous and four lags of the state unemployment rate. We also include the state unemployment rate interacted with firm size as a control variable. The reason we do so is that 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 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.[16] 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. Figure B.2.1 in Appendix B.2 plots those results. We also find, and show in Figure B.2.2 in Appendix B.2, that in a specification that excludes monetary policy shocks and resembles that of Moscarini and Postel-Vinay (2012), 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).

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. Our impulse response functions presented in the results Section 3 below, are constructed using the coefficients $\beta^h_{s,Target}$ from corresponding regressions.

3 Empirical results

In this section, we present results for the effects of monetary policy shocks on the growth of hiring, employment, and earnings of new hires. As discussed in Section 2.1, we examine the response of labor market variables to target monetary policy shocks. Given the evidence

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

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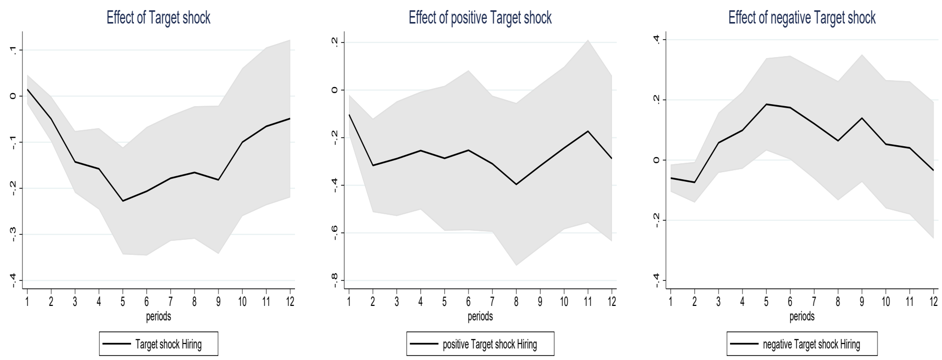

Figure 4: Response of hiring growth to a target shock

Notes: The figure plots the impulse response functions of hiring growth to a target shock (left panel), positive (contractionary) target shock (middle panel) and the negative (expansionary) target shock (right panel). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

presented in Section 2.1 on the differences across the negative and positive target shocks (Table 2), we examine the effects of contractionary and expansionary target shocks on the labor market separately. We also test the null hypothesis that the impulse response is zero for each horizon.

Our first set of results highlights the effects of target shocks on the labor market variables, distinguishing between monetary tightening and expansion. Our second set of results shed light on the transmission of monetary policy: the response to contractionary and expansionary target shocks differ across firms of different sizes. Finally, we check the robustness of our findings.

3.1 Effects of positive and negative target shocks

Using the estimates of equation (1), Figure 4 shows that a monetary policy tightening (an increase in target shock, shown in the left panel) decreases hiring growth. Furthermore, when estimating equation (2) and looking at the response of hiring to positive and negative target monetary policy shocks (middle and right panels), we also see that the contractionary and expansionary policy effect is what one would expect. A positive target shock decreases hiring growth while a negative target shock increases hiring growth. However, there is a delayed response to monetary expansions, with hiring growth increasing only after the first

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Figure 5: Response of employment growth to a target shock

Notes: The figure plots the impulse response functions of employment growth to a target shock (left panel), positive (contractionary) target shock (middle panel) and the negative (expansionary) target shock (right panel). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands

three quarters.

Given that the standard deviation of the positive target shock differs from that of a negative target shock, to interpret the magnitude of the impulse response functions we need to appropriately adjust the responses. With such adjustment, our results imply that a one standard deviation positive target shock decreases hiring growth by about 1.7% (0.38×4.53) over the period of 8 quarters, two years after the shock, and over the same period a one standard deviation negative target shock increases hiring growth by 0.95% (0.09×10.57). Note that in this calculation 0.38 and 0.09 are the cumulative changes in the eighth quarter to positive and negative shocks respectively, while 4.53 and 10.57 are the standard deviations of the positive and negative shocks measured in basis points as reported in Table 2.

Figure 5 shows that the response of employment has the expected sign, although there is also a delayed response after an expansionary target shock.[17] In terms of magnitude, our results are comparable with the existing literature studying employment responses. 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.[18] Our empirical

[17]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, Jaimovich and Siu, 2020, Berger, 2018).

[18]Note that in Bahaj, Foulis, Pinter, and Surico (2022) monetary policy shocks are identified through a

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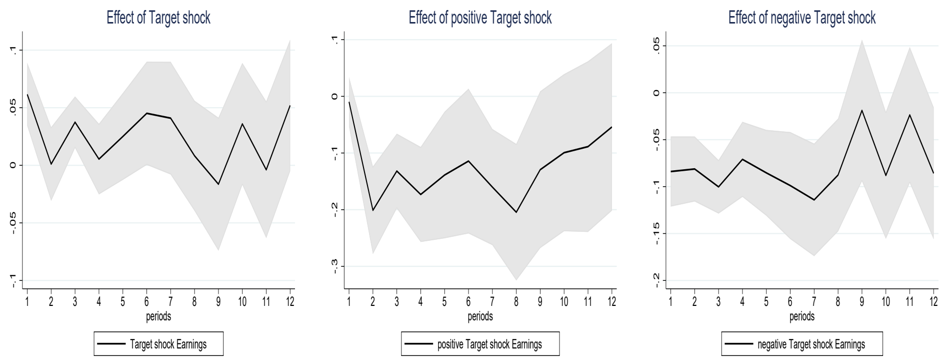

Figure 6: Response of nominal earnings growth to a target shock

Notes: The figure plots the impulse response functions of nominal earnings growth of new hires to a target shock (left panel), positive (contractionary) target shock (middle panel) and the negative (expansionary) target shock (right panel). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

results suggest that a positive target shock decreases employment growth by about 0.61% in the eighth quarter; and over the same period, a standard deviation negative target shock increases employment growth by 1.1%.

Figure 6 shows the response of the growth of earnings of new hires. The right panel shows that when the sign is not taken into account, a contractionary policy shock does little to affect earnings. However, the middle and right panels show that after both expansionary and contractionary target shocks, the growth of earnings of new hires decreases.

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.[19] We note that the length of the sample might not be adequate for making conclusions; exploiting the variation across firm size, as we do in the next subsection, allows us to estimate with confidence the sign asymmetries.

VAR and their results are for the U.K.

[19] 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.

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3.2 Response of small and large firms

In this subsection, we study the response of small and large firms to positive and negative target monetary policy shocks, estimating equation (3), and an equivalent specification that considers target shocks without taking into account sign asymmetries.

Hiring

We first investigate the effects of target shocks on the hiring growth of large and small firms, without considering possible shock sign asymmetries. Looking across firm size, the top row of Figure 7 shows that the hiring growth of small and large firms drops after a target shock. Small firm hiring growth drops faster than that of large firms, and the cumulative difference across size classes is significant. After eight quarters, small firms decrease hiring growth 2.3% more than large firms following a one standard deviation target shock (this is 0.18×12.72, where 0.18 is the difference in responses and 12.72 is the standard deviation of the target shock, as shown in Table 2). The p-value for the null hypothesis that the impulse response is zero at each horizon is zero for small firms and 0.57 for large firms. As such, without considering sign asymmetries, our conclusion would be that small firms react more than large firms to monetary policy shocks.[20] Similar conclusions have been reached in the literature, starting with the seminal work of Gertler and Gilchrist (1994), who examined sales and inventories after monetary policy shocks.

However, we arrive at different conclusions when we consider sign asymmetries. Our empirical results in Figure 8 show that contractionary target shocks (top row) impact small firms less relative to large firms, and expansionary target shocks (bottom row) impact small firms more relative to large firms. In particular, small firms decrease hiring growth less in response to a contractionary monetary policy shock and increase hiring growth more in response to an expansionary monetary policy shock than large firms. The p-value for the null hypothesis that the impulse response is zero at each horizon after a contractionary shock is 0.166 for small firms, and 0.007 for large firms, showing that a monetary contraction has truly significant effects on 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 0.012 for small firms and 0.738 for large firms, showing that small firms are the ones that benefit

[20]We make those conclusions too when comparing the employment growth response across small and large firms as seen in the the middle column of Figure 7.

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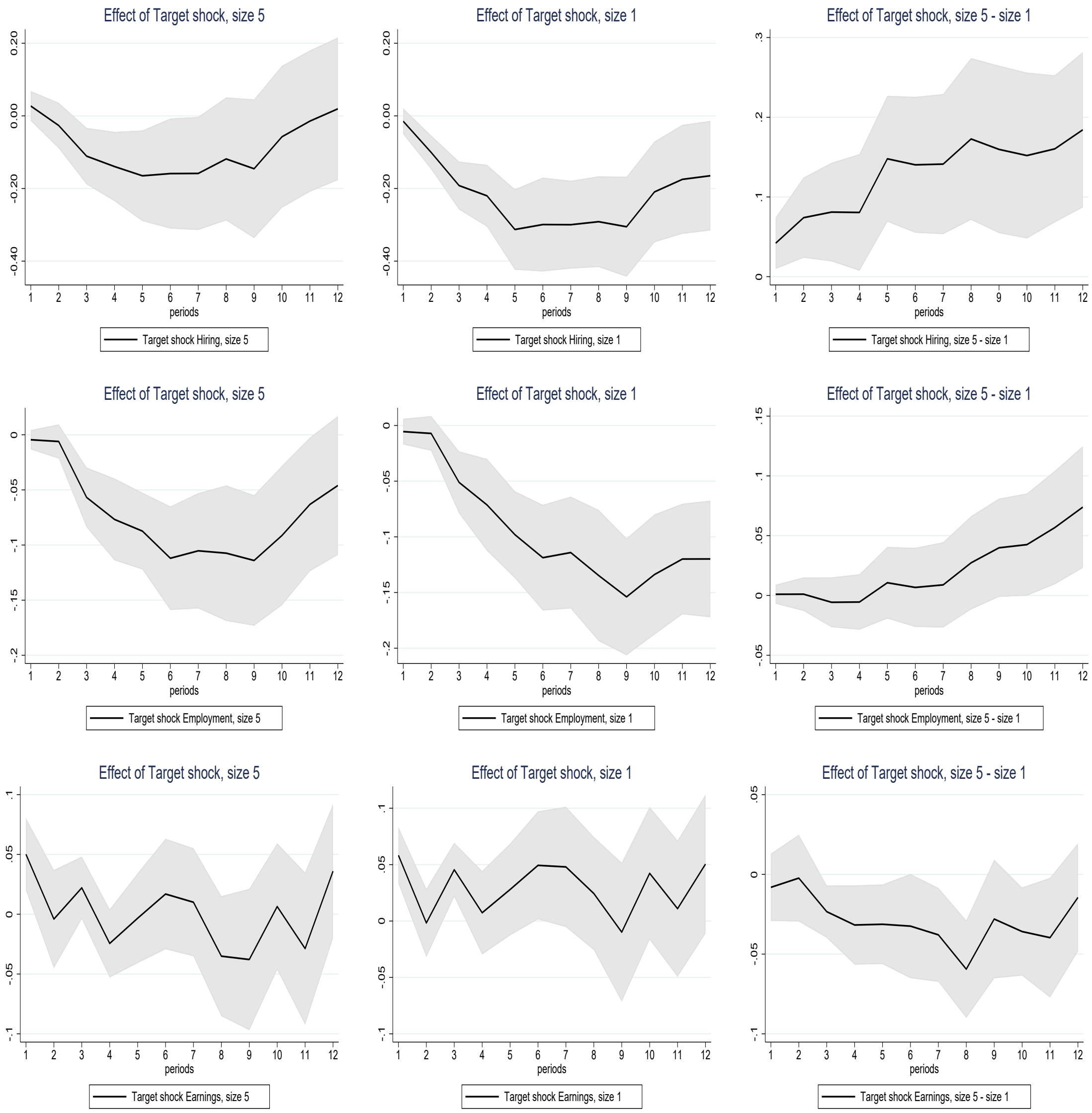

Figure 7: Response of hiring, employment and average nominal earnings growth of small and large firms to a target shock

Notes: The top row plots the impulse response function to a target shock for large firms (left panel), small firms (middle panel), and the difference in the response in large and small firms (right panel), to a target shock. The middle and bottom rows show the equivalent effects for employment growth and growth in average nominal earnings, respectively. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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most during monetary expansions.

Here again, the response of the firms to an expansionary shock is delayed relative to their response to a contractionary shock. In the right panel of Figure 8, where the differences in responses between large and small firms are shown, after a positive/contractionary target shock, having the line below zero means that large firms tighten more than small firms. Similarly, for a negative/expansionary target shock, having the line below zero means that large firms expand less than small firms.

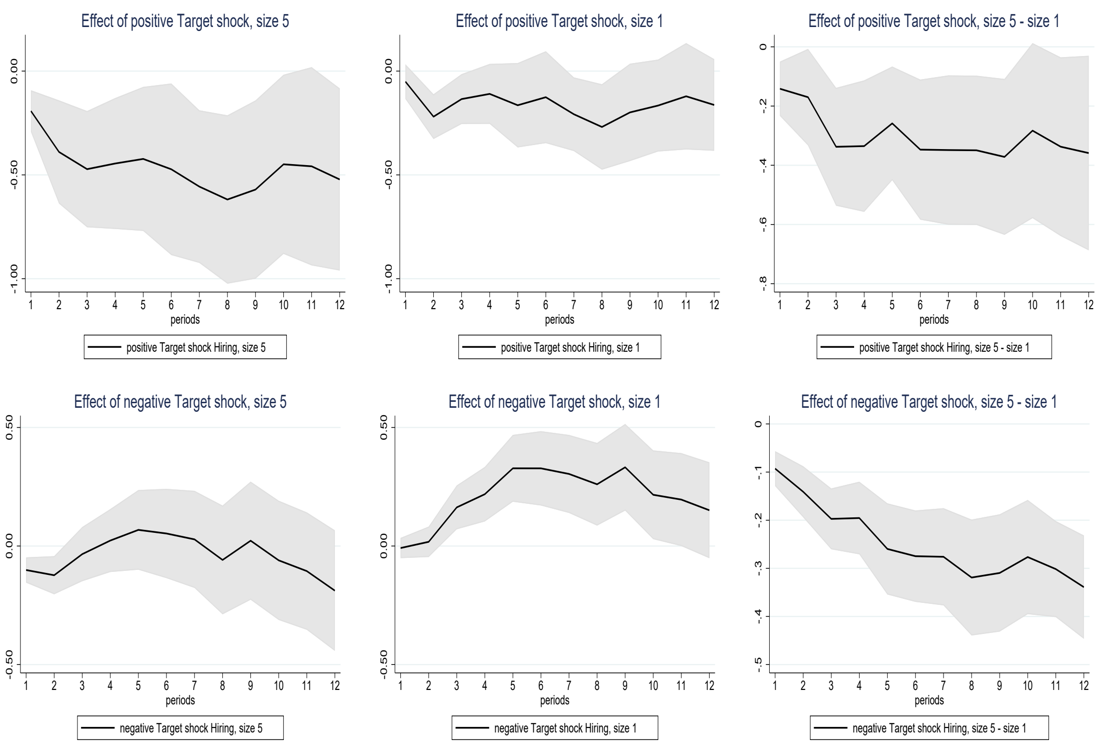

Figure 8: Response of hiring growth in small and large firms to a positive and negative target shock

The top row plots the impulse response function for hiring growth to a positive (contractionary) target shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response function for hiring growth to a negative (expansionary) target 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) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

As before, taking into account the differences in standard deviations among positive and negative shocks as seen in Table 2, we find that a standard deviation positive shock

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decreases the hiring growth of large firms by 3% (0.66×4.53) and of small firms by 1.1% (0.25×4.53) after eight quarters. Hence the fall in hiring growth in large firms is more than two and a half times more than the small firms. The decrease in the hiring growth of large firms is always significant, and the difference in the responses is also significant. For a standard deviation negative shock, hiring growth in small firms increases by 3.3% (0.31×10.57) and in large firms decreases by 0.85% (0.08×10.57) in the eighth quarter. The increase in the hiring growth of small firms is always significant, and the difference in the responses is also significant.

Our results suggest that after taking into account the target shock sign and firm size asymmetries, small firms drop hiring growth less compared to large firms in response to a monetary contraction; they increase hiring growth more than large firms after a monetary expansion. The difference in responses across firms is strong and significant for both contractions and expansion.

Employment

We analyze the response of employment growth and find that our conclusions of impulse and response asymmetry for hiring, hold in this case as well. Figure 9 presents the response of large (left column) and small firms (middle column), and the difference in the responses of the two (right column). As we see in Figure 9, a monetary policy tightening (top row) decreases employment growth, and it does so less for small firms than for large firms. The p-value for the null hypothesis that the impulse response is zero at each horizon is 0.913 for small firms, and zero for large firms. Moreover, a monetary policy loosening (bottom row) increases employment growth and it does so more for small firms. The p-value for the null hypothesis that the impulse response is zero at each horizon is zero for small firms, and 0.006 for large firms. Also, we find that for employment as well, the response of the firms to an expansionary shock is delayed relative to their response to a contractionary shock.

Looking at the magnitude of the effects, we find that a standard deviation positive shock decreases the employment growth of large firms by about 1.0% (0.21×4.53), and of small firms by 0.4% (0.09×4.52) in the eighth quarter; that is, large firms respond almost two and half times more than small firms after monetary contractions. A standard deviation

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negative shock increases employment growth of large firms by 0.6% (0.06×10.57), and of small firms by 1.4% (0.13×10.57) in the eighth quarter; that is, small firms respond almost two and half times more than large firms after monetary expansions.

Taken together, our empirical results suggest that in fact large firms are more responsive to a contractionary target shock while small firms are more responsive to an expansionary shock. Our results also show that employment responds weakly, compared to hiring, to monetary policy target shocks. That is, looking at the effect of monetary policy on employment growth 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.

Earnings of new hires

One advantage of using the QWI dataset is that it reports both employment and average earnings of those employed. The bottom row of Figure 7 shows how the nominal average earnings growth of new hires in small and large firms responds to monetary policy target shocks.[21] From there we see that a target shock does not have significant effects on the earnings paid in large firms; the growth of earnings paid by small firms increases and this rise is significant during the earlier quarters. The p-value for the null hypothesis that the impulse response if zero at each horizon is 0.90 for large firms and 0.38 for small firms, implying limited effects of monetary policy on average earnings.

Figure 10 shows the changes in the earnings of new hires when both the size of the firms and the sign of the shock are taken into account. In the left and middle panels, we see that average earnings growth decreases after a monetary policy tightening (positive target shock—top row) and decreases after a monetary expansion (negative target shock—bottom row) for both types of firms. The p-value for the null hypothesis that the impulse response if zero at each horizon is 0.013 for small firms and zero for the large ones after a monetary contraction; those p-values are zero for small firms and 0.016 for large firms, after a monetary expansion. That is, our results are strongly significant.

For the positive target shock, the responses are of similar magnitude across small and

[21] In Appendix B.7 we also report results for real average earnings.

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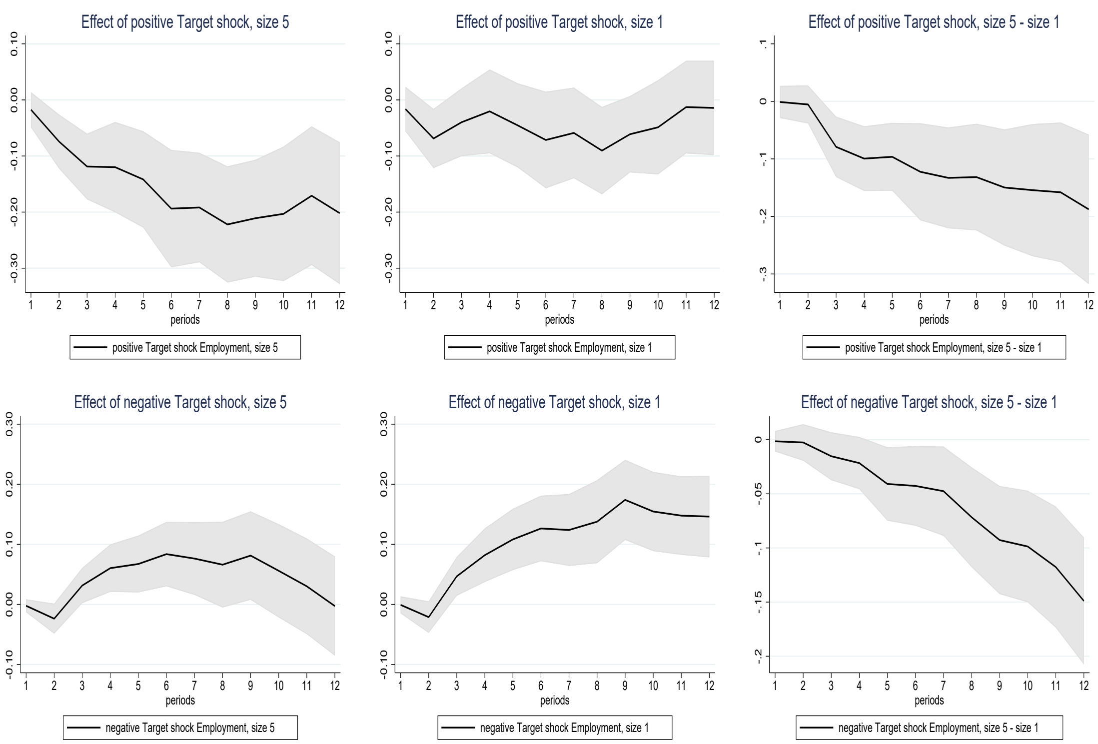

Figure 9: Response of employment growth in small and large firms to a positive and negative target shock

Notes: The top row plots the impulse response function for employment growth to a positive (contractionary) target shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response function for employment growth to a negative (expansionary) target 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) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The shaded area is the 68% confidence bands. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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large firms; the difference between the responses of the two types is not statistically significant, as seen in the top right panel of Figure 10, with the exception of a few periods that the earnings drop for small firms is deeper than that of the large firms. That is, after monetary contractions, the average earnings growth drops in both large and small firms, and the drop is of similar magnitude, and at times deeper for small firms.

For the negative target shock, the difference between the large and small firms is statistically significant, where the drop in the earnings growth of new hires is deeper in small firms compared to large firms.

In terms of magnitude, we see that a standard deviation positive shock decreases average earnings growth in firms of either size by about 1% (0.2×4.53) in the eighth quarter. A standard deviation negative shock decreases the average earnings growth of small firms by about 1.2% (0.11×10.57) and of large firms by about 0.42% (0.04×10.57); that is, after a negative target shock the growth of earnings paid by small firms decreases by more than two a half times more compared to earnings paid by large firms, and the difference is statistically significant.

We report results for nominal average earnings, instead of average real earnings, because the monetary policy shocks induce a well-known price puzzle, as lately documented by Ramey (2016). Using our target shocks, we find and show in Appendix B.7 an initial increase in the log of CPI after a monetary contraction, as it is common in the literature. The response is overall not significantly different than zero. We also report in Appendix B.7 that the results for real earnings are qualitatively the same as that for nominal earnings, but weaker quantitatively.

3.3 Monetary policy shocks in first quarter

In this section, we present results using the fact that in the QWI data, firms' size is reported once per year in the first quarter, and firms stay in the same size bin for the rest of the year. We examine the effects of monetary policy target shocks that occur in the first quarter and study the responses in the next three quarters; we refer to this exercise as Q1-robustness. Through this robustness check, we address the possibility that our results so far on the relative response of large versus small firms are impacted by reclassification bias. Note

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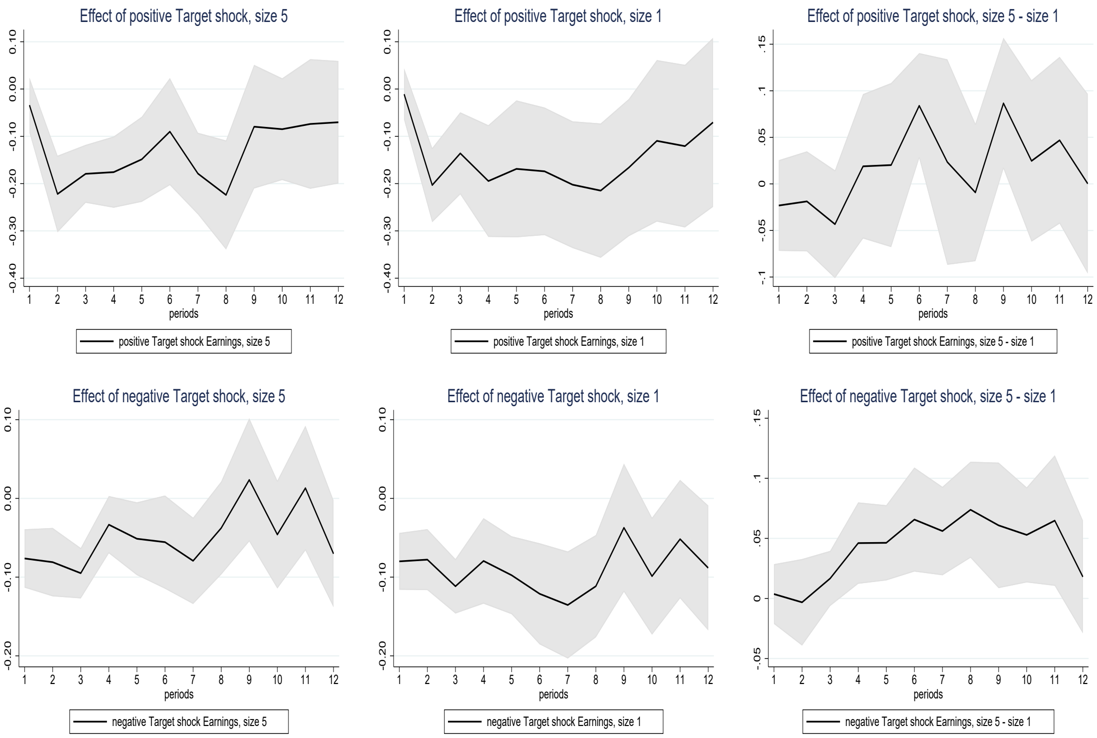

Figure 10: Response of nominal earnings growth in small and large firms to a positive and negative target shock

Notes: The top row plots the impulse response function for nominal earnings growth to a positive (contractionary) target shock for large (size 5—left column) and small (size 1—middle column) firms while the right column plots the impulse response function for nominal earnings growth to a negative (expansionary) target shock large (size 5—left column) and small (size 1-middle column) firms. The top right panel plots the difference in the response of nominal earnings growth in large and small firms to a positive (contractionary) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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that the 12-period impulse response function is presented mainly to allow us to compare the Q1-robustness results with our benchmark results. The summary statistics for the positive and negative target shocks occurring in the first quarter of each year are reported in the Data Appendix A.5.

In the top panels of Figures 11 and 12 we see that large firms (left column) decrease employment and hiring growth more than small firms (middle column) after a contractionary target shock. The drop is sharper for large firms than for small firms; the difference in the response is statistically significant for employment, as shown in the top right panel of Figure 12. Overall, our conclusions regarding a monetary policy tightening are robust to the Q1-robustness exercise; 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. Moreover, the top panels of Figure 13 show that earnings growth decreases for both types of firms in a similar manner after a monetary contraction, similar to our baseline results.

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 response of total employment and hiring growth in Figures 4-5, and in the responses of firms of different sizes, in Figures 8-9. As such, the Q1-robustness exercise, which is only valid for the first three quarters after the shock occurs, is harder to be reconciled with the expansionary shock. On the bottom panels of Figures 11 and 12, we see that the employment and hiring growth of large (left column) and small (middle column) firms during the first three quarters decreases after a monetary expansion. Figures B.5.1-B.5.3 in Appendix B.5 show that when all sizes of firms are considered, a monetary expansion occurring in the first quarter decreases the total hiring and employment growth, consistent with the small and large firms' response documented above. As such, the peculiar response of firms to monetary expansion stems from behavior particular in the first quarter of the year.

A comment is in order given that we estimate the effect of monetary policy shocks on the first quarter, which might have a different impact on the economy compared to

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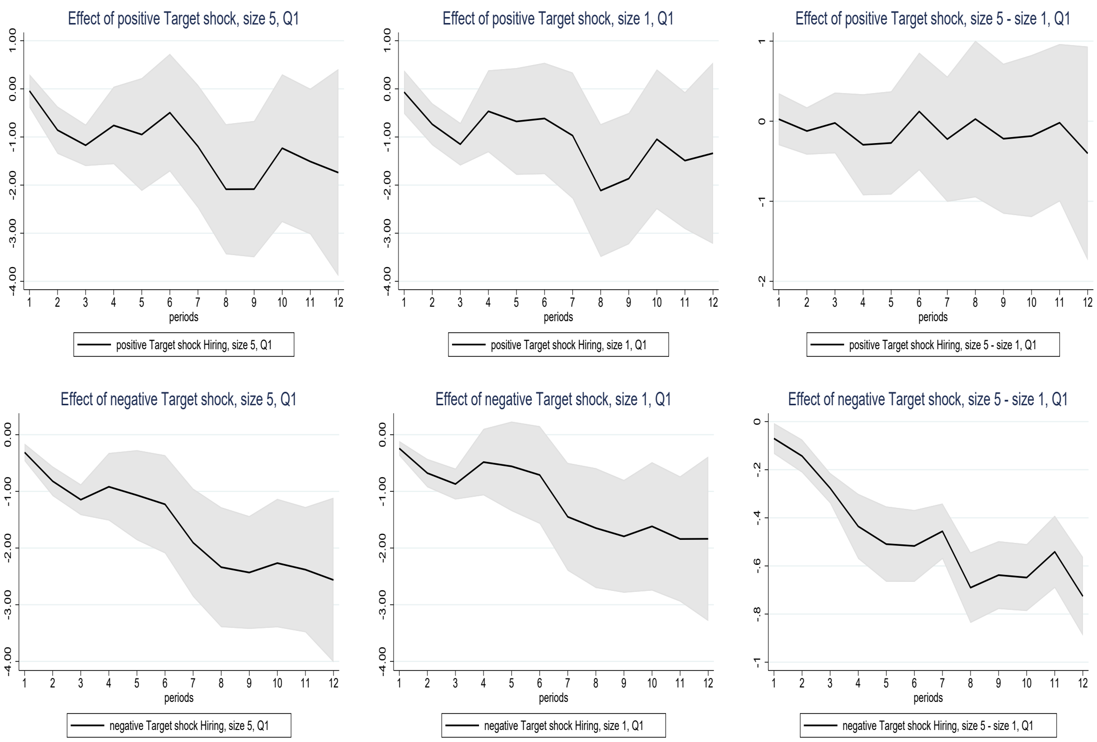

Figure 11: Response of hiring growth in small and large firms to a positive and negative target shock; Q1-robustness

The top row plots the impulse response function 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 function 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) target shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock in Q1. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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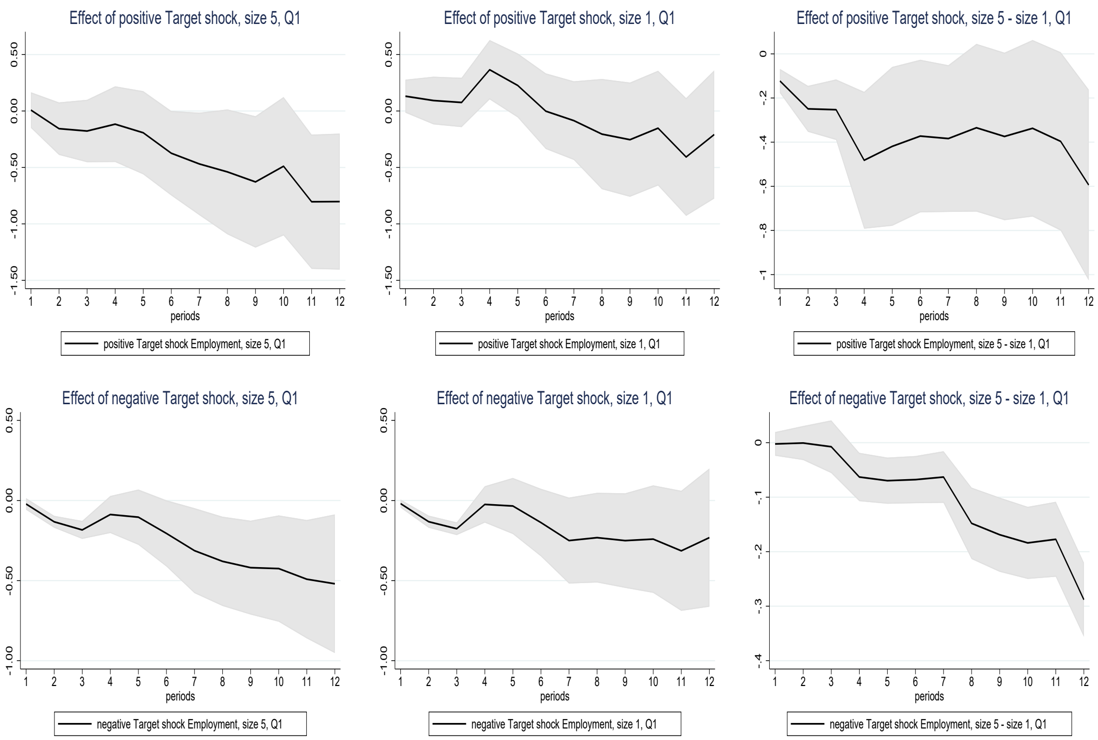

Figure 12: Response of employment growth in small and large firms to a positive and negative target shock; Q1-robustness

Notes: The top row plots the impulse response function for employment 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 plots the impulse response function for employment 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 employment growth in large and small firms to a positive (contractionary) target shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock in Q1. The shaded area is the 68% confidence bands. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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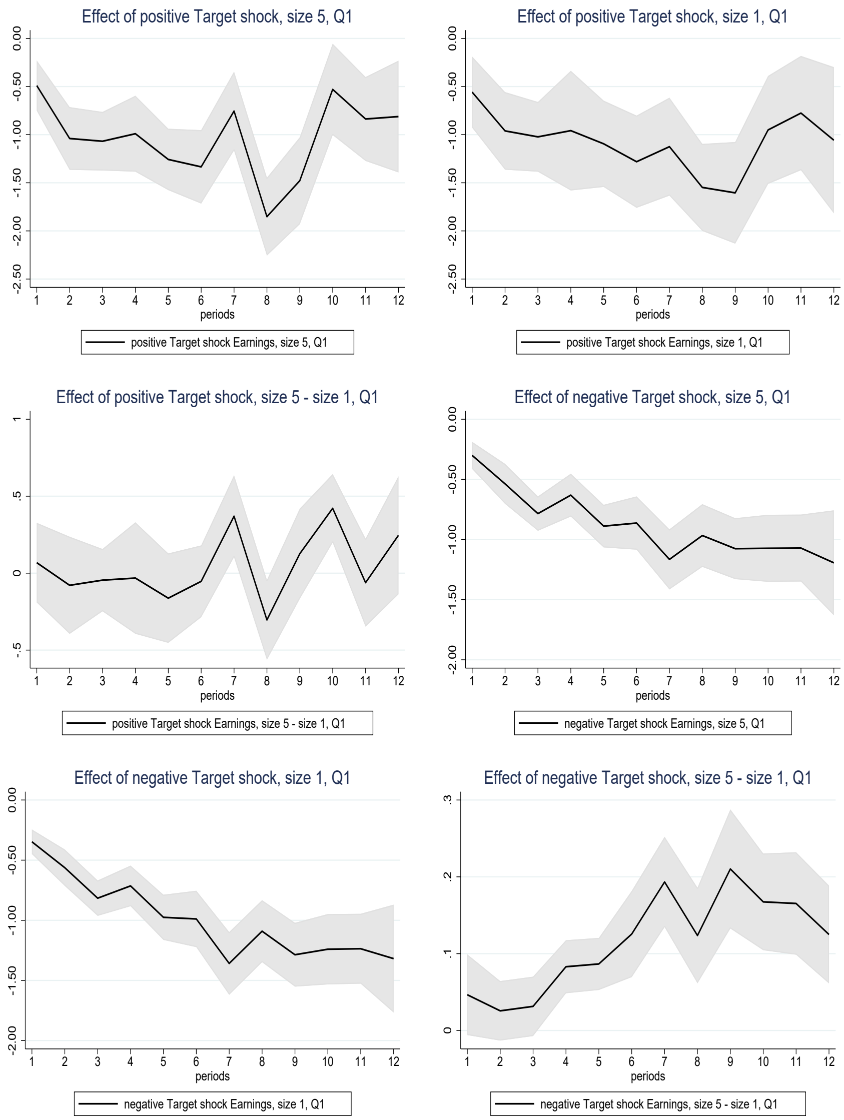

Figure 13: Response of average earnings of new hires growth in small and large firms to a target shock; Q1-robustness

Notes: The top row plots the impulse response function for nominal earnings 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 function for nominal earnings 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 nominal earnings growth in large and small firms to a positive (contractionary) target shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock in Q1. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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monetary policy shocks occurring at a different time in the year.[22] Earlier work by Olivei and Tenreyro (2007) estimated a quarter-dependent VAR and find 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.[23] The Q1-robustness exercise that we implement refers to the number of hires and the average earnings of the new hires, and not to the total workers employed and their earnings. As such, the negotiations of earnings and hours happen simultaneously and the results are not imputed by the uneven staggering of wage contract re-negotiations, that takes place with the already employed individuals.[24]

3.4 Additional robustness

Apart from the Q1-robustness exercise presented above, we also consider the following robustness exercises. First, our results are robust when we exclude the Great Recession period verifying that our results are not driven by that specific event. Figures B.3.1-B.3.7 in Appendix B.3, plot the results for the sample period 1995:1-2007:3. In Appendix B.4 we also present results for the Q1-robustness for the sample that excludes the Great Recession period.

In addition, we perform a robustness exercise where we redefine small firms in our data, using as small firms 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.6 shows that our main conclusions remain with this redefinition of small firms, emphasizing that our results are not driven by small firms' adjustments in the extensive margin.

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

[23] 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 monetary policy shocks, and monetary policy affects real variables.

[24] However, our analysis does not address possible job composition effects, beyond controlling for industry, which might affect average wages, an issue studied recently by Hazell and Taska (2020).

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In Appendix B.7 we present results for the growth of average real earnings instead of the growth of average nominal earnings that we have shown so far. Those results are similar to the ones we obtained for the nominal earnings, presented in Section 3.2.

Finally, apart from the above robustness tests, our empirical results are also robust to multiple variations of the empirical specification, like clustering variations, and the exclusion of lagged controls.[25]

4 Model

In this section, we present a theoretical model that demonstrates how the *wage effect* channel operates. Our starting point is the model of Ottonello and Winberry (2020), in a partial equilibrium employment-focused setting, as adopted by Bahaj, Foulis, Pinter, and Surico (2022). The models of Ottonello and Winberry (2020) for investment and of Bahaj, Foulis, Pinter, and Surico (2022) for employment, feature two antagonizing channels of monetary transmission: (i) the convex marginal cost channel and (ii) the financial accelerator. We incorporate a third channel, the *wage effect* channel, motivated by our empirical findings about earnings response to monetary policy, shown in Section 3.

For monetary policy to affect the firms' employment decisions, the model includes a working capital constraint. If a firm needs to borrow to finance its working capital, an increase in the interest rate decreases its labor demand. Recent papers have introduced working capital constraints to emphasize the transmission mechanism where shocks impact employment demand through financing constraints (e.g., Arellano, Bai, and Kehoe, 2019 for uncertainty shocks; Bahaj, Foulis, Pinter, and Surico, 2022 for monetary shocks; Mendoza, 2010 for productivity shocks). The working capital constraint has been traditionally thought of as a cash-in-advance constraint in production. 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.

Following Bahaj, Foulis, Pinter, and Surico (2022), firms indexed by j produce good quantity Y^j using labor N^j and a production technology such that $Y_t^j = A_t^j (N_t^j)^\alpha$, where

[25] These additional results are available upon request.

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$\alpha \leq 1$. A_t^j is the idiosyncratic productivity realized at the end of the period where $\mathrm{E}_t(A_t^j) = 1$. There is only one final good and the firms sell their output at the price P_t. Each firm enters the period with liquid resources D_t^j and illiquid resources L^j, where Q_t is the price per unit of the illiquid resource. 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. Bahaj, Foulis, Pinter, and Surico (2022) who study housing as collateral, interpret this illiquid resource as land; we allow for a broader interpretation, such as physical capital or intangible capital, with $\frac{\partial Q}{\partial i} < 0$.

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 the nominal wage. We assume that all firms face the working capital constraint and they all value internal funds, and thus do not distribute dividends; also, firms cannot raise funds by issuing new equity.[26] In order to borrow, firms pay the short-term nominal interest rate i_t and an additional spread $\lambda(B_t^j, Q_t L^j) \equiv \lambda_t^j \geq 0$. The spread increases with borrowing ($\lambda_1^j \geq 0$) in an increasing rate ($\lambda_{11}^j \geq 0$); importantly, the rate at which the spread increases with the firm's borrowing, is decreasing with the level of firm's illiquid assets ($\lambda_{12}^j \leq 0$). Furthermore, the spread decreases in the amount of illiquid resources ($\lambda_2^j \leq 0$). The firms' next period liquid resources can be written as:

$$D_{t+1}^j = P_t A_t^j (N_t^j)^\alpha - (1 + i_t)(W_t^j N_t^j - D_t^j) - \lambda_t^j \max\{W_t^j N_t^j - D_t^j, 0\} \tag{4}$$

In this economy, the aggregate state is given by $S_t = \{P_t, i_t, Q_t\}$. When the monetary authority changes the nominal interest rate i_t, it impacts the aggregate state vector. The firm's problem subject to equation (4) is therefore

$$\max_{N_t^j} V(D_t^j; S_t) = \frac{1}{1 + i_t} \mathrm{E}_t[V(D_{t+1}^j; S_{t+1})] + Q_t L^j, \tag{5}$$

where we assume that the firm does not default.[27] Substituting in the above equation the

[26] Earlier work by Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas-Sanchez (2017) shows that this type of external financing is important for firms.

[27] Here we think of L^j as 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 $(N_t^j)^a - (1 + i_t + \bar{\lambda})(W_t^j N_t^j) > i_t Q_t L^j$.

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firm's next period cash, we can re-write the optimization problem as:

$$\max_{N_t^j} V(D_t^j; S_t) = \frac{1}{1+i_t} \mathrm{E}_t \left[V(P_t A_t^j (N_t^j)^\alpha - (1+i_t)(W_t^j N_t^j - D_t^j) \right.$$
$$\left. - \lambda_t^j \max\{W_t^j N_t^j - D_t^j, 0\}; S_{t+1})\right] + Q_t L^j \tag{6}$$

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

$$\mathrm{E}_t[V'(D_{t+1}^j; S_{t+1})] \left[P_t A_t^j \alpha (N_t^j)^{\alpha-1} - (1+i_t) W_t^j - \mathbb{1}(B_t^j > 0) \right.$$
$$\left. \left(\lambda_t^j W_t^j + (W_t^j N_t^j - D_t^j) \frac{\partial \lambda_t^j}{\partial B_t^j} \frac{\partial B_t^j}{\partial N_t^j}\right) \right] = 0. \tag{7}$$

Simplifying equation (7) by suppressing time subscripts and substituting in $\frac{\partial B^j}{\partial N^j} = W^j$ and $\frac{\partial \lambda^j}{\partial B^j} \equiv \lambda_1^j$, we have:

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

Taking logs of the first order condition, we get the following equation:

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

We focus on the case that $B^j > 0$ and use a first-order Taylor expansion of $i + \lambda^j + (W^j N^j - D^j)\lambda_1^j$ around zero.[28] We define the value of the marginal product of labor as $MPN^j \equiv P\alpha(N^j)^{\alpha-1}$ and we derive the following expression:

$$\log(MPN^j) - \log W^j - i = \lambda^j + (W^j N^j - D^j)\lambda_1^j. \tag{8}$$

Further, we define $MB^j \equiv \log(MPN^j) - \log W^j - i = \log P + \log \alpha + (\alpha - 1)\log N^j - \log W^j - i$ and the marginal spread from hiring a worker as $MS^j \equiv \lambda^j + (W^j N^j - D^j)\lambda_1^j$. Thus, for all

[28]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.

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firms, we have that $MB^j - MS^j = 0$. To see the impact of changes in the nominal interest rate on employment, we use the implicit function theorem on equation (8). The resulting equation is given below:

$$\frac{\partial N^j}{\partial i} = -\frac{\frac{\partial (MB^j - MS^j)}{\partial i}}{\frac{\partial (MB^j - MS^j)}{\partial N^j}} = -\frac{\frac{\partial MB^j}{\partial i} - \frac{\partial MS^j}{\partial i}}{\frac{\alpha-1}{N^j} - 2\lambda_1^i W^j - \lambda_{11}^i (W^j N^j - D^j) W^j}, \tag{9}$$

given that $\frac{\partial MB^j}{\partial N^j} = \frac{\alpha-1}{N^j}$ and $\frac{\partial MS^j}{\partial N^j} = 2\lambda_1^j W^j + \lambda_{11}^j (W^j N^j - D^j) W^j$. Note that because of our assumptions regarding the spread, the denominator in equation (9) is negative. In addition, the higher the amount of illiquid asset L^j, the higher the denominator (lower in absolute value). That is, a firm with more illiquid asset will have the same extra benefit from hiring an extra worker as the firm with less illiquid asset. However, the firm with more illiquid asset has a lower cost from hiring the extra worker because it pays a lower spread for borrowing than what does the firm with a less illiquid asset.[29] This is the effect analyzed by Ottonello and Winberry (2020), and a reason for firms with higher illiquid assets to respond more after a change in the nominal interest rate (and in general).

We now focus on the numerator of equation (8), which depends on the response of the net marginal benefit, MB^j, and on that of the marginal spread, MS^j, to nominal interest rate changes. This is the point where we incorporate the wage channel, based on our empirical finding that monetary policy impacts the growth of nominal wages of new hires. As we show, this channel introduces a new avenue for firms' response to monetary policy shocks. The change in nominal wages impacts both the marginal benefit and the marginal spread. We first analyze a monetary tightening where the decrease in nominal wages is homogeneous across firms of different sizes, as found in our empirical work in Section 3. We then alter the model to incorporate the asymmetry in the response of wages for large and small firms after a monetary expansion.

In the homogeneous wage response case, we allow the nominal wage rate to respond to changes in interest rate, decreasing after tightening, in a similar manner across the j firms, i.e., we can drop the j superscript from the wage growth expression $\frac{1}{W^j}\frac{\partial W^j}{\partial i}$. The price level may also change in response to changes in the nominal interest rate i. Then,

[29]Since $\frac{\partial [\frac{\alpha-1}{N^j} - 2\lambda_1^j W^j - \lambda_{11}^j (W^j N^j - D^j) W^j]}{\partial L^j} = -2W^j \lambda_{12}^j q \geq 0$ given that $\lambda_{12}^j \leq 0$.

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$\frac{\partial MB^j}{\partial i} = \frac{1}{P}\frac{\partial P}{\partial i} - \frac{1}{W}\frac{\partial W}{\partial i} - 1$, where we see that we can drop the j superscript from $\frac{\partial MB}{\partial i}$ since this effect is 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 make restrictive assumptions on the response of the price level, which given the empirical evidence in the literature, it could increase, decrease or stay constant; it suffices to assume that $\frac{\partial MB}{\partial i} \leq 0$, so firms observe monetary policy tightening as a contraction. Finally, substituting the response of the marginal spread to changes in interest rate, we get:

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

In equation (10), 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 and more recently Ottonello and Winberry, 2020), 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 new in our work. This term summarizes the wage effect found on our empirical analysis, suggesting that $\frac{\partial W^j}{\partial i} < 0$; that term was zero in Bahaj, Foulis, Pinter, and Surico, 2022 and Ottonello and Winberry (2020) work. 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 wage rate decrease. The intuition is that as a monetary tightening decreases the wage rate, it decreases the total borrowing by a firm and hence lowers the marginal cost. 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 that does not pay spread for the relevant levels of employment hired, and hence $\lambda^U = 0$ and

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$MS^U = 0$. 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:

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

We analyze how monetary policy shocks impact constrained versus unconstrained firms differently, using equation (11). 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.[30] 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, 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 14. The second term in equation (11) 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 (11) 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 wage effect. This is because, in the case of a monetary tightening accompanied by a wage decrease, constrained firms need to borrow less to finance employment, pay a lower spread and thus scale down less than the unconstrained

[30]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 (11) 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.

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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 14-16. 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 wages among firms. The convex MS curves differ for the two types of firms, constrained (steeper/blue) and unconstrained (flatter/black). For the unconstrained firm, the MS curve is flat for the levels of employment considered, although it is not for the constrained firms.

Figure 14 shows the response of the two types of firms to a monetary contraction, ignoring the effect of the financial accelerator and the wage effect, therefore capturing only the first term in equation (11). 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 incorporated in Figure 15. 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 16 we add the wage effect, depicting all three effects combined. The wage effect makes the marginal spread MS curve flatter than what it was in Figure 15, 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 the wages, 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 wage growth similarly across firms of both size classes.

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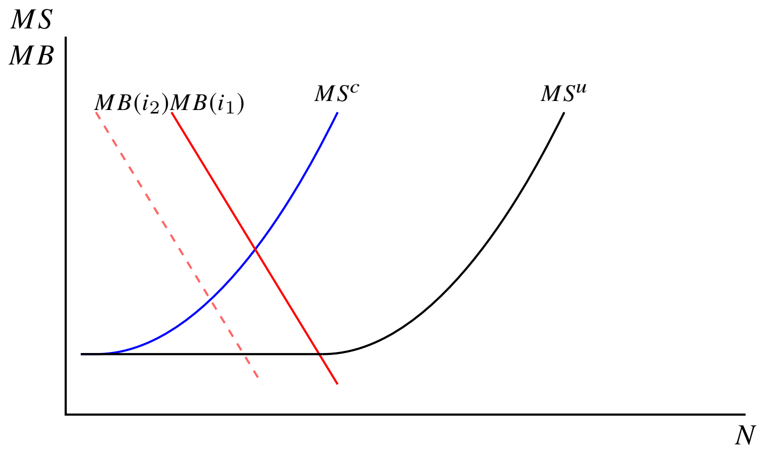

Figure 14: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. Model without taking into account the accelerator effect and the change in spread due to change in wages.

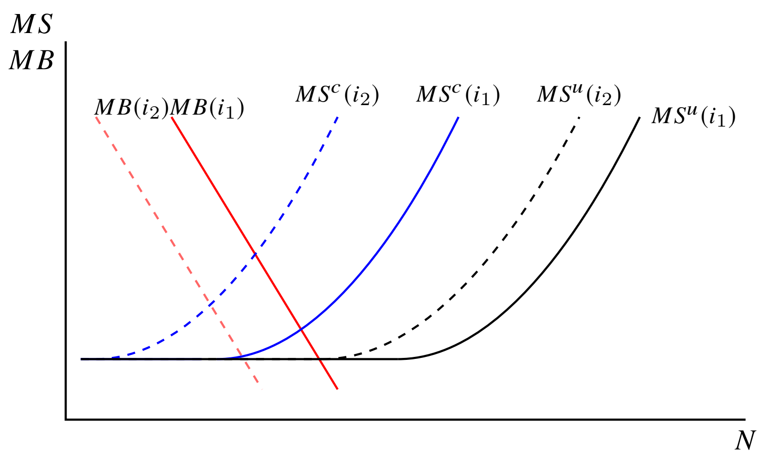

Figure 15: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. The financial accelerator effect moves the MS curve of constrained firms to blue dashed and of unconstrained to black dashed curves. Model without taking into account the change in spread due to change in wages.

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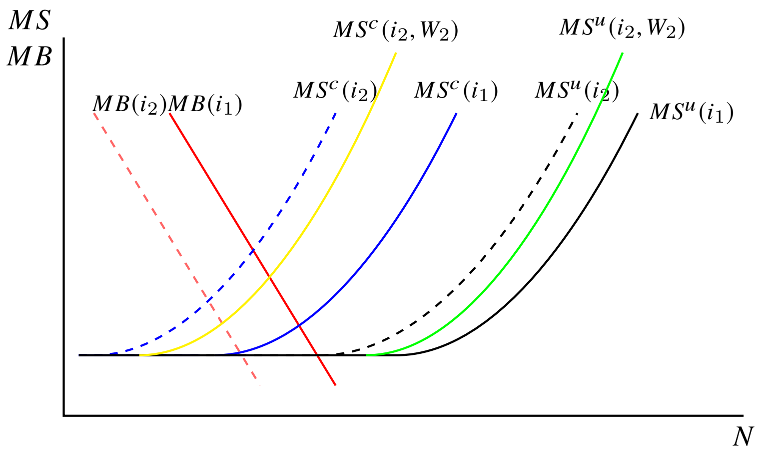

Figure 16: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. The financial accelerator effect moves the MS curve of constrained firms to blue dashed and of unconstrained to black dashed curves. Taking into account the wage effect moves those curves to yellow for constrained and to green for unconstrained firms. Model with homogeneous changes in wage growth.

We now show how the above model can incorporate heterogeneous wage responses among the constrained and unconstrained firms, which is what happens after monetary expansions as we found in our empirical results in Section 3. Specifically, we found that both large and small firms decrease 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 (10) now becomes:

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

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

$$\frac{\partial N^C}{\partial i} - \frac{\partial N^U}{\partial i} = \left(\Lambda^C \frac{\partial MB^C}{\partial i} - \Lambda^U \frac{\partial MB^U}{\partial i}\right) - \Lambda^C \left[\frac{\partial Q}{\partial i} L^C [\lambda_2^C + (W^C N^C - D^C)\lambda_{12}^C]\right] - \Lambda^C \left[\frac{\partial W^C}{\partial i} N^C [2\lambda_1^C + \lambda_{11}^C (W^C N^C - D^C)]\right]. \quad (13)$$

The second and third terms of equation (13) are the same as those in equation (11). That is, the financial accelerator and wage channels (second and third term, respectively) affect

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the relative response of large versus small firms as before, through the cost of external financing. However, given that there is a wage decrease, 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 their illiquid asset would ease their borrowing costs. Similarly, the wage channel suggests that having to finance lower wage, the constrained firms borrow less, and the spread decreases.

Moreover, the first term of equation (13) is now different than that of equation (11). Focusing on this first term, we have, as before, $0 < \Lambda^C < \Lambda^U$; however, the heterogeneous changes in the wage 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 wage growth of small firms drops more than that of large firms, and thus the net marginal benefit of expanding increases more for small firms relative to large.[31]

If there was a homogeneous wage increase across firm size categories, then the graphical representation of the monetary expansion would look very similar to that of the monetary contraction shown in Figures 14-16, with the curves moving on the opposite directions. However, given that for monetary expansion the wage decreases and the drop for the small firms is found to be deeper than that of the larger firms, the graphical representation of the expansion differs from that of a contraction. 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 17. 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 equation (13) leads on 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 wage effect channels 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, the theoretical implications of the model are even clearer, suggesting that constrained firms increase employment more than large firms, consistent with our empirical evidence in Section 3.

[31] 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 $0 > \frac{\partial MB^U}{\partial i} > \frac{\partial MB^C}{\partial i}$.

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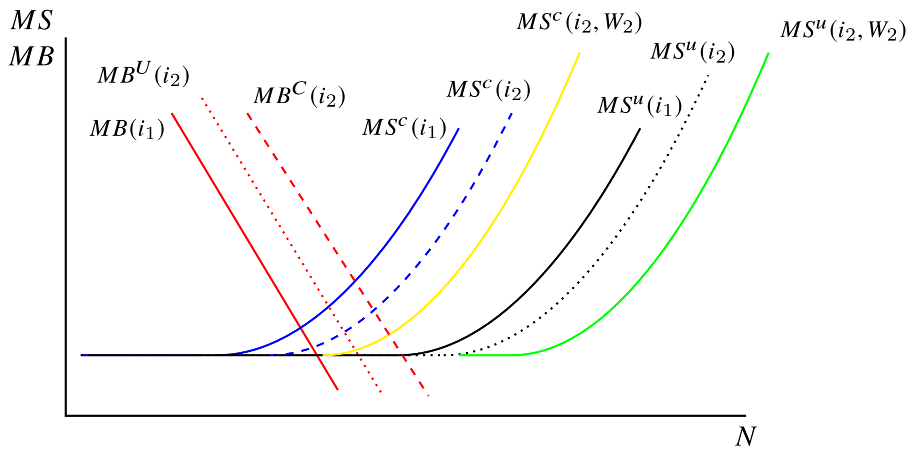

Figure 17: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary expansion $i_2 < i_1$, the MB curve moves from red solid to red dashed line for constrained firms, and to red dotted for unconstrained firms. The financial accelerator effect moves the MS curve of constrained firms to blue dashed and of unconstrained to black dotted curves. Taking into account the wage effect moves those curves further, to yellow for constrained and to green for unconstrained firms. Model with heterogeneous changes in wage growth.

5 Conclusion

Our paper examines the effects of monetary policy on key employment variables and documents how those effects vary with the direction of the shock (positive versus negative) and the size of the firm (small versus large). Using detailed data to study the response of firms of different sizes to surprise interest rate increases and decreases we uncover novel effects of monetary policy on the labor market. Specifically, we find that there are important wage effects of monetary policy shocks with the earnings growth of newly hired employees decreasing after a monetary tightening and expansion. We present a model which demonstrates how those wage effects explain our main empirical findings that large firms decrease hiring and employment growth more than small firms in monetary contractions, although small firms expand hiring and employment growth more after monetary expansions.

Our analysis has implications for policy. Specifically, the empirical finding that large firms respond more after monetary contraction although small firms respond more after monetary expansions suggests that monetary policy discourages employment concentration into large firms. Furthermore, the finding that a monetary contraction acts fast to decrease hiring and employment growth of firms, although a monetary expansion takes longer time to manifest, implies a reduced role of a monetary authority to help labor markets recover.

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Finally, our analysis suggests that studying the effect of monetary policy on employment growth alone is not informative of the true effect of monetary policy on the labor market. To understand the effects of monetary policy on employment, policy makers need to examine the impact on employment flows such as hiring.

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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 (firm age, size, 2, 3, and 4-digit NAICS Sectors, county located, metropolitan or not, workforce investment area) and employee (sex, age, race, ethnicity, education) information. All private (i.e., not Federal) employers that are covered by unemployment insurance in the U.S. are included (both part and full-time).[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 (of privately owned firms) is obtained. This is reported on the employer/firm level (not on establishment).[33] 4) Various sources provide information about 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). 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

[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.

[33]That means that a firm could be classified as "large" (e.g. size 5) at the national level, but we observe the number of employees that an establishment is employing to be less than that of size 1.

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

Figure A.2.1 plots the share of large and small firms in total employment using the QWI. The share of employment in large firms has been increasing over time, and that of small firms decreasing over time, as also shown in Figure 1 in the main text.

A.3 Target and path shocks

Gürkaynak, Sack, and Swanson (2005) suggest that at the dates of policy announcements, the public is receiving information both about the current federal funds rate target and, through the statement that follows, about the future path of the economy. This latter

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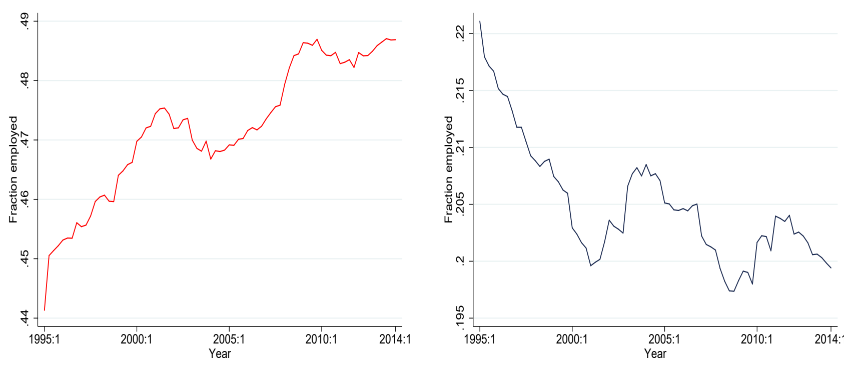

Figure A.2.1: Employment concentration in large and small firms

Notes: The figure plots the time series of the fraction (in % points) of employment in large (more than 500 employees) and small firms (1-19 employees) in the U.S. using QWI for the period 1995:1-2014:1.

information might be superior information that the Fed has over the public, and when revealed through the statement, might trigger changes in the economy itself, even if there are no changes in the federal funds rate target itself. We explore how the surprise information revealed through changes in the current federal funds rate target, or just the 'target factor' as is often referred to in the literature, affects firms of various sizes.

We use the data from Campbell, Evans, Fisher, Justiniano, Calomiris, and Woodford (2012), who extended Gürkaynak, Sack, and Swanson (2005)'s analysis to the period of February 1990 through June 2007, excluding the September 2001 observation. Campbell, Evans, Fisher, Justiniano, Calomiris, and Woodford (2012) use daily observations from the current month and three months ahead federal funds futures contracts and the two, three, and four-quarters ahead Eurodollar futures contracts, to each of which they add a 1 basis points per month risk premium. Then they perform factor analysis and try to identify and interpret the factors that explain those rates. They find, similarly to Gürkaynak, Sack, and Swanson (2005), that two factors explain almost all the variation of those rates. With an appropriate rotation that does not allow the second factor to affect the current rate, the two factors can be given the 'target' and 'path' interpretations. Specifically, Campbell, Evans, Fisher, Justiniano, Calomiris, and Woodford (2012) find that the target factor accounts for almost all variance of the current quarter rate and almost all variance of the next quarter rates. The target and path factors each explain about half of the variance in interest rates

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expected two quarters ahead. Finally, the path factor accounts for most of the variance in the two longer contracts.

A.4 Distribution of employment and new hires

Figures A.4.1 and A.4.2 plot the distribution of employment and new hires in small and large firms across industries and states.

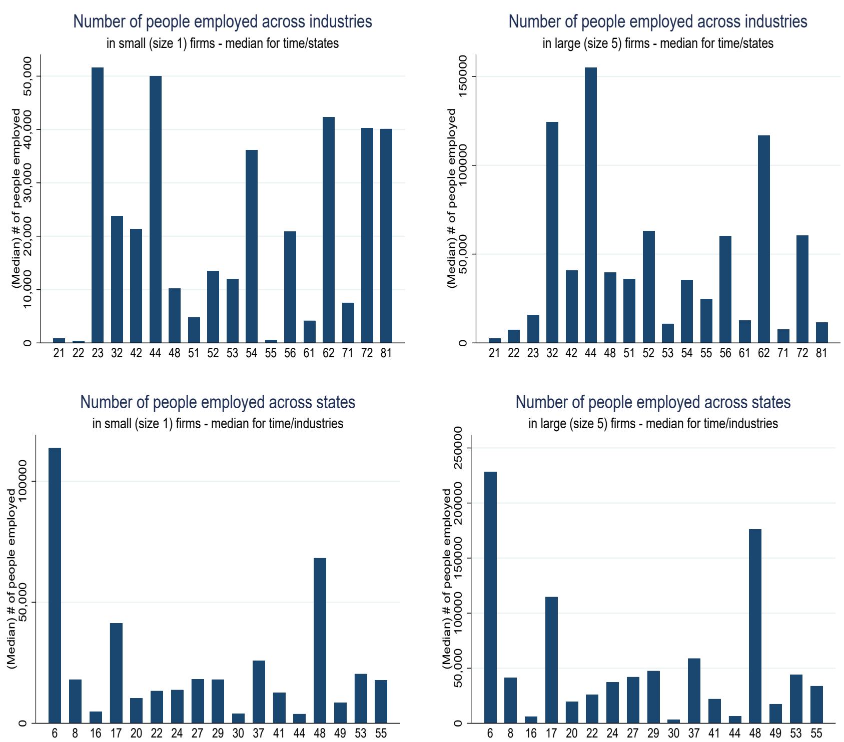

Figure A.4.1: Distribution of employment across industries and states in small and large firms

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

A.5 Q1 target shocks

Table A.1 reports the summary statistics for all shocks and shocks that occur in quarter 1. It also reports the positive and negative target 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) target shocks occur during the first

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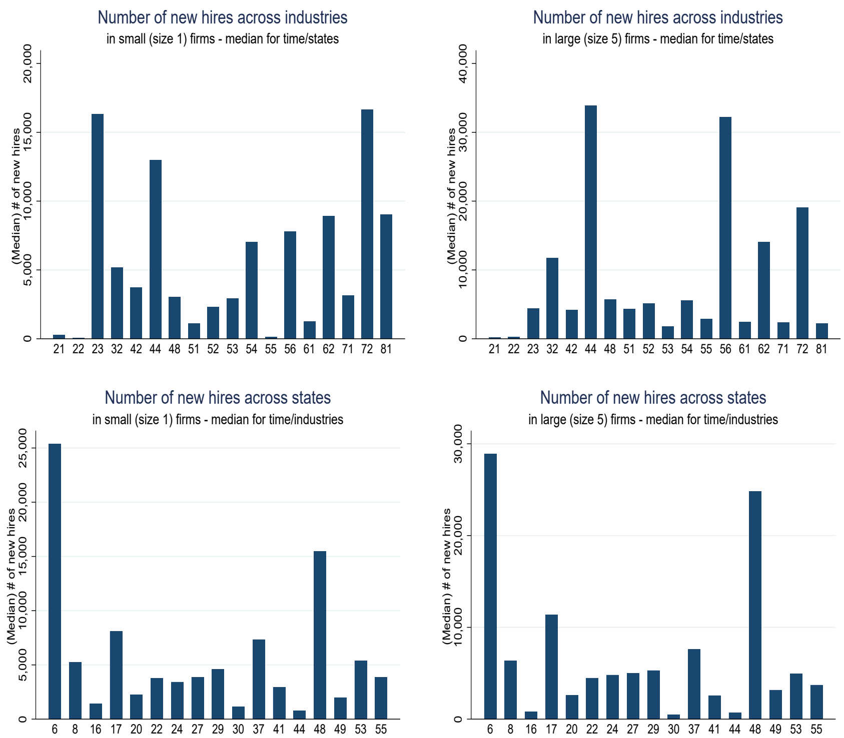

Figure A.4.2: Distribution of hiring across industries and states in small and large firms

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

quarter of our sample have very similar mean and standard deviation to those occurring in all quarters. The positive (contractionary) target shocks occurring during the first quarter of our sample, however, are on average 30% smaller and have half the standard deviation than those occurring in all quarters.

B Results appendix

B.1 Aggregate data

We examine the effect of the target shocks, and positive and negative target 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 Ad-

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

	Qs	Q1	Qs (+)	Q1 (+)	Qs (-)	Q1 (-)
Mean	-0.66	-1.57	3.53	2.48	-4.19	-4.06
Standard deviation	12.72	11.58	4.53	2.05	10.57	10.47

Notes: The table reports mean and standard deviation (in basis points) of the change in the target shock for the period 1995:1-2014:1, occurring in all quarters (Qs) and in the first quarter (Q1). It also reports the same statistic for positive and negative target shocks.

justed) and unemployment (UNEMPLOY, Unemployment Level, Thousands of Persons, Quarterly, Seasonally Adjusted). The data are from the St. Louis FRED database, for the period 1995:1-2014:1. We estimate the following equation

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

where Z includes the current and four lags of the federal funds rate.

Figure B.1.1 shows that an increase in the target shock decreases real GDP and employment growth, and increases unemployment. As such, the target shocks that we use in this paper, generate the expected effects on the aggregate variables.

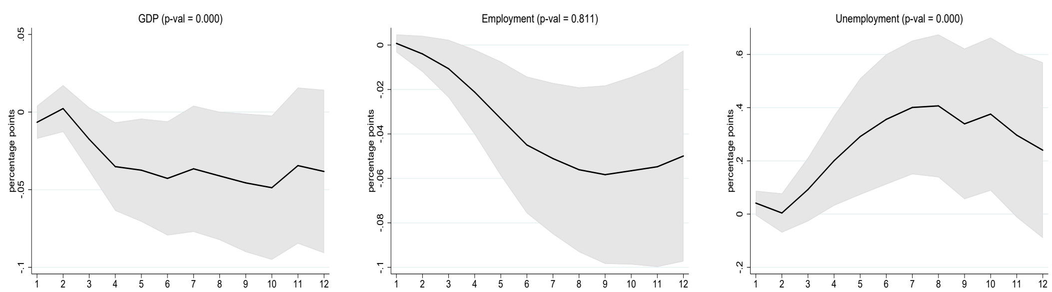

Figure B.1.1: Response of real GDP, aggregate employment and unemployment

Notes: The figure plots the response of real GDP (left panel), aggregate employment (middle panel) and unemployment (right panel), to target shocks. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

B.2 State unemployment

In this subsection, we show how the employment growth of large and small firms responds to state unemployment changes. Figure B.2.1 shows the response of employment growth

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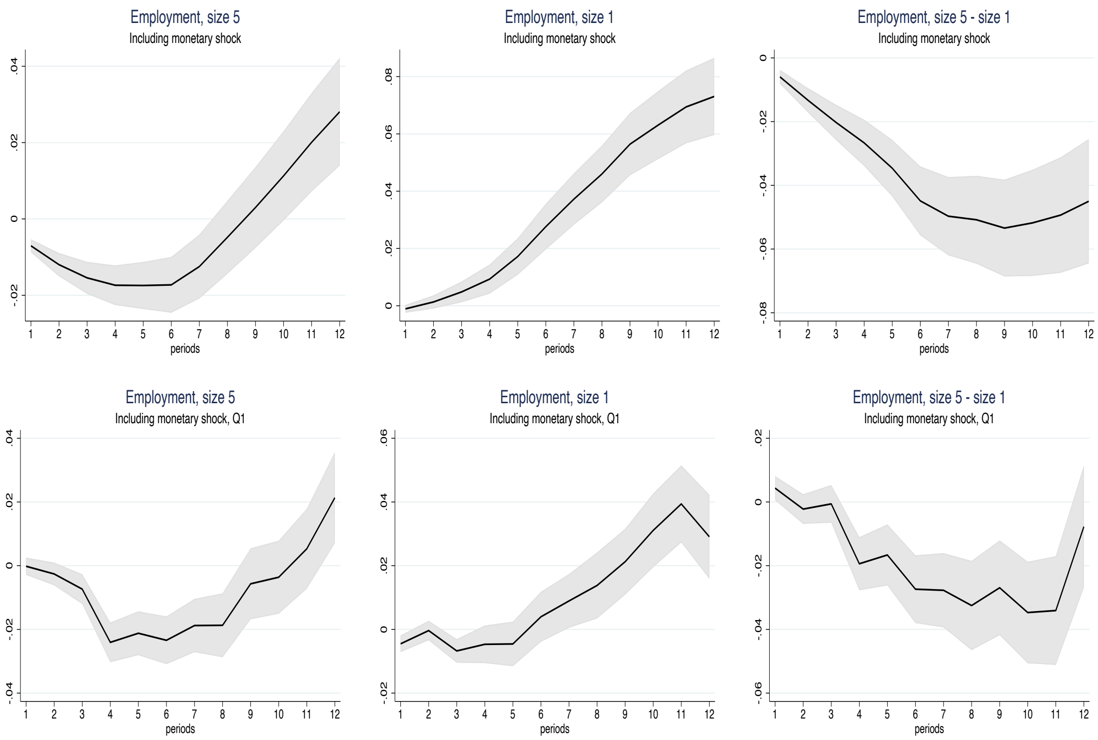

Figure B.2.1: Response of employment growth to state unemployment, Qs and Q1.

Notes: The figure plots the response of employment growth to state unemployment to large (left column) and small (middle column) firms and the difference between them (right column). The top row uses shocks in all quarters and the bottom row uses only the first quarter shocks. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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of large (left panels) and small (middle panels) firms using the estimates from equation (3). The top row of the figure shows that the employment growth of large firms decreases, while that of small firms increases after an increase in the state unemployment rate. The difference between large and small firms, shown in the top right panel, is statistically significant, consistent with the theory of Moscarini and Postel-Vinay (2013). Focusing on the first three quarters, those results are robust to the Q1-robustness exercise shown in the bottom row of Figure B.2.1.

We also examine whether these results hold when we exclude monetary policy shocks, in estimations that resemble those of Moscarini and Postel-Vinay (2012).[34] Those results are presented in Figure B.2.2, where we see that for our specification and dataset the central message of 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. Similarly to the specification that includes the monetary policy shocks, the difference in response of large and small firms is statistically significant when all quarters are used although it loses significance in the Q1-robustness exercise for the relevant three first quarters.

B.3 Excluding the Great Recession

We plot figures where the sample period is 1995:1-2007:3. Figures B.3.1 and B.3.2 show the response of hiring and employment growth respectively, to target, positive target, and negative target shocks for the sample that ends before the Great Recession. We see that our baseline results (main text, Figures 4 and 5) are robust to excluding the Great Recession period from the sample. That is, contractionary target shocks result in lower hiring and employment growth (left and middle columns). Like the full sample results, the right columns of the figures show that there is a delay in the responses after expansionary monetary policy shocks. Moreover, Figure B.3.3 for earnings, shows similar patterns to Figure 6 in the main text, where the full sample is used.

When only size differences are taken into account (and not sign asymmetries), we see

[34] Specifically, the regression is a fixed effects regression with clustering, similar to the benchmark regressions. However, in this specification, we do not include the target and path shocks or their interaction with industry.

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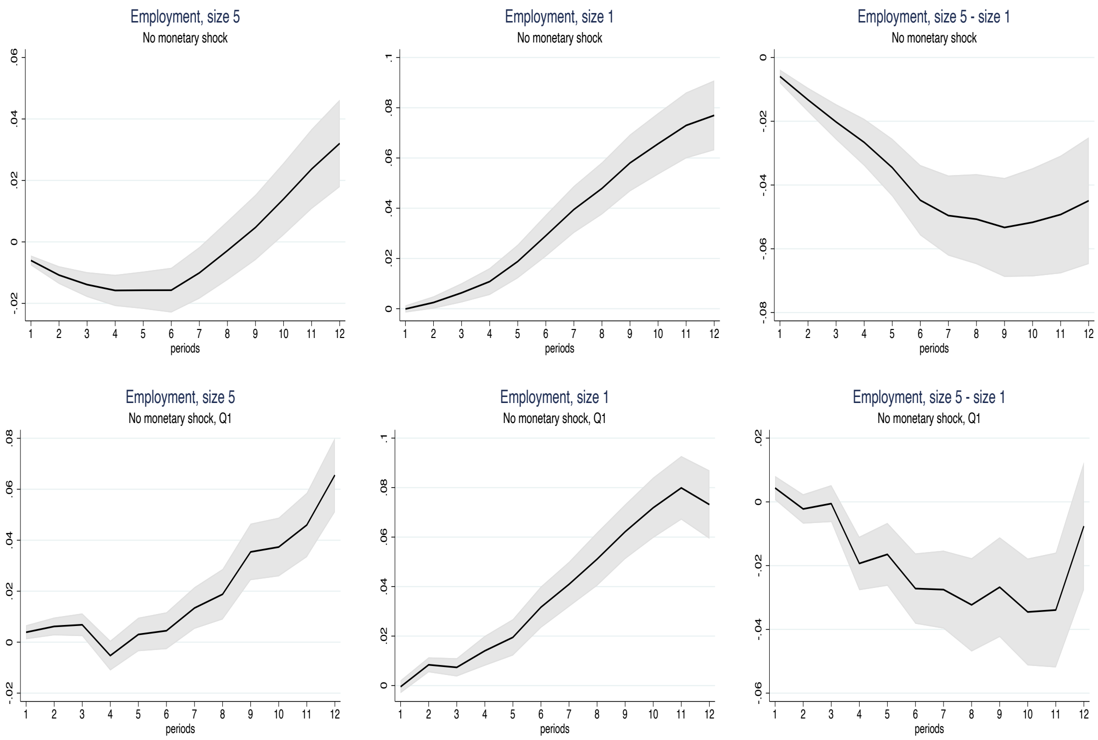

Figure B.2.2: Response of employment growth to state unemployment in the specification without monetary policy shocks (MP-V style), Qs and Q1.

Notes: The figure plots the response of employment growth to state unemployment to large (left column) and small (middle column) firms and the difference between them (right column) when monetary policy shocks are not included in the regression. The top row uses shocks in all quarters and the bottom row uses only the first quarter shocks. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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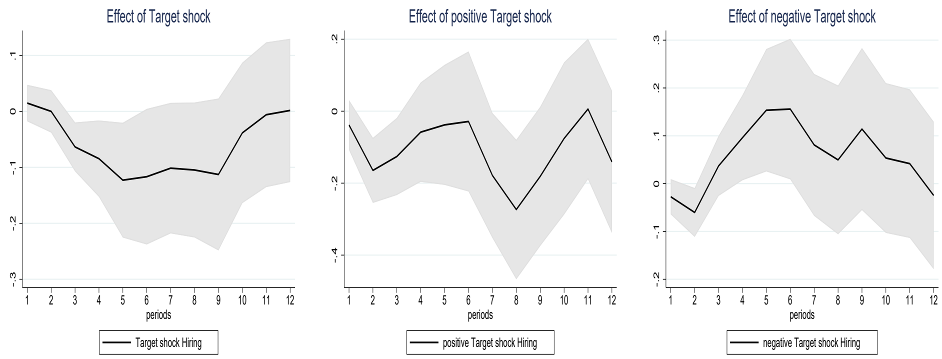

Figure B.3.1: Response of hiring growth to a target shock, before GR sample

Notes: The figure plots the impulse response functions of hiring growth to a target shock (left panel), positive (contractionary) target shock (middle panel) and the negative (expansionary) target shock (right panel). The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

Figure B.3.2: Response of employment growth to a target shock, before GR sample

Notes: The figure plots the impulse response functions of employment growth to a target shock (left panel), positive (contractionary) target shock (middle panel) and the negative (expansionary) target shock (right panel). The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands

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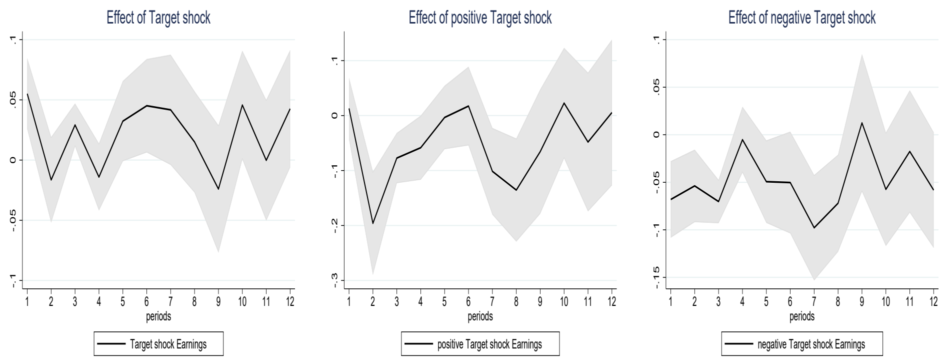

Figure B.3.3: Response of nominal earnings growth to a target shock, before GR sample

Notes: The figure plots the impulse response functions of nominal earnings growth to a target shock (left panel), positive (contractionary) target shock (middle panel) and the negative (expansionary) target shock (right panel). The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands

in the first two rows of Figure B.3.4 that as in Figure 7 where the full sample is considered, small firms react more than large firms to target monetary policy shocks. This is a consequence of not considering sign asymmetries of target shocks, as emphasized in the main text. For nominal earnings changes, like the full sample results shown in the bottom row of Figure 7, the last row of Figure B.3.4 shows that large firms react more to monetary policy shocks, but here the difference across firm size is not statistically significant.

We now turn to the results that consider both sign and size differences. Figures B.3.5 and B.3.6 show that, similarly to Figures 8 and 9 in the main text, large firms respond more to monetary contractions and small firms respond more to monetary expansions, when it comes to their hiring and employment growth. The differences in the responses are always strong and statistically significant. Figure B.3.7 shows, similarly to Figure 10 in the main text, that earnings growth of both types of firms decreases after monetary contractions and after monetary expansions. The difference in the response is stronger for small firms versus large firms, however, the difference is not significant for monetary expansions.

B.4 Excluding the Great Recession, Q-1 robustness

Starting with the contractionary monetary policy shocks, the results of the Q1-robustness exercise for the sample period that excludes the Great Recession are consistent with the

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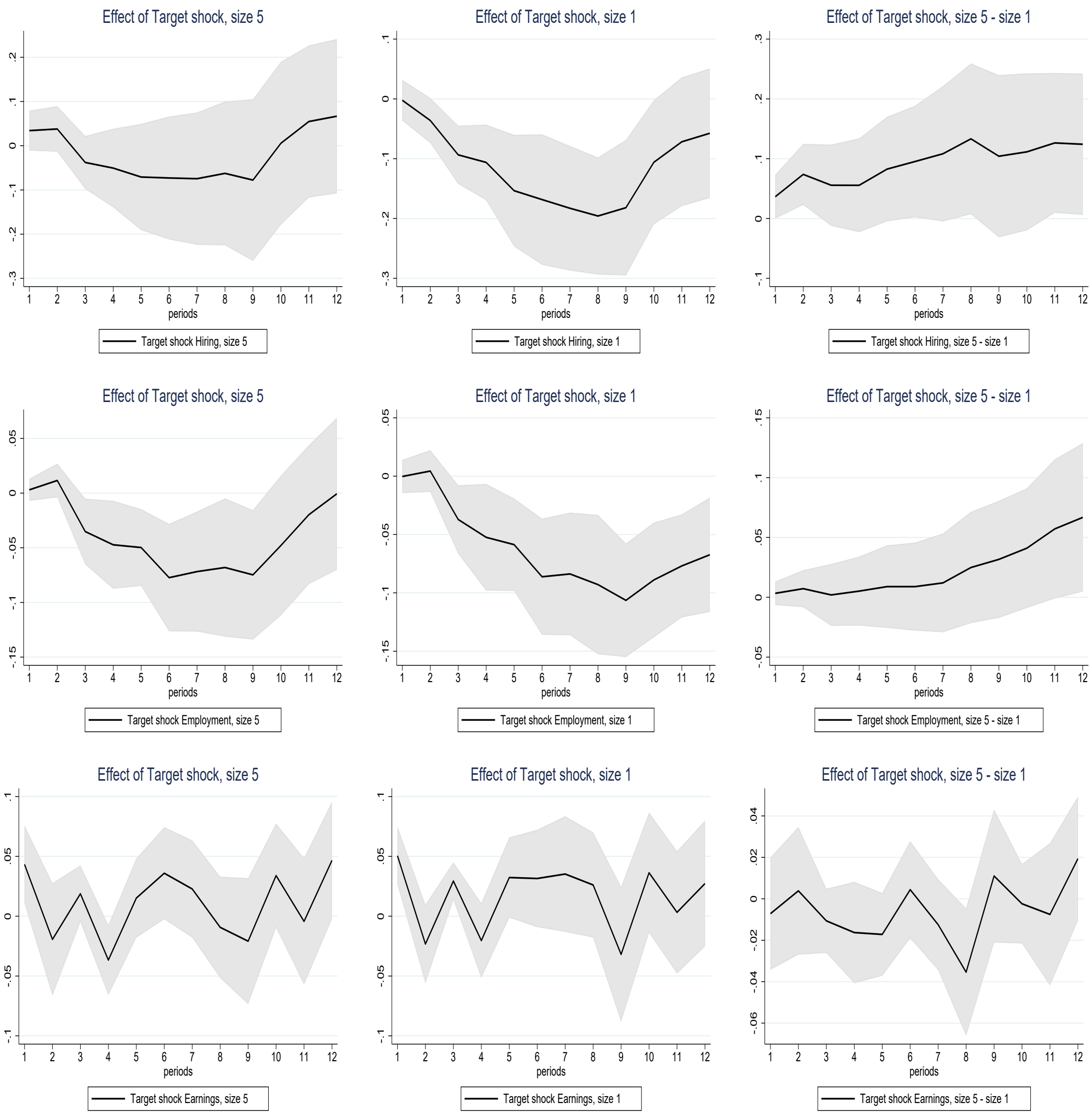

Figure B.3.4: Response of hiring, employment and average nominal earnings growth of small and large firms to a target shock, before GR sample

Notes: The top rows plots the impulse response function to a target shock for large firms (left panel), small firms (middle panel), and the difference in the response in large and small firms (right panel), to a target shock. The middle and bottom columns show the equivalent effects for employment growth and growth in average nominal earnings, respectively. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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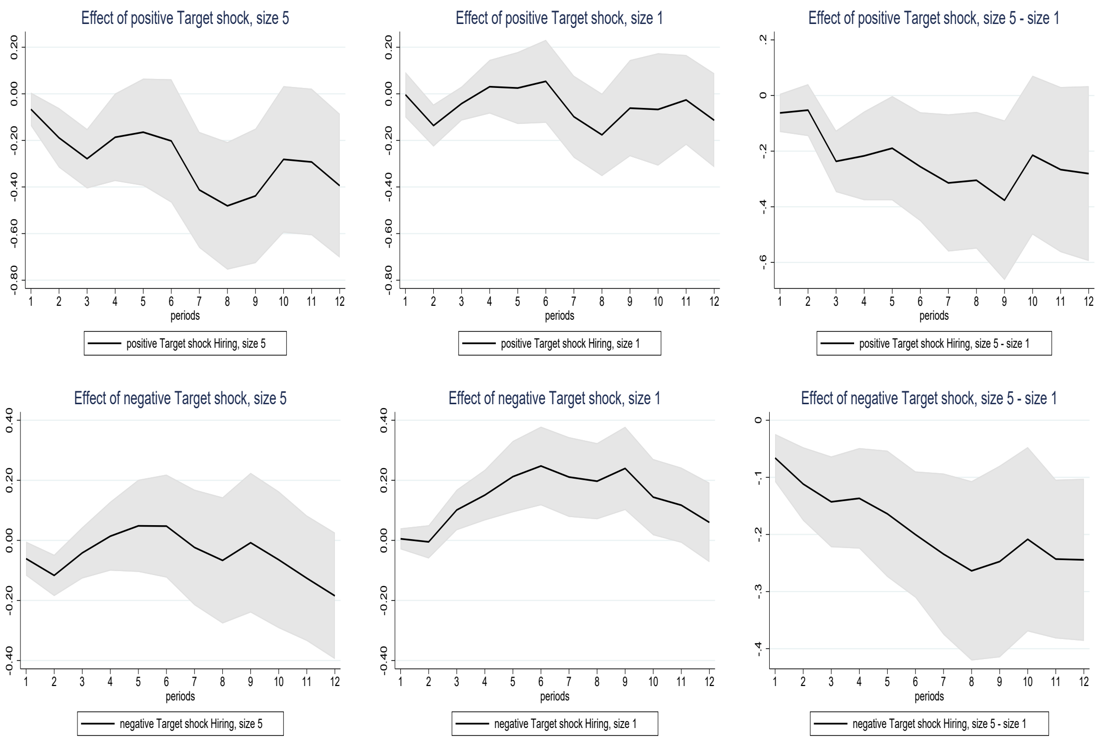

Figure B.3.5: Response of hiring growth in small and large firms to a positive and negative target shock, before GR sample

The top row plots the impulse response function for hiring growth to a positive (contractionary) target shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response function for hiring growth to a negative (expansionary) target 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) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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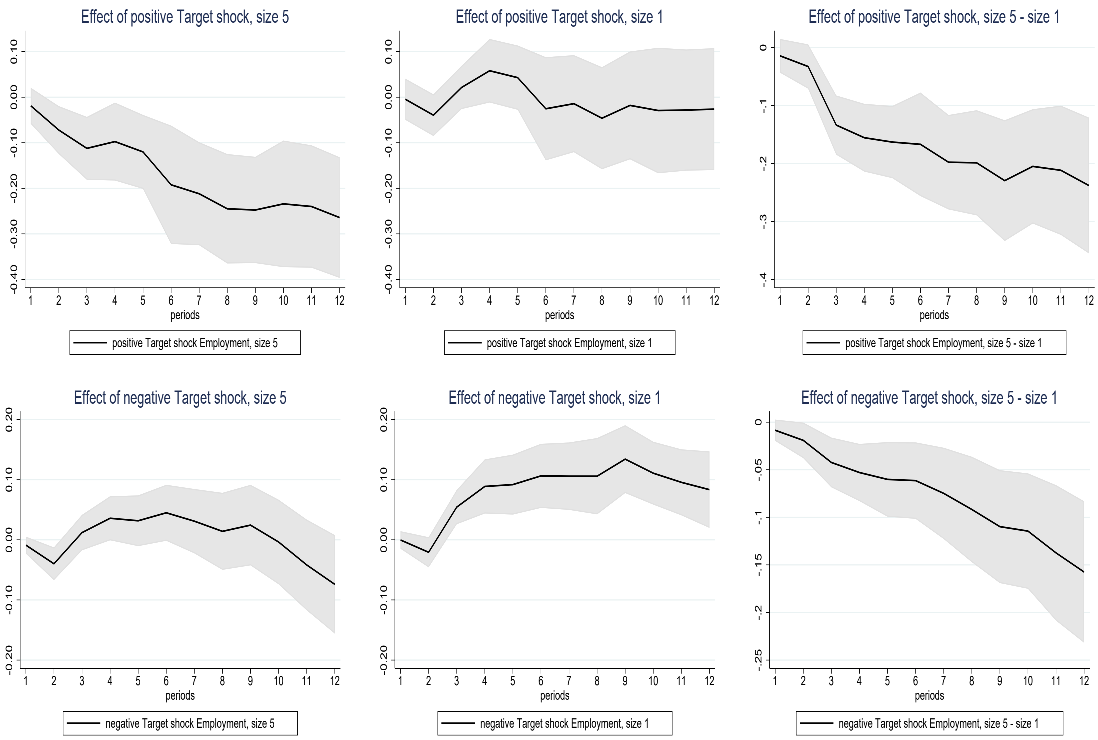

Figure B.3.6: Response of employment growth in small and large firms to a positive and negative target shock, before GR sample

Notes: The top row plots the impulse response function for employment growth to a positive (contractionary) target shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response function for employment growth to a negative (expansionary) target 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) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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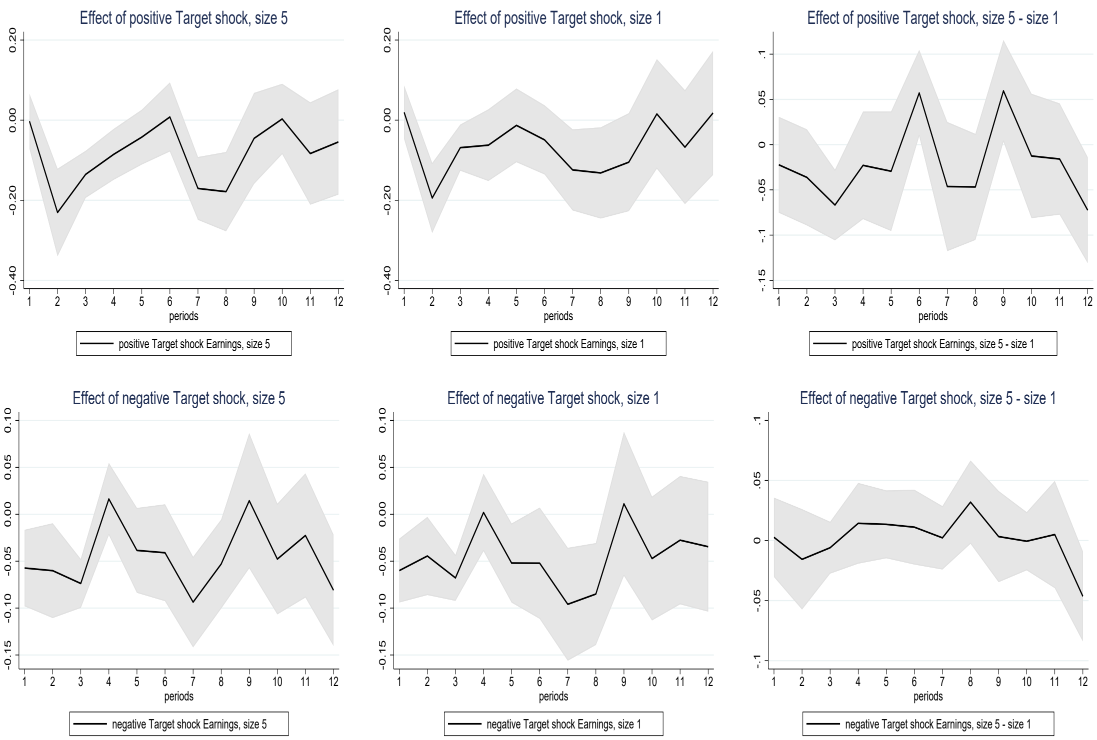

Figure B.3.7: Response of nominal earnings growth in small and large firms to a positive and negative target shock, before GR sample

Notes: The top row plots the impulse response function for nominal earnings growth to a positive (contractionary) target shock for large (size 5—left column) and small (size 1-middle column) firms while the bottom row plots the impulse response function for nominal earnings growth to a negative (expansionary) target 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 nominal earnings growth in large and small firms to a positive (contractionary) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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results for the whole sample shown in Section 3.2. Examining the first three quarters, the left and middle columns of Figures B.4.1 and B.4.2 show that the hiring growth and employment growth of large firms drop more than that of small firms. Figure B.4.3 shows that the average earnings growth decreases for both types of firms, it does so in a similar fashion, and the difference of responses is not statistically significant. That is, for contractionary target shocks, the Q1 robustness exercise for the sample without the Great Recession, is robust to all the conclusions in Section 3.2.

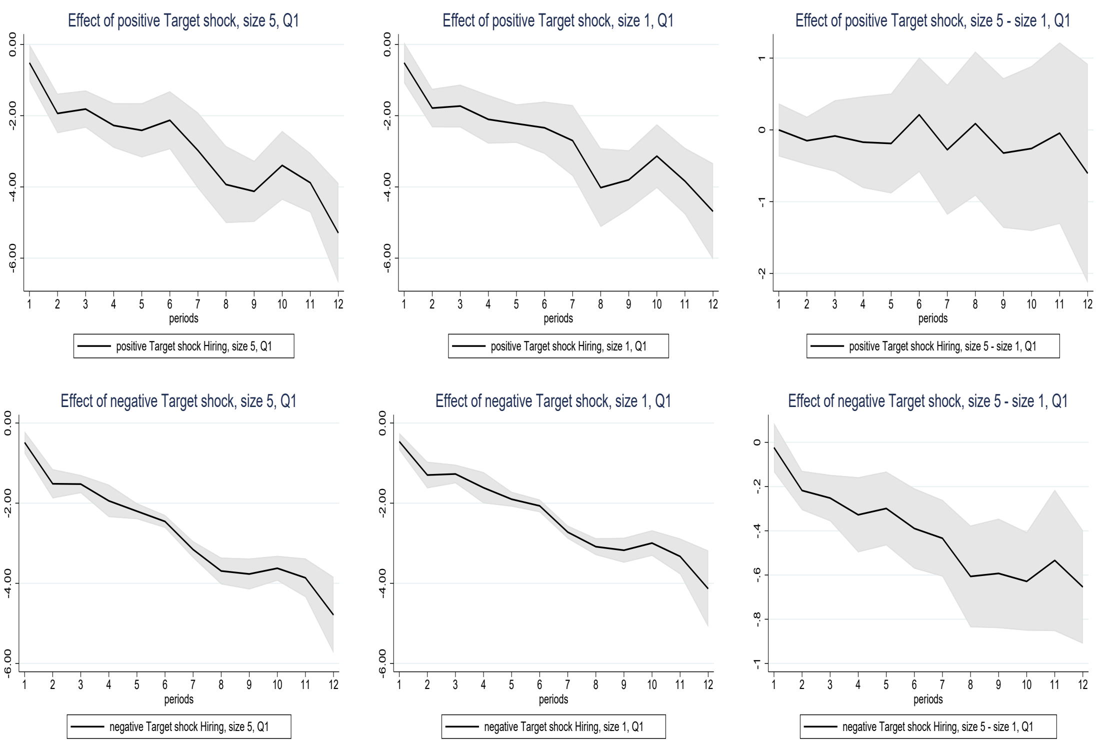

Figure B.4.1: Response of hiring growth in small and large firms to a positive and negative target shock, before GR sample; Q1-robustness

The top row plots the impulse response function 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 function 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) target shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock in Q1. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

The results for monetary expansions are the same as in the Q1-robustness exercise for

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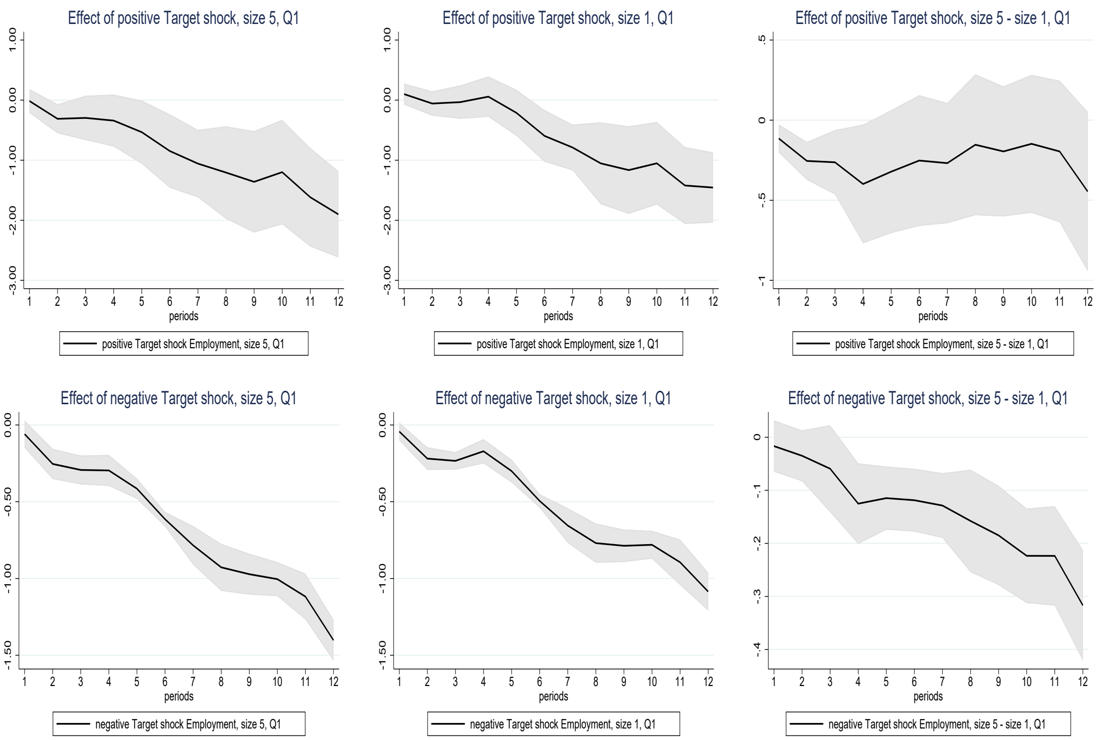

Figure B.4.2: Response of employment growth in small and large firms to a positive and negative target shock, before GR sample; Q1-robustness

Notes: The top row plots the impulse response function for employment 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 function for employment 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 employment growth in large and small firms to a positive (contractionary) target shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock in Q1. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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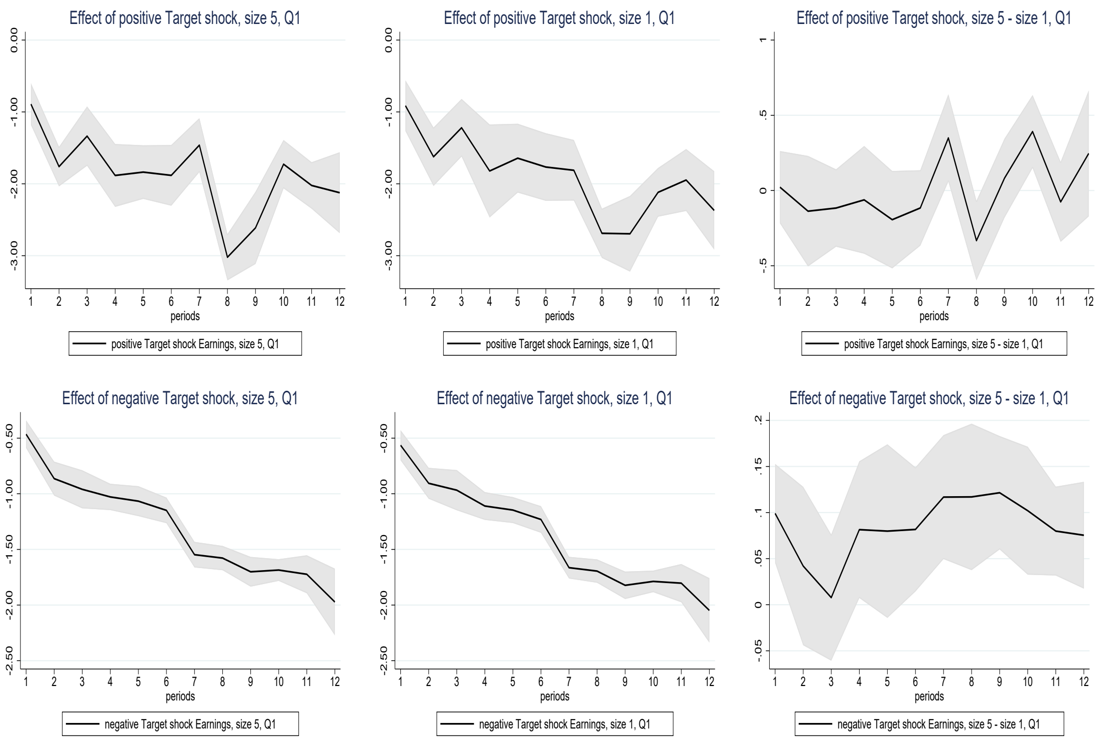

Figure B.4.3: Response of nominal earnings growth in small and large firms to a positive and negative target shock, before GR sample; Q1-robustness

Notes: The top row plots the impulse response function for nominal earnings 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 function for nominal earnings 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 nominal earnings growth in large and small firms to a positive (contractionary) target shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock in Q1. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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the full sample, shown in Section 3.3 in the main text. The left and middle bottom rows of Figures B.4.1 and B.4.2 show that the hiring growth and employment growth of large and small firms drop, similarly with the results in the main text (Section B.5 below, offers an explanation for those results). In addition, the bottom right panel shows that small firms gain more than large ones in terms of employment and hiring growth after monetary expansions, and the difference is statistically significant. The bottom row panels of Figure B.4.3 show a drop in earnings growth for both large and small firms, and the difference between the two is larger for small firms, and is statistically significant.

Overall, our conclusions based on the sample before the Great Recession for the Q1-robustness exercise, are unchanged.

B.5 Additional Q1 results

Figures B.5.1-B.5.3 show the response of hiring, employment, and earnings of new hires growth response to a target, positive target, and negative target shocks, for the first quarters of the sample (Q1-robustness), when all firm size categories are considered. Comparing those figures to the main text Figures 4-6 where all quarters are taken into account, we see that the main difference refers to expansionary target shocks. When only the first quarter is considered, then an expansionary target shock decreases employment and hiring growth. This is what drives the results in the main text and in Section B.4 above, where the employment and hiring growth of small and large firms decreases after an expansionary monetary policy shock in the Q1-robustness exercise.

B.6 Redefining small firms

In this section, we present the results where we consider a broader definition of small firms. In the figures B.6.1-B.6.3, small firms are defined as firms with a total number of employees of 20-49, instead of 1-19. Our conclusions are unchanged, i.e., hiring and employment growth falls more for large firms compared to small firms during monetary contractions, while hiring and employment growth expands more for small firms compared to large firms during monetary expansions. The earnings growth decreases in a homogeneous manner across firms in monetary contractions, although it decreases more for small firms in expan-

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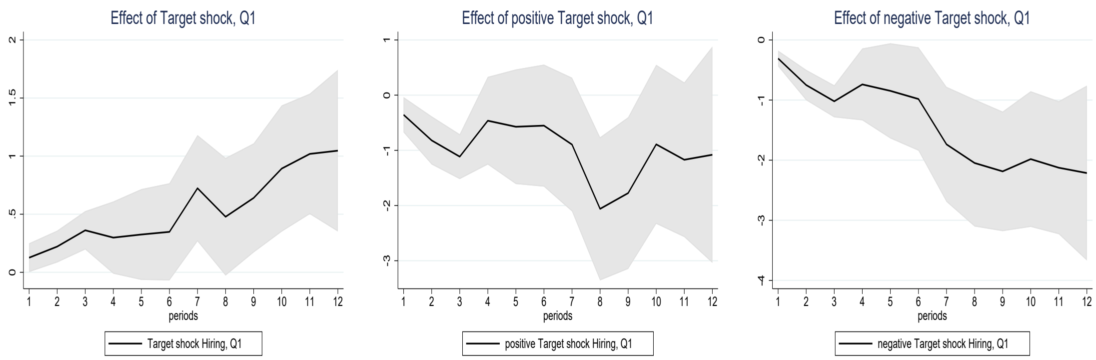

Figure B.5.1: Response of hiring growth to a target shock; Q1-robustness

Notes: The figure plots the impulse response functions of hiring growth to a target shock in Q1 (left panel), positive (contractionary) target shock in Q1 (middle panel) and the negative (expansionary) target shock in Q1 (right panel). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

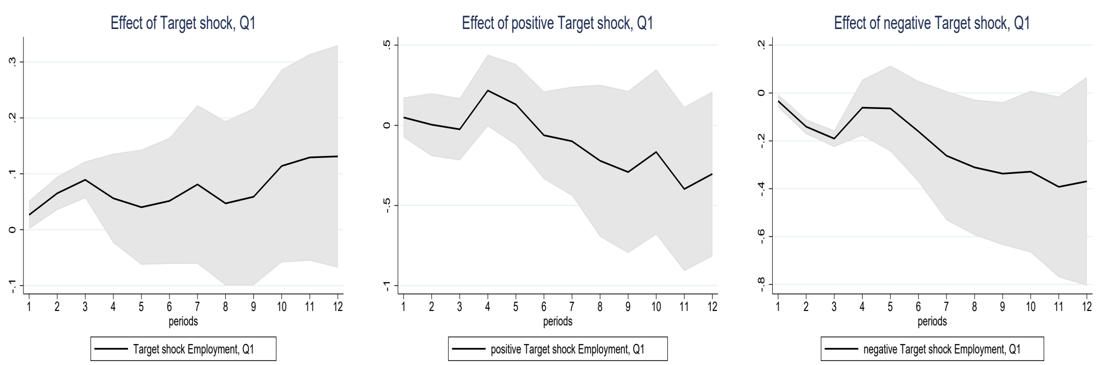

Figure B.5.2: Response of employment growth to a target shock; Q1-robustness

Notes: The figure plots the impulse response functions of employment growth to a target shock in Q1 (left panel), positive (contractionary) target shock in Q1 (middle panel) and the negative (expansionary) target shock in Q1 (right panel). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands

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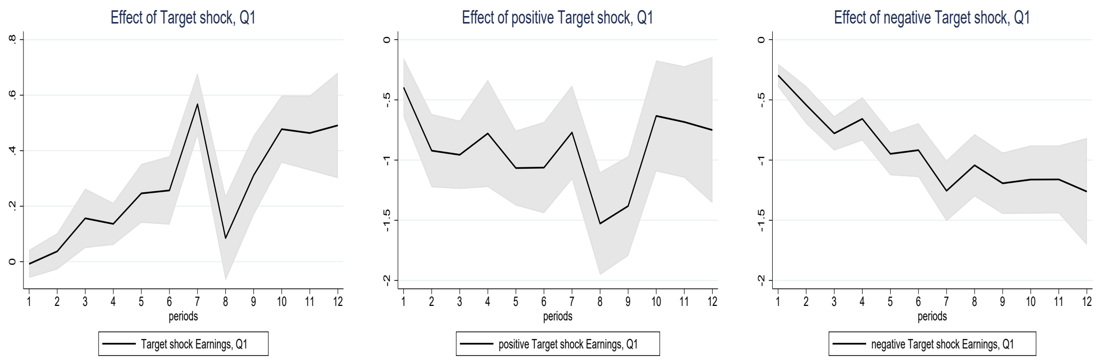

Figure B.5.3: Response of nominal earnings growth to a target shock; Q1-robustness

Notes: The figure plots the impulse response functions of earnings growth of new hires to a target shock in Q1 (left panel), positive (contractionary) target shock in Q1 (middle panel) and the negative (expansionary) target shock in Q1 (right panel). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

sions.

B.7 Average real earnings and price puzzle

In the main text, we report the response of the average nominal earnings of new hires. Here we report results for the average real earnings of new hires. Our overall conclusions for the average nominal earnings response remain when we examine the real earnings response, although the response of real earnings is milder than that of nominal earnings.

Figure B.7.1 shows, as in the last column of Figure 7 for nominal earnings, that the target shock does not affect much the real earnings of large firms, and slightly increases that of small firms. Figures B.7.2, B.7.3 and B.7.4 show that as for nominal earnings, the growth of earnings falls for both large and small firms after both monetary contractions and expansions. The difference is not significantly different across large and small firms for monetary contractions, but is deeper for small firms versus large firms, after monetary expansions. As such, the real earnings responses follow the same patterns as the nominal earnings ones shown in the main text.

We also proceed to examine the existence of a possible price puzzle in our data, that could contribute to the milder response of average real earnings versus that of nominal earnings.

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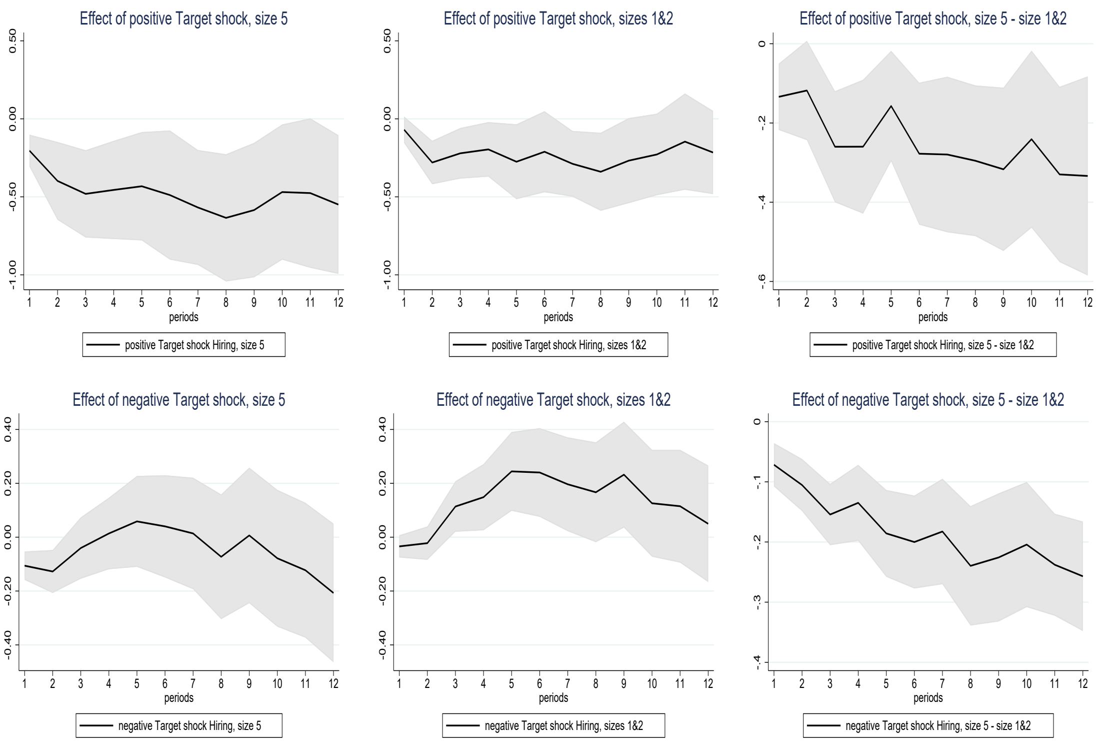

Figure B.6.1: Response of hiring growth in small and large firms to a positive and negative target shock

The top row plots the impulse response function for hiring growth to a positive (contractionary) target 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 function for hiring growth to a negative (expansionary) target 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) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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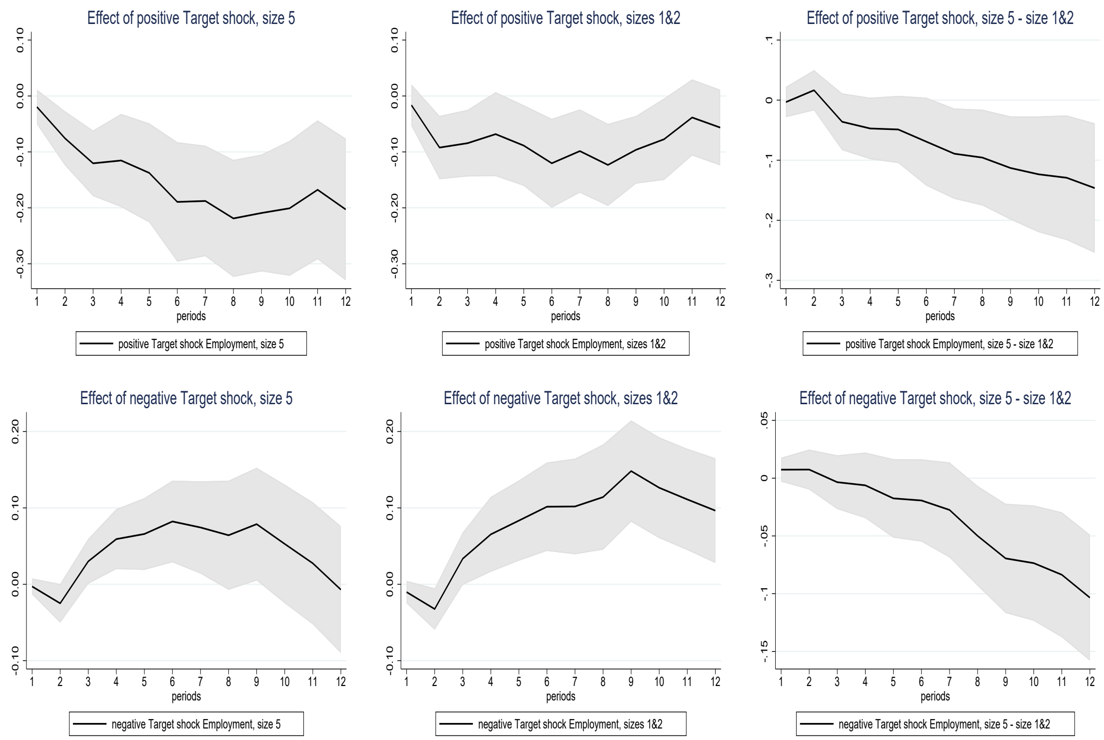

Figure B.6.2: Response of employment growth in small and large firms to a positive and negative target shock

Notes: The top row plots the impulse response function for employment growth to a positive (contractionary) target 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 function for employment growth to a negative (expansionary) target 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) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The shaded area is the 68% confidence bands. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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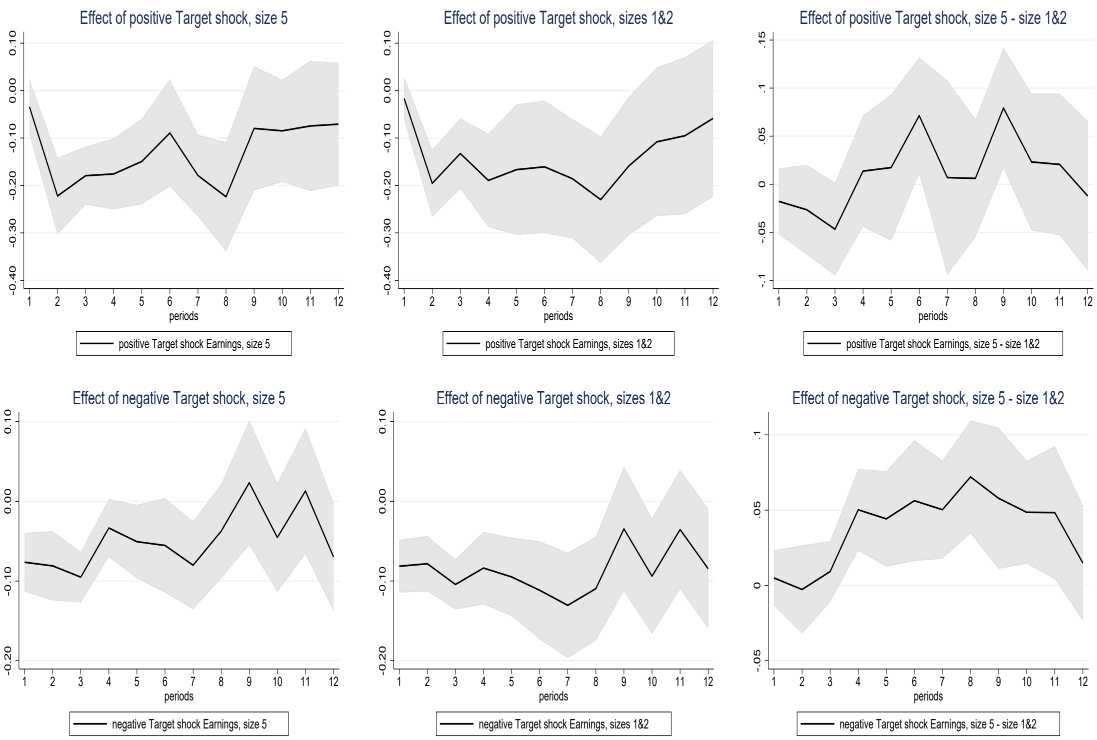

Figure B.6.3: Response of nominal earnings growth in small and large firms to a positive and negative target shock

Notes: The top row plots the impulse response function for nominal earnings growth to a positive (contractionary) target 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 function for nominal earnings growth to a negative (expansionary) target 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 nominal earnings growth in large and small firms to a positive (contractionary) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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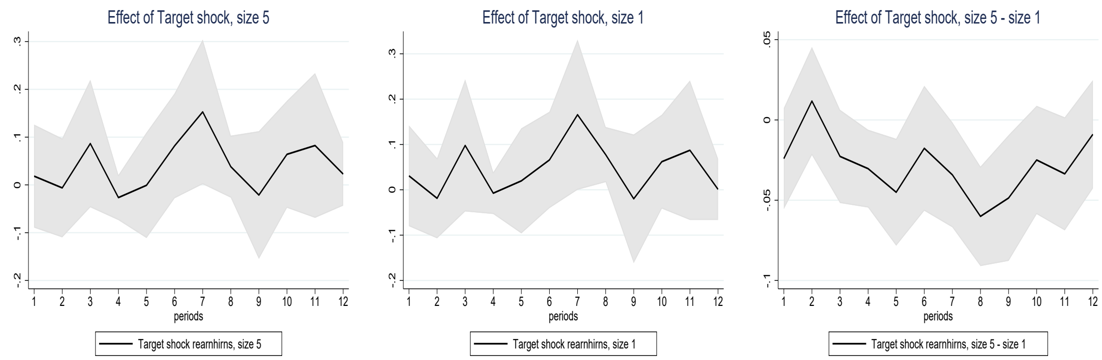

Figure B.7.1: Response of real earnings of new hires growth in small and large firms to a target shock

Notes: The left panel plots the impulse response function for real earnings of new hires growth to a target 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. The shaded area is the 68% confidence bands.

To test for the presence of the price puzzle we estimate the following equation

$$P_{t+h} = \alpha^h + \beta^h \epsilon_t^{Target} + \Gamma^{h\prime} Z_t + u_{t+h}^h, \qquad \text{(B.2)}$$

where P_{t+h} is the logarithm of CPI in period $t+h$, ϵ_t^{Target} is the target shock in period t, and Z_t is the vector of control variables. We include the current federal funds rate and four lags of the federal funds rate, four lags of log CPI, as well as the contemporaneous values of total capacity utilization. Since the error term, u_{t+h}^h, is likely serially correlated, we correct for it by applying Newey–West. Using target shocks, we find, as shown in Figure B.7.5, an initial increase in the log of CPI, as it is common in the literature. The response is overall not significantly different than zero, and the price level does not decrease after contractionary monetary policy shocks.

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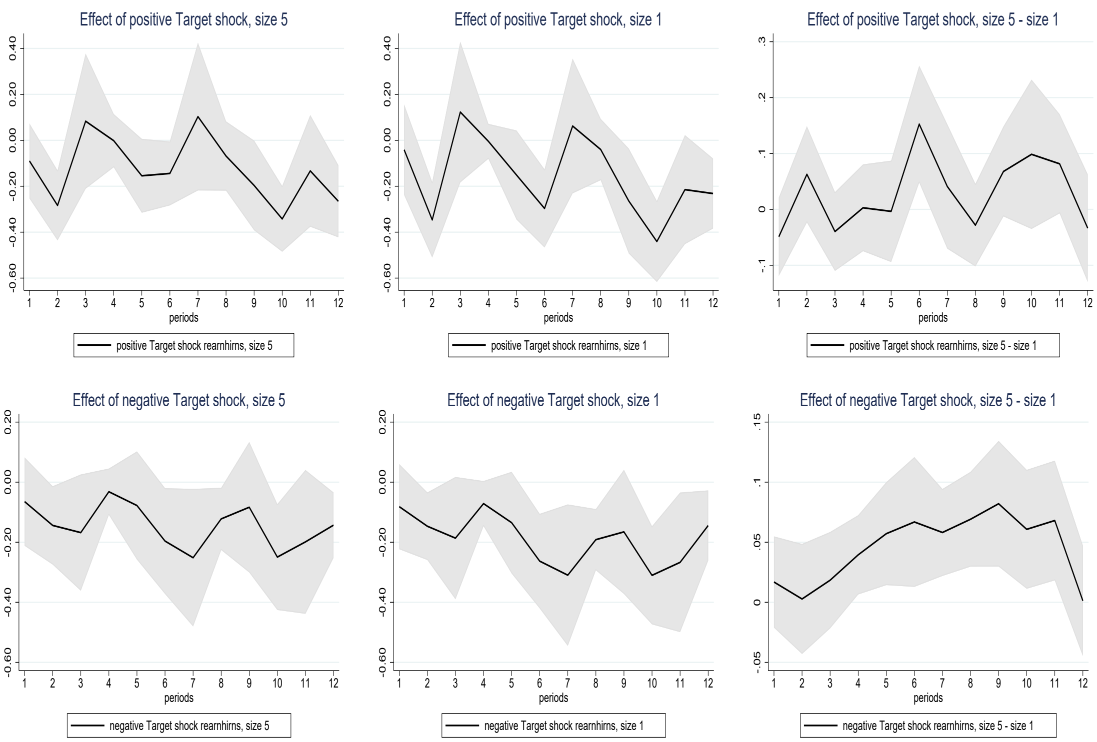

Figure B.7.2: Response of real earnings growth in small and large firms to a positive and negative target shock

Notes: The top row plots the impulse response function for real earnings growth to a positive (contractionary) target shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response function for real earnings growth to a negative (expansionary) target 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 real earnings growth in large and small firms to a positive (contractionary) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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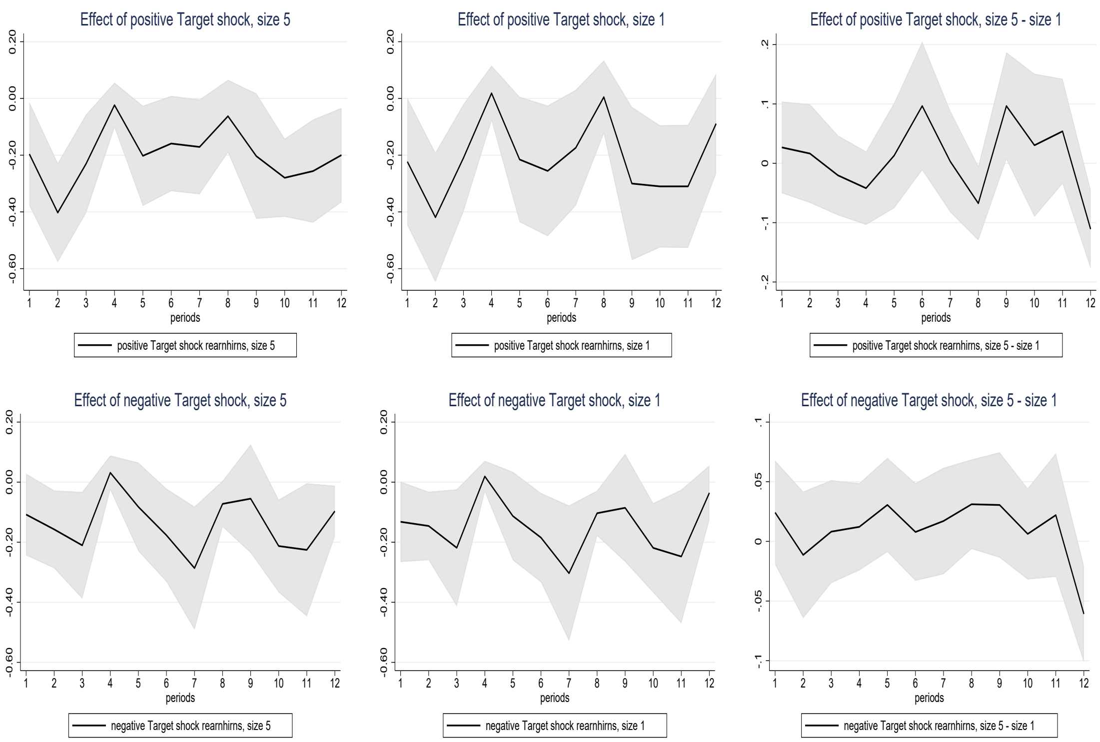

Figure B.7.3: Response of real earnings growth in small and large firms to a positive and negative target shock, before GR sample

Notes: The top row plots the impulse response function for real earnings growth to a positive (contractionary) target shock for large (size 5—left column) and small (size 1—middle column) firms while the bottom row plots the impulse response function for real earnings growth to a negative (expansionary) target shock large (size 5—left column) and small (size 1—middle column) firms. The top right panel plots the difference in the response of real earnings growth in large and small firms to a positive (contractionary) target shock and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock. The sample ends before the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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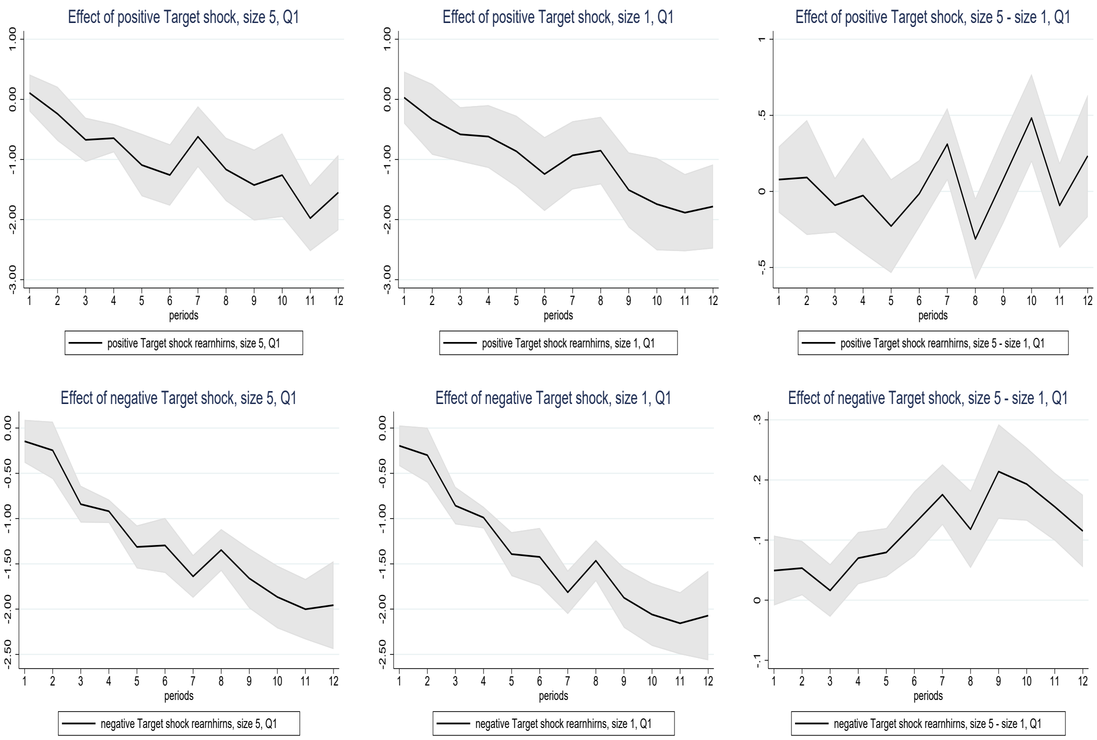

Figure B.7.4: Response of real earnings of new hires growth in small and large firms to a target shock; Q1-robustness

Notes: The top row plots the impulse response function for real earnings 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 function for real earnings 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 real earnings growth in large and small firms to a positive (contractionary) target shock in Q1 and the bottom right panel plots the difference in the response of large and small firms to a negative (expansionary) target shock in Q1. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 68% confidence bands.

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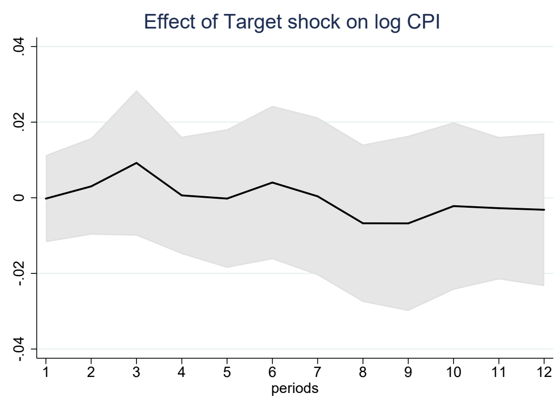

Figure B.7.5: The impulse response of CPI to target shock.

Notes: The figure plots the impulse responses of lnCPI following the target shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percentage points. The shaded area is the 90% confidence bands.

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