

Heterogeneous labour market response to monetary policy: small versus large firms^{*}

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Abstract

We study the effects of monetary policy shocks on the growth rates of hiring, employment and earnings of new hires across firms of different sizes. We find that contractionary and expansionary monetary policy shocks have different effects on hiring and employment growth for small and large firms. Relative to large firms, small firms are less responsive to contractionary monetary policy shocks while they are more responsive to expansionary shocks; contractionary shocks have immediate effects although expansionary ones take time to get realized. We also find that, as a consequence of monetary policy shocks, the earnings of new hires changes, and this wage effect depends on the sign of the shock and the size of the firm. We use a heterogeneous firm model with a working capital constraint, an upward sloping marginal cost curve and a financial accelerator effect, and augment it with the wage effect. We find that our empirical results are consistent with the model as long as the combined effect due to varying steepness of the marginal cost curve and the wage effect is stronger than the financial accelerator channel.

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

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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 conjecture that monetary policy affects employment. The objective of this paper is to examine the effects of monetary policy shocks on hiring, employment and earnings of new hires and study how these effects depend on the size of the firm.

Studying the effect of monetary policy on 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 worker flows in heterogeneous firms we re-examine the effects of monetary policy on the aggregate variables of interest.¹ Second, studying the effects of monetary policy on heterogeneous firms is central for emphasizing the channels of monetary policy transmission. This approach has been widely adopted by the related literature which examines the effects of monetary policy on investment (e.g., [Gertler and Gilchrist, 1994](#); [Cloyne, Ferreira, Froemel, and Surico, 2018](#); [Ottonello and Winberry, 2020](#)), but has been less explored for employment (e.g., [Abo-Zaid and Zervou, 2020](#); [Bahaj, Foulis, Pinter, and Surico, 2020](#); [Yu, 2021](#)). Third, the relative employment growth of small versus large firms has been in the forefront of policy discussions, and has resulted in policy enactment, such as the protection of small businesses by the the U.S. Small Business Administration (SBA), which focuses on helping small businesses overcome frictions and credit constraints. 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, 2014](#)), although there is less research on the relative employment response of small versus large firms to monetary policy shocks.

We use the publicly available Quarterly Workforce Indicators (QWI) dataset from the [Census \(2020\)](#) and employ local projections to compute impulse responses of labour market

¹Note that aggregate employment features worker flows that exhibit cyclical behavior. For example, [Krusell, Mukoyama, Rogerson, and Sahin \(2017\)](#) find procyclical behavior for transitions from unemployment to nonparticipation even when participation rate is procyclical. In order to examine these flows and their responses to changes in policy, we use data on hiring.

variables to high frequency monetary policy shocks. The QWI dataset includes all private (i.e., non-Federal) employers that are covered by unemployment insurance in the United States, aggregated by state, industry and firm size. Apart from employment, the dataset also includes information on hiring and earnings of new hires, helping us examine aspects of the labour market that are potentially masked when analyzing employment alone.

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 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. 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 labour market variables to both contractionary (positive) and expansionary (negative) target monetary policy shocks. We also take into account that these responses could be different for small and large firms.

We find that contractionary and expansionary monetary policy shocks have different effects on hiring and employment growth for small and large firms. Comparing the response across small and large firms, we find that a surprise monetary contraction decreases hiring and employment growth in all firms, but it does so less for smaller firms. Examining the effect of a surprise monetary expansion we find that hiring and employment growth of all firms increases, but it does so more for smaller firms. Monetary contractions are realized fast, although monetary expansions take time; that is, sign asymmetries matter for aggregate effects but they also affect the size distribution of firms operating. Overall, we find that the response of employment to monetary policy shocks is weaker than that of hiring growth, highlighting the importance of studying flows in gaining an understanding of the effects of monetary policy on the labour market. We also find that a surprise monetary contraction decreases the growth in earnings of new hires and the decrease is similar across small and large firms. In addition, a surprise monetary expansion increases the growth in

earnings of new hires and the increase is larger for large firms compared to small firms. That is, monetary policy introduces variation in employees earnings, affecting the firms' cost of hiring. The results for contractionary monetary policy shocks are robust when we exclude the Great Recession period and when we implement a method which allows us to overcome the reclassification bias.² The results for expansionary monetary policy shocks are, however, less robust on those exercises.

Reclassification bias might arise in our analysis because given constant size cutoffs in the QWI, firms are changing size bins and are re-classified over time and as economic conditions evolve. Thus, when studying the dynamic monetary policy effects on firms of certain size, it is possible that the size of some firms may change over the response period.³ 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. 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 exercise allows us to measure and compare responses of firms that differ in size; we call this exercise Q1-robustness.⁴

Given that financing constraints impact the transmission of monetary policy, we use a model of heterogeneous firms that features financing frictions and a working capital constraint to interpret our empirical results.⁵ In the model there are three channels due to which the employment response to a monetary policy shock of financially constrained firms might differ from that of unconstrained firms. The first channel is via the financial

²We discuss the reclassification bias below; for a detailed discussion of the reclassification bias see [Moscarini and Postel-Vinay \(2012\)](#).

³QWI 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 to small firms' bin, we are only studying the firms that are currently in the bin, and not the ones that have changed bins.

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

⁵[Mishkin \(1996\)](#) reviews various monetary policy transmission mechanisms. For example, the credit channel dictates that monetary policy matters because the nominal interest rate affects the cost of external financing which in turns affects the operation of firms that borrow. Furthermore, the collateral channel dictates that a monetary policy expansion increases the value of the firm and thus firms that use collateral to borrow can borrow more.

accelerator mechanism (Bernanke, Gertler, and Gilchrist, 1999) which in the presence of working capital constraints causes constrained firms to react more to a monetary policy shock compared to unconstrained firms. The second channel is through the upward sloping marginal cost curve, where the curve is flatter for unconstrained firms compared to constrained firms. Due to lower cost of borrowing, unconstrained firms are able to borrow more and hire workers at lower cost than the constrained firms. As a result, unconstrained firms are more responsive compared to constrained firms due to the marginal cost effect. These two opposing mechanisms through which monetary policy affects investment (Ottonello and Winberry, 2020) and employment (Bahaj, Foulis, Pinter, and Surico, 2020) have been previously emphasized in the literature. Given our empirical results on the response of earnings of new hires to a monetary policy shock, we incorporate a third channel in our theoretical model, the *wage effect*. 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 for financing employment. Although the decrease in wages is homogeneous across firms, the response is not, as constrained firms pay a spread on the amount that they borrow. The new wage effect channel suggests that unconstrained firms tend to be more responsive to monetary policy shocks. Meanwhile the marginal cost effect suggests that unconstrained firms will be more sensitive while the financial accelerator effect suggests that the constrained firms will respond more. As such, as long as the the combined effect due to varying steepness of the marginal cost curve and the wage effect is stronger than the financial accelerator channel, large firms will respond more to a contractionary monetary shock, as seen in our empirical findings. Our model can also suggest a reasoning behind our finding that large firms respond less than small ones to an expansionary monetary policy shock, through an heterogeneous wage effect. The growth of wages of new hires is higher in large firms compared to small firms after a monetary expansion, reducing the marginal benefit of new hires for large firms. This would then suggest that unconstrained firms tend to respond less than constrained ones to expansionary monetary policy shocks, as we find in our empirical results.

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 and to the cycle, like the work of [Sharpe \(1994\)](#), [Gertler and Gilchrist \(1994\)](#), [Davis and Haltiwanger \(1999\)](#), [Moscarini and Postel-Vinay \(2012\)](#), [Chari, Christiano, and Kehoe \(2013\)](#), [Fort, Haltiwanger, Jarmin, and Miranda \(2013\)](#), [Haltiwanger, Jarmin, and Miranda \(2013\)](#), [Kudlyak and Sanchez \(2017\)](#), [Sedláček and Sterk \(2017\)](#), [Jeenas \(2019\)](#), [Bahaj, Foulis, Pinter, and Surico \(2020\)](#), [Crouzet and Mehrotra \(2020\)](#), [Ottonello and Winberry \(2020\)](#), [Howes \(2021\)](#), [Yu, 2021](#), among others.

A strand of this literature has focused on the effects of monetary policy on the investment and sales of heterogeneous firms ([Gertler and Gilchrist, 1994](#), [Chari, Christiano, and Kehoe, 2013](#), [Kudlyak and Sanchez, 2017](#), [Jeenas, 2019](#), [Crouzet and Mehrotra, 2020](#), [Ottonello and Winberry, 2020](#)). Another strand has examined employment responses to other variables, but not with respect to monetary policy shocks ([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 those 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 \(1994\)](#) in their seminal paper show that after tight money episodes, sales and inventories of small (in terms of assets) firms are more responsive than those of larger firms. Based on an earlier literature e.g., [Fazzari, Hubbard, and Petersen \(1988\)](#), that finds a relationship between firm size and financing constraints, [Gertler and Gilchrist \(1994\)](#)'s results emphasize 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. More recent analysis by [Jeenas \(2019\)](#), [Cloyne, Ferreira, Froemel, and Surico \(2018\)](#) and [Ottonello and Winberry \(2020\)](#) explores the strength of the investment channel. Like this literature, 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 labour market.

The second strand of the literature explores the cyclicalities 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 results are supported by theoretical work (Moscarini and Postel-Vinay, 2013) based on labour market frictions, where firms' size proxies for firms' productivity. Our work contributes to this literature by studying the differential response in employment dynamics of large and small firms to a specific type of macroeconomic shock, i.e., the monetary policy shock.⁶ Additionally, we contribute to this literature through our Q1-robustness analysis which provides an alternative way for addressing the reclassification bias in the QWI dataset.

Our paper is closely related to Bahaj, Foulis, Pinter, and Surico (2020) and Yu (2021) who study the effect of monetary policy shocks on employment among heterogeneous firms, as we do. However, the data and empirical methods employed in those papers are different. Bahaj, Foulis, Pinter, and Surico (2020) use yearly firm-level data in the United Kingdom and we use quarterly data on employment dynamics, aggregated by state, industry, and firm size, in the United States. Given their firm-level data, Bahaj, Foulis, Pinter, and Surico (2020) can directly examine collateral constraints and verify the existence of the financial accelerator channel. We use the detailed information on hiring and earnings of the newly hired employees, through which we are able to observe labour flows and uncover a novel channel that affects relative employment response of large versus small firms to monetary policy shocks, i.e., the wage effects. Yu (2021) uses data from the United States, a different than ours monetary policy shocks series and model, focusing on collateral constraints and not on the wage channel, as we do.

Lastly, our paper relates to the literature that studies the effects of monetary policy on aggregate employment. Earlier literature, for example Christiano, Eichenbaum, and Evans (1996), shows that employment decreases and unemployment increases after a monetary policy tightening. However, using similar methods and more recent data while excluding the 1981 recession, Ramey (2016) finds that unemployment decreases after monetary policy tightening, a puzzling result. In order to better understand the effects of monetary policy on macroeconomic aggregates, Ramey (2016) calls for careful identification of monetary policy shocks. In addition to careful identification of monetary policy shocks, our empirical results

⁶In our empirical specifications we control for differential state-unemployment effects across firm sizes.

also highlight the relevance of examining the effects of both contractionary (positive) and expansionary (negative) target monetary policy shocks. Our empirical results also suggest the importance of studying worker flows, as also noted in [White \(2018\)](#), and heterogeneity of responses among heterogeneous firms, as also argued by [Yu, 2021](#) and [Bahaj, Foulis, Pinter, and Surico \(2020\)](#), in understanding the aggregate employment responses to monetary policy shocks.

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.

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 (i.e., not Federal) employers that are covered by unemployment insurance in the United States, 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 US 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 1995:1.⁷ 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,

⁷The fact that the announcement of the Federal Funds rate target becomes official after this period has contributed in making the cutoff decision.

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 hires, employment, and 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 mutual agreement between firms and employees for the match to occur. It allows us to also understand the role of monetary policy in creating labour 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, average monthly earnings of newly hired employees, allows us to measure current wage rate that is not related to previous wage contracts and negotiations. The data are seasonally adjusted using X-12 ARIMA from the U.S. Census Bureau.

Table 1 presents summary statistics of the labour 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 employment and earnings of newly hires.⁸ 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. Figures A.1 and A.2 in Appendix A.3 plot the distribution of employment and new hires for small and large firms across industries and states. While the distribution is not uniform, the figures illustrate that small and large firms are not specific to any industry and/or geographic location. Comparing the aggregate employment in our sample with the total private employment from the Federal Reserve Economic data (FRED) in Figure 1, we

⁸These differences are statistically significant at 1% level.

Table 1: Summary statistics of labour market variables

Variables (growth rates, in percent)		All firms	Small (size 1) firms	Large (size 5) firms
Hiring	mean	-0.88	-1.38	0.10
	median	0.69	-0.86	1.76
	st. dev.	19.97	19.53	31.64
Employment	mean	1.10	0.65	1.88
	median	1.51	0.67	1.91
	st. dev.	5.59	10.54	11.27
Earning of new hires	mean	3.36	2.86	3.42
	median	3.32	2.80	3.40
	st. dev.	11.36	20.04	16.96

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.

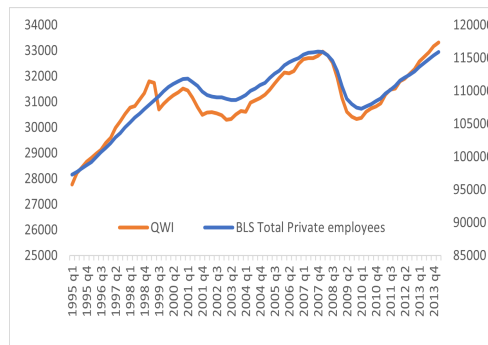


Figure 1: Employment from QWI

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).

see that the trends in our sample are closely related to the trends in the aggregate. This is despite 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 60 minute time window, starting 15 minutes before and ending 45 minutes after the announcement. Following [Wong \(2019\)](#) we construct a quarterly measure by adding

the shocks that occur within a quarter.⁹

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 future path of the economy. 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.¹⁰

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) and size (large or small) of monetary policy shocks. In our analysis we will focus on the sign asymmetry of the target monetary policy shocks. In our Q1-robustness exercise, we also address asymmetric effects across quarters as Olivei and Tenreyro (2007) have done before.

Table 2 reports the summary statistics of the high frequency monetary policy (MP) shocks and target shocks, and the positive and negative MP shocks and target shocks, where the latter is the focus of our empirical analysis. What is striking is that the standard deviation of the negative monetary policy shock is approximately 3 times larger relative to the positive one; moreover, the standard deviation of the negative target shock is more than double relative to its positive counterpart. This can also be seen from Figure 2. Given that the positive and negative shocks have distinct characteristics, they are likely to impact the labour market variables differently. We address this in our empirical analysis by studying the effects of positive and negative shocks separately. Appendix A provides

⁹We 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 possible noise that the terrorist attack created.

¹⁰We 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.

Table 2: Summary statistics of monetary policy shocks

	MP shocks	Target shocks
Overall		
Mean	-3.20	-0.66
Standard deviation	10.14	12.72
Positive (rate increase)		
Mean	1.04	3.53
Standard deviation	2.56	4.53
Negative (rate decrease)		
Mean	-4.21	-4.19
Standard deviation	9.35	10.57

Notes: The table reports mean and standard deviation (in basis points) of the change in 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.

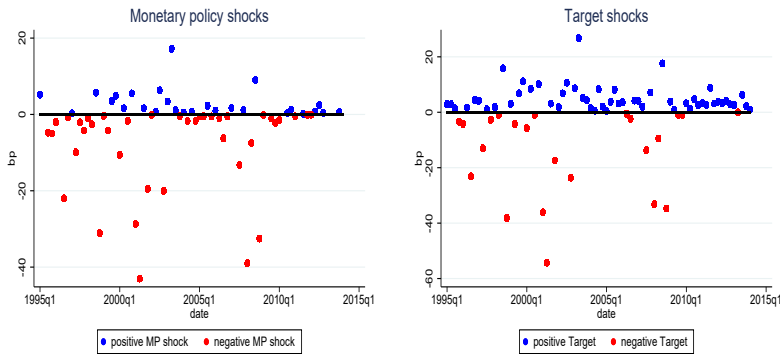


Figure 2: Positive and negative monetary policy shocks

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

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 labour 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. Our baseline equation is

$$\Delta_h n_{gis,t+h} = \alpha_{gis}^h + \beta_{Target}^h \epsilon_t^{Target} + \beta_{Path}^h \epsilon_t^{Path} + \delta_i^h \epsilon_t \mathbb{I}_i + \Gamma^{h'} Z_t + u_{gis,t+h}^h \quad (1)$$

where $\Delta_h n_{gis,t+h} \equiv \log N_{gis,t+h} - \log N_{gis,t}$ is the cumulative difference of the log labour market variable N in state g , industry i , firm-size s , h periods after the monetary policy shock in period t . The coefficient of interest is β_{Target} which is the effect of target shock ϵ_t^{Target} . We control for state-industry-size specific fixed effects, α_{gis}^h . The differential effects of monetary policy across industries are captured by industry-shock interactions, $\epsilon_t \mathbb{I}_i$, where \mathbb{I}_i is the industry indicator and ϵ_t is the monetary policy shock. We also include state unemployment interacted with firm size as the control variable, Z_t .

The reason we include state unemployment interacted with firm size in our specification is because previous literature on firms' cyclical sensitivity ([Moscarini and Postel-Vinay, 2012](#)) has emphasized that large firms increase (decrease) net job creation more than small firms at times when the unemployment rate is low (high). By including the interaction of state unemployment with firms' size as an explanatory variable, we capture the effect of monetary policy on the labour market variables while controlling for their fluctuations due to changes in state unemployment.¹¹ In fact, we do find that the effect of state unemployment on employment growth is consistent with the response of large firms being stronger than that of smaller firms. [Figure B.1](#) in [Appendix B.1](#) plots those results. We also find, and show in [Figure B.2](#) in [Appendix B.1](#), that in the specification without monetary policy shocks, large firms increase employment growth more than small firms at times when the unemployment rate is low and vice versa, consistent with the results in [Moscarini and Postel-Vinay \(2012\)](#).

As noted in [Jordà \(2005\)](#), for regressions where $h \geq 1$ the error term in equation (1) is serially correlated. We follow [Jordà, Schularick, and Taylor \(2015\)](#) and cluster standard errors by the panel identifier "state-industry-size". Such clustering produces standard errors that are robust to flexible time dependence of shocks and as a result we have wider bands compared with [Driscoll and Kraay \(1998\)](#) standard errors.

In our empirical analysis, we also examine the effect of positive and negative shocks. The equation that we estimate is the following

¹¹We thank Giuseppe Moscarini for making this suggestion.

$$\begin{aligned}\Delta_h n_{gis,t+h} = & \alpha_{gis}^h + \beta_{Target+}^h \epsilon_t^{Target+} + \beta_{Target-}^h \epsilon_t^{Target-} \\ & + \beta_{Path+}^h \epsilon_t^{Path+} + \beta_{Path-}^h \epsilon_t^{Path-} + \delta_i^h \mathbb{I}_i + \Gamma^{h'} Z_t + u_{gis,t+h}^h.\end{aligned}\tag{2}$$

Finally, to examine the heterogeneous response of firms that differ in size to positive and negative target policy shocks, we interact the monetary policy shock with firm size. The specification is given below

$$\begin{aligned}\Delta_h n_{gis,t+h} = & \alpha_{gis}^h + \beta_{s,Target+}^h \epsilon_t^{Target+} \mathbb{I}_s + \beta_{s,Target-}^h \epsilon_t^{Target-} \mathbb{I}_s \\ & + \beta_{s,Path+}^h \epsilon_t^{Path+} \mathbb{I}_s + \beta_{s,Path-}^h \epsilon_t^{Path-} \mathbb{I}_s + \delta_i^h \epsilon_t \mathbb{I}_i + \Gamma^{h'} Z_t + u_{gis,t+h}^h\end{aligned}\tag{3}$$

where \mathbb{I}_s is a size specific indicator variable. Our impulse response functions presented below are constructed using the coefficients $\beta_{s,Target}^h$ 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 labour market variables to target monetary policy shocks after appropriately controlling for forward guidance or information effects (e.g. [Gürkaynak, Sack, and Swanson, 2005](#), [Campbell, Evans, Fisher, Justiniano, Calomiris, and Woodford, 2012](#), [Nakamura and Steinsson, 2018](#)). In Section 2.1, we also show that the negative and positive target shocks series are strikingly different (Table 2); as such, we examine separately the effects of contractionary and expansionary target monetary policy shocks on the labour market variables of interest.

Our first set of results highlights the effects of target shocks on the labour market variables, distinguishing between monetary tightening and expansion. Our second set of results sheds light on the transmission of monetary policy showing that the response to contractionary and expansionary target shocks differ across firms of different size. Finally, we check the robustness of our findings by conducting our analysis using target shocks that occur only in the first quarter, the ‘‘Q1-robustness’’ exercise, to address the reclassification bias.

3.1 Effects of positive and negative target shocks

Using the estimates of equation (1), Figure 3 shows that a monetary policy tightening (an increase in target shock, shown in the left panel) decreases hiring growth. Furthermore, when estimating equation (3) and looking at the response of hiring to positive target monetary policy shocks (middle panel), we see that the contractionary policy effect is what one would expect, decreasing hiring growth. The response of hiring to negative target monetary policy shocks (right panel) however, shows a delayed response, with hiring growth increasing only after the first 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 3.7% (0.82×4.53) in the eighth quarter, two years after the shock, and over the same period, a one standard deviation negative target shock increases hiring growth by 2.6% (0.25×10.57). Note that in this calculation 0.82 and 0.25 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. Similarly, Figures 4 and 5 show that the response of employment and nominal wages of new hires has the expected sign, although there is also a delayed response after an expansionary monetary policy shock.¹²

Overall, when we consider sign asymmetries, we observe that a monetary contraction results in expected changes considering the monetary shock as an adverse shock in the labour market. However, for monetary expansions, we often see responses that do not suggest, especially in the first periods after the shock hits, this intuition.¹³ We note that the length of the sample might not be adequate for making conclusions; however, the same results carry over when we consider variation across firm size, as we show in the next

¹²It 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. [Groschen and Potter, 2003](#), [Schreft and Singh, 2003](#), [Jaimovich and Siu, 2020](#), [Berger, 2018](#)).

¹³[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 labour market matches survive. We do not take this modelling approach, but we note here that reasons that might affect the quality of the labour market matches, apart from the unemployment rate that we control for, might be operating after monetary policy shocks, driving the initial labour market response during monetary expansions.

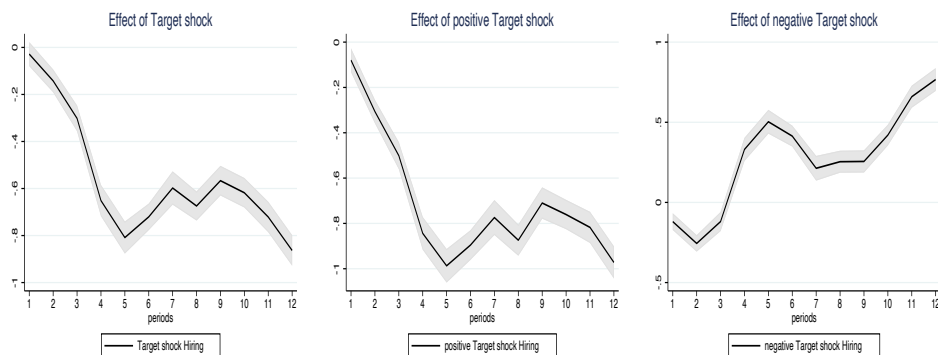


Figure 3: Response of hiring growth to a target shock

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 90% confidence bands.

subsection.

In terms of magnitude, our results are comparable with the existing literature. For example, Bahaj, Foulis, Pinter, and Surico (2020) using employment data find that employment falls by 1% after two years as a result of a one standard deviation monetary policy shock.¹⁴ Our empirical results suggest that a positive shock decreases employment growth by about 1.47% in the eighth quarter; and over the same period a standard deviation negative shock increases employment growth by 1.2%.

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.

Hiring Looking across firm size, our empirical results in Figure 6 show that contractionary target shocks (left panel) impact large firms more relative to small firms, and expansionary target shocks (right panel) impact small firms more. In particular, large firms decrease hiring growth more in response to a contractionary monetary policy shock and they increase hiring growth less in response to an expansionary monetary policy shock, compared to small

¹⁴Note that in Bahaj, Foulis, Pinter, and Surico (2020) monetary policy shocks are identified through a VAR and their results are for the U.K.

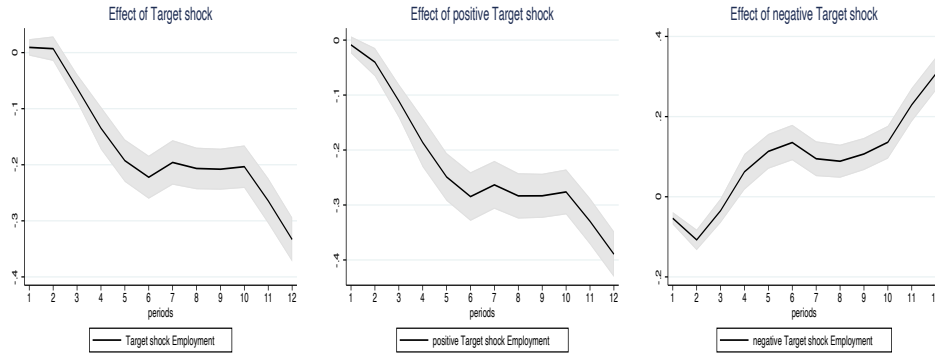


Figure 4: Response of employment growth to a target shock

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 90% confidence bands

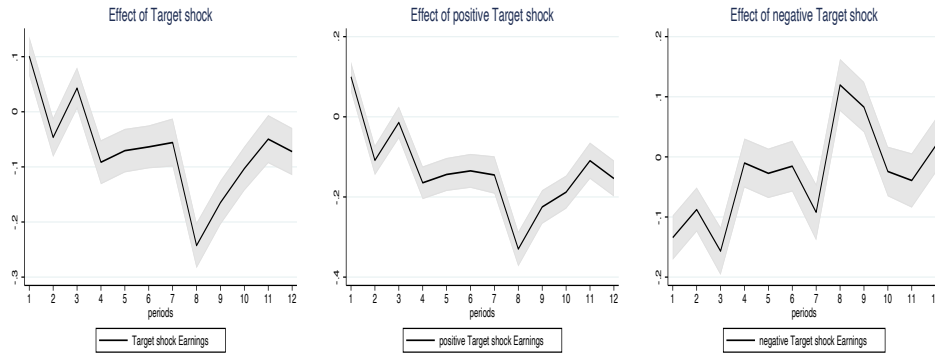


Figure 5: Response of nominal earnings growth to a target shock

Notes: The figure plots the impulse response functions of 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 90% confidence bands.

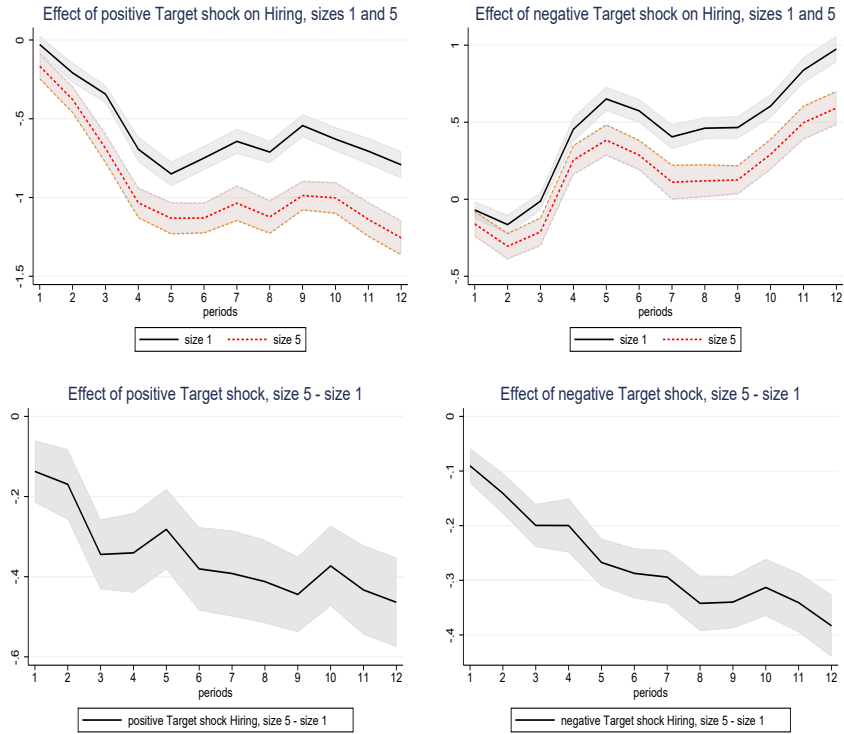


Figure 6: Response of hiring growth in small and large firms to a target shock

Notes: The top left panel plots the impulse response function for hiring growth to a positive (contractionary) target shock for small (size 1-black line) and large (size 5-red dotted line) firms while the top right panel plots the impulse response function for hiring growth to a negative (expansionary) target shock for small (size 1-black line) and large firms (size 5-red dotted line). The bottom left 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 90% confidence bands.

firms. Here again, the response of the firms to an expansionary shock is delayed relative to their response to a contractionary shock. Figure 6 shows separately the response of small and large firms (top panel), and the difference in the responses of the two (bottom panel). On the bottom panel 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 (for the portion of the graph that firms expand).

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 decreases hiring growth of large firms by 5.0% (1.1×4.53) and of small firms by 1.1% (0.25×4.53) after eight quarters. Hence the fall in hiring growth in large firms is close to 5 times more than the small firms. For a standard deviation negative shock, hiring growth in large firms increases by 1.1% (0.1×10.57) and in small firms by 5.3% (0.5×10.57) in the eighth quarter. So in this case, the rise in hiring growth in small firms is close to 5 times more than the large firms. These results suggest that after taking into account the impulse and response asymmetries, monetary policy affects the hiring growth of large firms more compared to that of small firms in response to a contractionary monetary policy shock and vice versa when considering an expansionary target shock. The difference in responses across firms is significant and increases (in absolute value) over time, for both positive and negative shocks.

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 7 presents the response of small and large firms (top panel), and the difference in the responses of the two (bottom panel). As we see in Figure 7, a monetary policy tightening decreases employment growth, and it does so more for large firms than for small firms; also, a monetary policy loosening increases employment growth and it does so more for small firms. 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 employment growth of large firms by about 1.7% (0.38×4.53), and of small firms by 1.0% (0.21×4.52) in the eighth quarter; a standard deviation negative shock increases employment growth of large firms by 0.8% (0.08×10.57), and of small firms by 1.3% (0.12×10.57) in the eighth quarter.

Taken together, our empirical results suggest that in fact large firms are more responsive to a contractionary monetary policy 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 labour 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. Figure 8 shows how the average earnings growth of new hires in small and large firms respond to monetary policy shocks. On the top panel we see that average earnings growth decreases after a monetary policy tightening (positive target shock) and increases after a monetary expansion (negative target shock) for both types of firms. For the positive target shock, the responses seem similar across small and large firms (black and red dotted line, respectively), and the difference of the responses of the two types is not statistically significant, as seen on the bottom panel of Figure 8. However for a negative shock, the difference between the large and small firms is statistically significant after three quarters, where the earnings growth of new hires is more in large firms compared to small firms.

In terms of magnitude, we see that a standard deviation positive shock decreases average earnings growth in firms of either size by 1.6% (0.35×4.53) in the eighth quarter. And a standard deviation negative shock increases average earnings growth of large firms by about 1.9% (0.18×10.57) and of small firms by about 0.9% (0.09×10.57) and the difference is statistically significantly different than zero in the later quarters.

We report results for nominal average earnings, instead of average real earnings, because

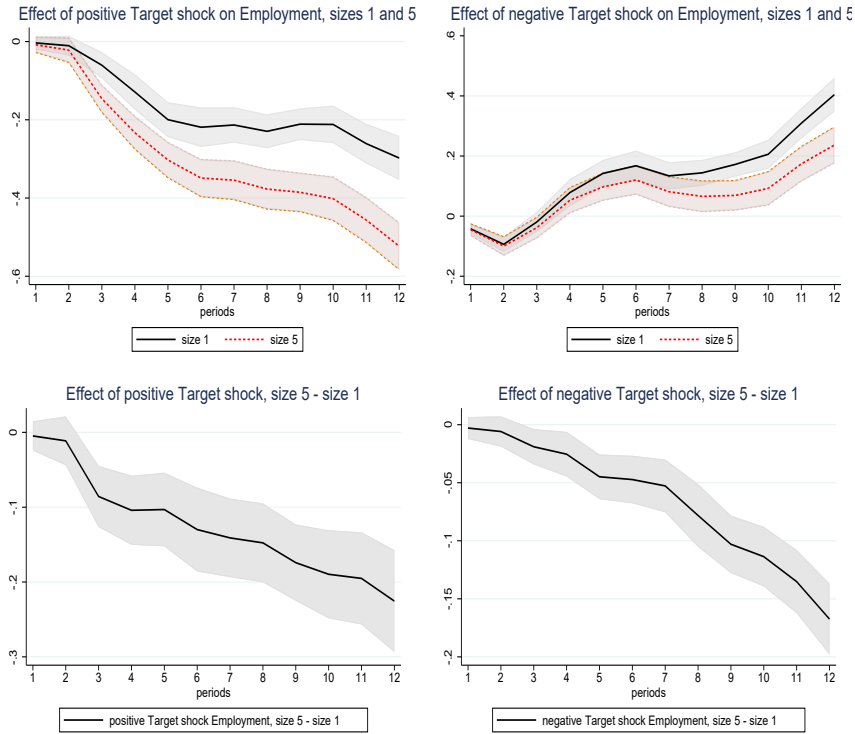


Figure 7: Response of employment growth in small and large firms to a target shock

Notes: The top left panel plots the impulse response function for employment growth to a positive (contractionary) target shock for small (size 1-black line) and large (size 5-red dotted line) firms while the top right panel plots the impulse response function for employment growth to a negative (expansionary) target shock for small (size 1-black line) and large firms (size 5-red dotted line). The bottom left 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 horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 90% confidence bands.

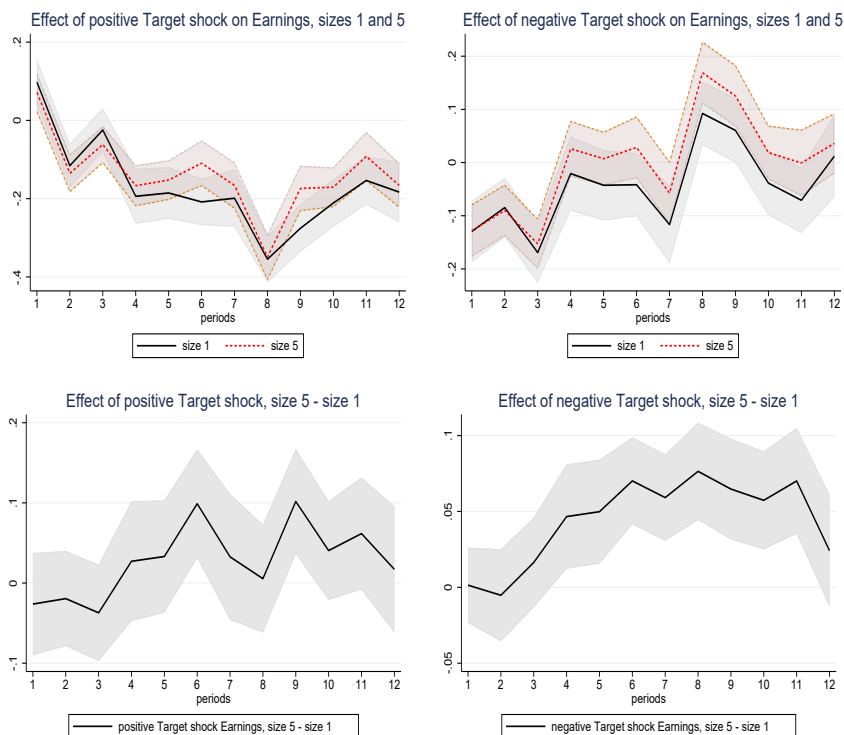


Figure 8: Response of nominal average earnings growth in small and large firms to a target shock

Notes: The top left panel plots the impulse response function for earnings growth to a positive (contractionary) target shock for small (size 1-black line) and large (size 5-red dotted line) firms while the top right panel plots the impulse response function for earnings growth to a negative (expansionary) target shock for small (size 1-black line) and large firms (size 5-red dotted line). The bottom left panel plots the difference in the response of 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 90% confidence bands.

the monetary policy shocks induce a well known price puzzle, as lately documented by [Ramey \(2016\)](#). In our dataset using monetary policy shocks and the CPI, we still find the price puzzle. Appendix [B.3](#) shows these results.

3.3 Monetary policy shocks in first quarter

In this section we present results utilizing the fact that in the QWI firms' 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. We examine the effects of monetary policy shocks that occur in the first quarter and study the responses in the next three quarters; we refer to that exercise as

Q1-robustness. In this way, we address the possibility that our results so far on the relative response of large versus small firms are impacted by reclassification bias. Note that the 12-periods impulse response functions are shown 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.4](#).

On the left panels of [Figure 9](#) we see that large firms decrease hiring and employment growth more than small firms after a contractionary target shock. The difference in response is significant for employment growth. Earnings growth decreases for both types of firms in a similar manner.¹⁵ Thus, our conclusions regarding a monetary policy tightening are robust to the Q1-robustness exercise.

For an expansionary policy shock the Q1-robustness analysis is less applicable. This is because the expansionary shocks are slower in affecting the labour market, as seen both in the aggregate figures, i.e., [Figures 3-5](#), and in the responses of firms of different sizes, i.e., [Figures 6-8](#). As such, the Q1-robustness exercise, that is only valid for the first three quarters after the shock hit, is harder to be reconciled for the expansionary shock. On the right panels of [Figure 9](#) we see that until the third quarter, when the Q1-robustness exercise is valid, both large and small firms decrease earnings growth after a monetary expansion; hiring and employment growth of small firms is not statistically significant different than zero, and hiring growth of large firms decreases, contrary to our benchmark results. The conclusion though that small firms gain more than large ones in terms of hiring and employment growth, remains, and the difference is statistically significant for hiring (shown in [Figure B.7](#) of [Appendix B.4.1](#)).

Overall, our main results are robust to the Q1-robustness exercise for a monetary tightening. For a monetary expansion however, our results are not as robust.¹⁶

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

¹⁵The differences in responses between large and small firms for the Q1-robustness exercise are shown in [Figure B.7](#) of [Appendix B.4.1](#).

¹⁶The same is true for another robustness exercise we perform, excluding the Great Recession period, where the sample period is 1995:1-2007:3. Specifically, the results are very robust for monetary contractions, but weaker for monetary expansions. The same is true for the Q1-robustness exercise performed for the 1995:1-2007:3 subsample. [Appendix B.2](#) plots these results.

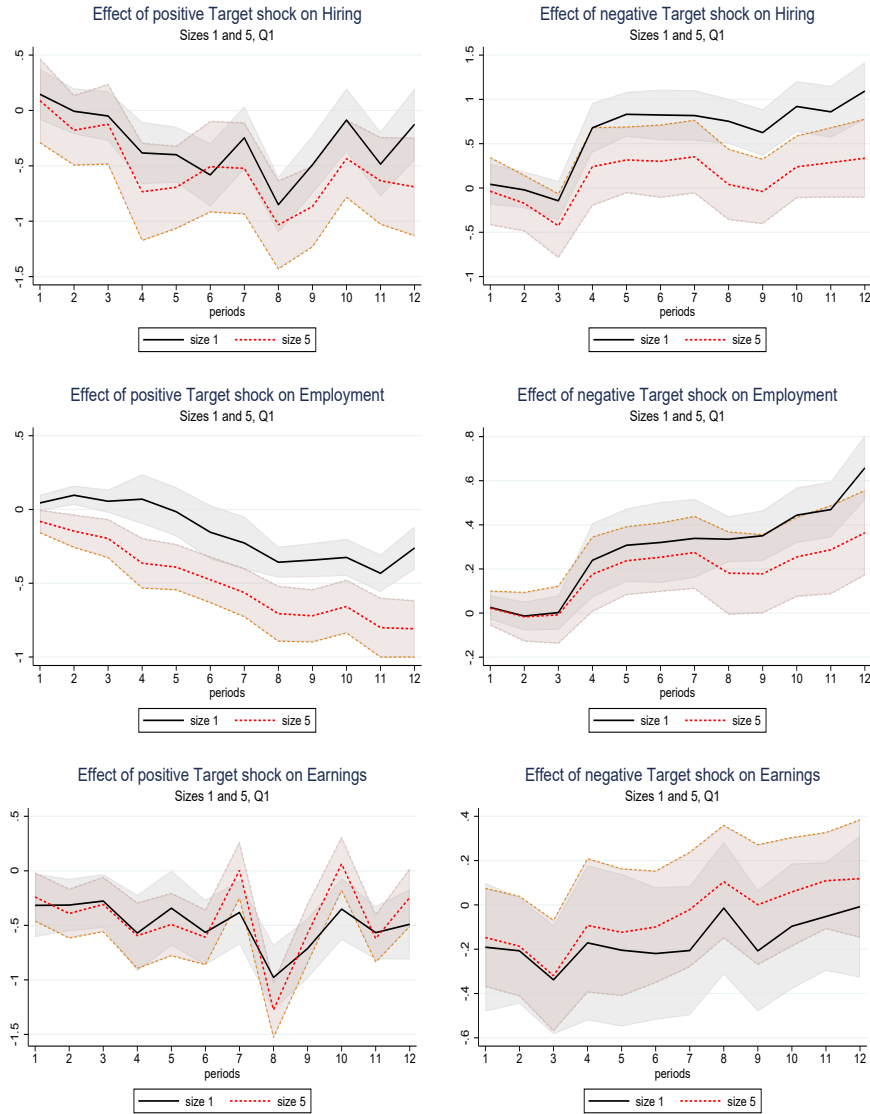


Figure 9: Response of hiring, employment and average earnings growth in small and large firms to a target shock; Q1-robustness

Notes: The top panel plots the impulse response functions for hiring growth, while the middle and bottom panels plot the impulse response functions for employment growth and earnings growth. In each of the panels, the left panel plots the impulse response function to a positive (contractionary) target shock for small (size 1-black line) and large (size 5-red dotted line) firms after shocks in Q1 while the right panel plots the impulse response function to a negative (expansionary) target shock for small (size 1-black line) and large firms (size 5-red dotted line) after shocks in Q1. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 90% confidence bands.

policy shocks occurring at a different time in the year. Earlier work by [Olivei and Tenreiro \(2007\)](#) estimate 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.¹⁷ The Q1-robustness exercise that we implement refers to the number of hires and the average earnings of the new hires, and not to total workers employed and their earnings. As such, the negotiations of earnings and hours happen simultaneously and the results are not imputed by uneven staggering of wage contracts re-negotiations, that take place with the already employed individuals.¹⁸

4 Model

In this section, we follow the model of [Bahaj, Foulis, Pinter, and Surico \(2020\)](#), which is an employment-focused adaptation of [Ottonello and Winberry \(2020\)](#) in a partial equilibrium setting. To relate this model with our empirical results in Section 3, we modify the model appropriately. Specifically, we allow nominal wages to change in response to changes in the nominal interest rate. This is because our empirical results suggest that the nominal earnings of new hires respond to monetary policy shocks and are not constant as assumed in [Bahaj, Foulis, Pinter, and Surico \(2020\)](#).

In the model there is a working capital constraint so if a firm needs to borrow to finance its working capital, then an increase in the interest rate would decrease its labour 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, 2020](#) for monetary shocks; [Mendoza, 2010](#) for productivity shocks). The empirical finding in [Bahaj, Foulis, Pinter, and Surico \(2020\)](#) lends support to the importance of working capital requirements in the transmission of monetary policy shocks as firms whose employment responds significantly to monetary policy shocks also react the most in terms of working capital changes. The working capital constraint has been traditionally thought of as a

¹⁷The 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, at 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.

¹⁸However, 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 \(2020\)](#).

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 labour input before the output is supplied. This interpretation allows for wider applicability of the working capital constraints.¹⁹

Following [Bahaj, Foulis, Pinter, and Surico \(2020\)](#), firms indexed by j produce good Y^j using labour N^j and a production technology such that $Y_t^j = A_t^j (N_t^j)^\alpha$, where $\alpha \leq 1$. A_t^j is the idiosyncratic productivity realized at the end of the period where $E_t(A_t^j) = 1$. The firm sells its output at 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. One can interpret the illiquid resource as land, as in [Bahaj, Foulis, Pinter, and Surico \(2020\)](#), or more broadly as other resources such as physical capital or intangible capital, like firm payback reputation or trust on repaying. In the context of our empirical analysis, L^j is firm size which is a proxy for financing constraints.

Firms borrow B_t^j to pay their labour input at the beginning of the period 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. 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 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:

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

¹⁹In a related paper, [Singh, Suda, and Zervou \(2021\)](#) examine whether the effects of target monetary policy shocks on the labour market variables vary across sectors such as the manufacturing (including mining, construction and utilities) sector and the service sector. The results clearly establish that sectors that are likely to take more time-to-produce and distribute their products and hold a larger stock of inventories (e.g., manufacturing), are more sensitive to monetary policy shocks than sectors with low time-to-produce, such as services.

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

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

where we assume that the firm does not default.²⁰ Substituting in firm's next period cash, we can re-write the optimization problem as:

$$\begin{aligned} \max_{N_t^j} V(D_t^j; S_t) &= \frac{1}{1+i_t} \mathbb{E}_t [V(P_t A_t^j (N_t^j)^\alpha - (1+i_t)(W_t^j N_t^j - D_t^j) \\ &\quad - \lambda_t^j \max\{W_t^j N_t^j - D_t^j, 0\}; S_{t+1})] + Q_t L^j \end{aligned} \quad (6)$$

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

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

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

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:

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

²⁰We can think of L^j as illiquid asset; alternatively, we assume that the firm, even if it has to finance all labour 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 $(N_t^j)^\alpha - (1+i_t + \bar{\lambda})(W_t^j N_t^j) > i_t Q_t L^j$.

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.²¹ We define the value of the marginal product of labour as $MPN^j \equiv P\alpha(N^j)^{\alpha-1}$ and we derive the following expression:

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

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 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:

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

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 given our assumptions for the spread, the denominator in equation (9) is negative. In addition, the higher the illiquid asset L^j , the higher is the denominator (lower in absolute value); that is, a firm with more illiquid asset will have the same benefit from hiring an extra worker as the firm with less illiquid asset has, yet, the firm with more illiquid asset has lower cost from hiring the extra worker because it pays lower spread for borrowing than the firm with lower illiquid asset.²² 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.

Focusing on the numerator, which depends on how MB^j and MS^j respond to interest rate changes, we incorporate our empirical evidence that monetary policy impacts the growth of nominal wages of new hires, increasing after monetary expansions and decreasing after monetary tightening. This is going to be a novel channel of responses to monetary policy shocks for the firms.

²¹As 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.

²² $\frac{\partial[\frac{\alpha-1}{N^j} - 2\lambda_1^j W^j - \lambda_{11}^j (W^j N^j - D^j)W^j]}{\partial L^j} = -2W^j \lambda_{12}^j q \geq 0$ given that $\lambda_{12}^j \leq 0$.

We will first analyze a monetary tightening where the decrease in nominal wages is homogeneous across firms of different sizes, as found 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, with the earnings growth of large firms responding more relative to that of small firms. Note that the change in nominal wages impacts both the marginal benefit and the marginal spread.

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 $\frac{1}{W^j} \frac{\partial W^j}{\partial i}$. We also allow the price level to change and since in the model there is only one final good, this means that we allow P_t to change in response to changes in the nominal interest rate i . Then, $\frac{\partial MB^j}{\partial i} = \frac{1}{P} \frac{\partial P}{\partial i} - \frac{1}{W^j} \frac{\partial W^j}{\partial i} - 1$, 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 was no price puzzle, we would expect $\frac{\partial P}{\partial i} < 0$. We 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:

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

In equation (10), the heterogeneous response of firms via the effect of interest rate on MS^j (i.e., the second term of the numerator which is inside the square brackets), can be analyzed in two parts. The first term 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 term is positive. That is, an increase in the interest rate decreases the value of the illiquid asset, increases the marginal spread, decreasing input demand. This is the financial accelerator effect that traditionally has been modeled for affecting capital (e.g., [Bernanke, Gertler, and Gilchrist, 1999](#) and more recently [Ottonello and Winberry, 2020](#)), or labour demand (as in [Bahaj, Foulis, Pinter, and Surico, 2020](#)). The second term in the square bracket is novel in our work, and is supported by our empirical findings; this term has that $\frac{\partial W^j}{\partial i} < 0$, while in [Bahaj, Foulis, Pinter, and Surico, 2020](#) it is assumed to be zero. 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 it does not pay spread for the relevant levels of employment hired, and hence $\lambda^U = 0$ and $MS^U = 0$. The *constrained* firm is denoted by $j = C$, where $B^C > 0$, pays spread $\lambda^C > 0$ and $MS^C > 0$. We denote $\Lambda^j \equiv -\frac{1}{\frac{\alpha-1}{N^j} - 2\lambda_1^j W^j - \lambda_{11}^j (W^j N^j - D^j) W^j}$. For unconstrained firms we have $\Lambda^U = -\frac{1}{N^U}$, 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:

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

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 are less responsive.²³ This is because when decreasing labour input, the constrained firms which are the ones that pay spread, need to borrow less and pay lower spread. As a result, constrained firms do not decrease the labour 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 10](#). 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 \(2020\)](#) 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

²³Note 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.

unconstrained firms respond more than constrained firms to monetary policy shocks.

The third term in equation (11) is new relative to the existing literature and suggests that unconstrained firms tend to react more to monetary policy shocks compared to constrained ones. This is because in the case of a monetary tightening accompanied by a wage decrease, constrained firms need to borrow less, pay lower spread and thus have reasons to scale down less than the unconstrained firms. The existence of this third channel allows the overall effect of monetary policy on unconstrained firms to be stronger than that on constrained firms, even in the presence of a strong accelerator channel, relative to the previous literature.

Graphically these 3 effects are depicted in Figures 10-12. In all figures, the vertical axes measures MB and MS and the horizontal axes measures 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.

Figure 10 shows the response of the two types of firms to a monetary contraction, ignoring the effect of the financial accelerator and the effect of a change in wages on the marginal spread, therefore capturing the first effect in equation (11). As noted earlier, because the constrained firms have to pay spread while the unconstrained firms do not have to pay spread, constrained firms will scale down less than unconstrained firms. The financial accelerator effect is incorporated in Figure 11. 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), as in Bahaj, Foulis, Pinter, and Surico (2020), where the strong accelerator effect results in constrained firms scaling down more than the unconstrained ones. Finally, in Figure 12 we add the change in the wages, and thus all three effects are combined, making the MS curve flatter than what it was in Figure 11 (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 the constrained ones to monetary policy shocks, even in the presence of a strong accelerator effect. This is because the additional effect we identify, coming from the

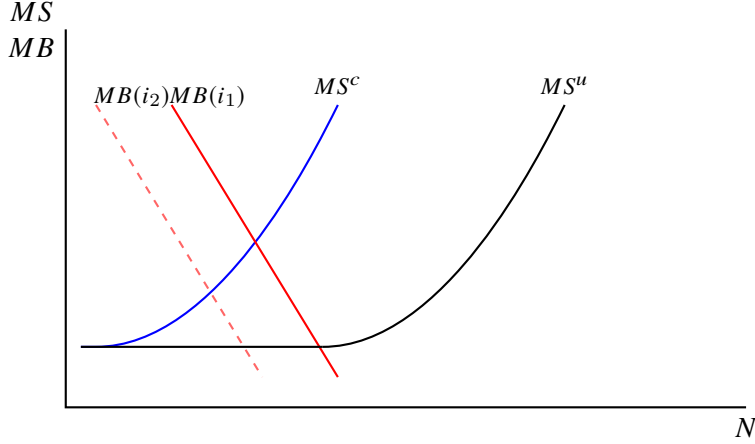


Figure 10: The figure plots MB, MS and choice of labour of constrained (blue) and unconstrained (black) firms after a monetary contraction $i_2 > i_1$ (from red solid to dashed), for constrained (blue) and unconstrained (black) firms, without taking into account the accelerator effect and the change in spread due to change in wages.

response of the wages, suggests that unconstrained firms tend to react more. This picture is consistent with the empirical results we show in Section 3, where large firms decrease hiring and employment growth more than small firms after a monetary policy tightening that decreases wages growth similarly across firms of different sizes.

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 large firms increase earnings growth more than small firms after a monetary expansion. If this is so, we cannot simplify and drop the j superscript in the MB^j function as we did before, so equation (10) now becomes:

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

As a result, equation (11) that determines the relative magnitude of responses of con-

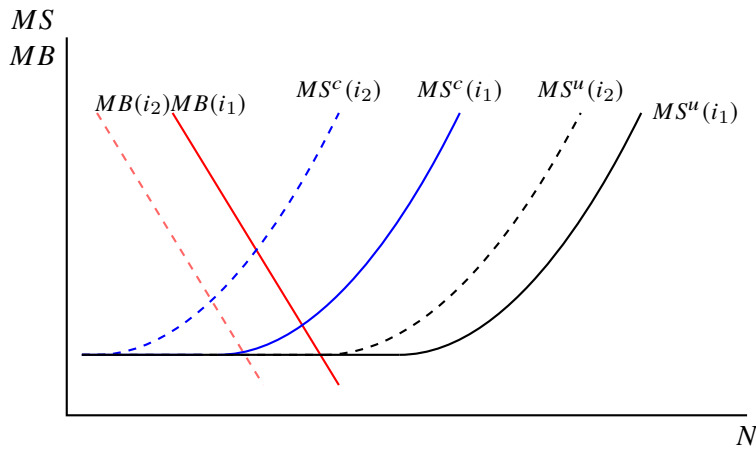


Figure 11: The figure plots MB, MS and choice of labour of constrained (blue) and unconstrained (black) firms after a monetary contraction $i_2 > i_1$ (from red solid to dashed), for constrained (blue) and unconstrained (black) firms, after incorporating the financial accelerator effect, without taking into account the change in spread due to change in wages.

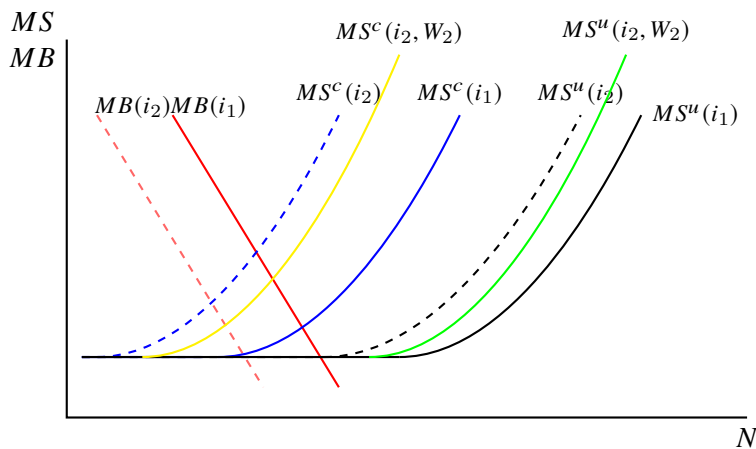


Figure 12: The figure plots MB, MS and choice of labour of constrained (blue) and unconstrained (black) firms after a monetary contraction $i_2 > i_1$ (from red solid to dashed), for constrained (blue) and unconstrained (black) firms, incorporating all the three effects in equation (11). This is the case where the change in wage is homogeneous across all firms.

strained versus unconstrained firms now is:

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

The second and third part of equation (13) are the same as those in equation (11); however, the first part is different. As before, $0 < \Lambda^C < \Lambda^U$, but now we also have that $0 > \frac{\partial MB^U}{\partial i} > \frac{\partial MB^C}{\partial i}$, given that the wage growth of large firms increases more than that of small firms, and thus the net marginal benefit of expanding is not as large.²⁴ Then, depending on the difference between Λ^C and Λ^U , and the relative wage growth in the two types of firms, it could be that $\Lambda^C \frac{\partial MB^C}{\partial i} < \Lambda^U \frac{\partial MB^U}{\partial i}$, resulting in constrained firms expanding more than unconstrained firms due to the first term of the right hand side of equation (13).

If the wage growth changes were homogeneous across firm types, the graphical representation of the monetary expansion would look very similar to that of the monetary contraction shown in Figures 10-12, with the curves moving on the opposite directions. However, given that for monetary expansion the growth of wages of the large firms is found to be larger than that of the smaller firms, the graphical representation of the expansion involves two different MB curves, with MB^U responding less than MB^C , as shown in Figure 13. Given the different movements of the MB curve for the two types of firms, and depending also on the slope of the MS curve, the first part of equation (13) could lead on constrained firms responding more than unconstrained firms.

Yet, even if the relative increase in wage growth and the slope of the MS curve are such that the first term of equation (13) does not result in constrained firms expanding more than unconstrained firms after a monetary expansion, it might do so after taking into account all terms of equation (13). The fact that the wage growth of the unconstrained firms increases more than that of the constrained firms, tends to suggest that relative to the case of homogeneous wage growth changes, constrained firms expand more after monetary expansions, consistent with our empirical evidence in Section 3.

²⁴ $|\frac{1}{W^U} \frac{\partial W^U}{\partial i}| > |\frac{1}{W^C} \frac{\partial W^C}{\partial i}|$, so $\frac{1}{W^U} \frac{\partial W^U}{\partial i} < \frac{1}{W^C} \frac{\partial W^C}{\partial i} < 0$ and $|\frac{\partial MB^U}{\partial i}| < |\frac{\partial MB^C}{\partial i}|$, so $0 > \frac{\partial MB^U}{\partial i} > \frac{\partial MB^C}{\partial i}$.

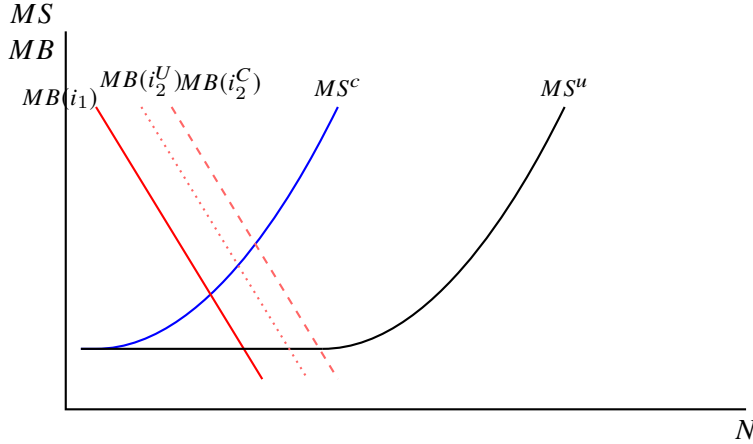


Figure 13: The figure plots MB , MS and choice of labour of constrained (blue) and unconstrained (black) firms after a monetary expansion $i_2 < i_1$, from red solid to dashed line for constrained firms and to dotted for unconstrained firms, without taking into account the accelerator effect and the change in spread due to change in wages. Model with heterogeneous changes in wage growth.

5 Conclusion

Our paper examines the effects of monetary policy on key employment variables and documents how the effects vary with the sign of the shock (positive versus negative) and the size of the firm (small versus large). Utilizing micro level data to study the response of firms of different sizes to interest rate increases and decreases has been proven useful in our analysis, uncovering novel effects of monetary policy on labour market variables. 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 increasing after expansion. We suggest a model with financing constraints through which we take into account these wage effects and demonstrate how they might affect the direction of employment response to monetary policy shocks.

Our analysis has implications for policy. We find, first, that higher-than-expected interest rate does not discourage small firms from hiring as much as it does the large ones. The decrease in wage growth that accompanies an unexpected monetary policy tightening implies lower cost of financing for small firms, which in turn might affect their decision not to scale down. Furthermore, we find that a monetary contraction acts fast to decrease hiring and employment growth of firms, although a monetary expansion takes long time to manifest, reducing the role of a monetary authority to help labour markets recover. Our

analysis also suggests that studying the effect of monetary policy on employment growth alone is not informative of the true effect of monetary policy on the labour market. To understand the effects of monetary policy on employment, it is useful 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 United States are included (both part and full-time).²⁵

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 United States) 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).²⁶ 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. 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 physical place of work within an employer (SEINUNIT). A single employer may have one or many establishments. Employee is a single worker, identified by Social Security Number (SSN), encoded to Protected Identification Key (PIK). Job is the association of an individual PIK with an establishment (SEINUNIT) in a given year and quarter. Our dependent variables

²⁵Examples 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.

²⁶That 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.

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 information on the employer size which is defined at the national level (not on 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 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 US 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 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 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 ‘target factor’ as is often referred in the literature, affects firms of various sizes.

We use the data from [Campbell, Evans, Fisher, Justiniano, Calomiris, and Woodford](#)

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.

(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 appropriate rotation that does not allow to 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 expected two quarters ahead. Finally, the path factor accounts for most of the variance in the two longer contracts.

A.3 Distribution of employment and new hires

Figures [A.1](#) and [A.2](#) plot the distribution of employment and new hires in small and large firms across industries and states.

A.4 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

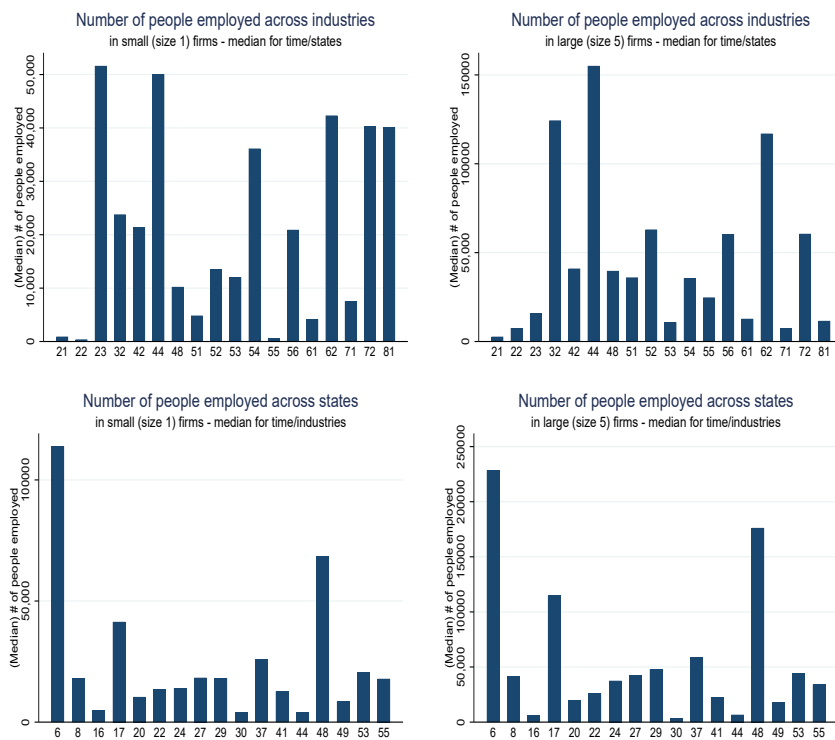


Figure A.1: Distribution of employment across industries and states in small and large firms

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.

columns we can see that the negative (expansionary) target shocks occur during the first 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 State unemployment

In this subsection we show how the employment growth of large and small firms responds to state unemployment. Figure B.1 shows the effects of an increase in the state unemployment rate on employment growth of small (left panels) and large (middle panels) firms using the

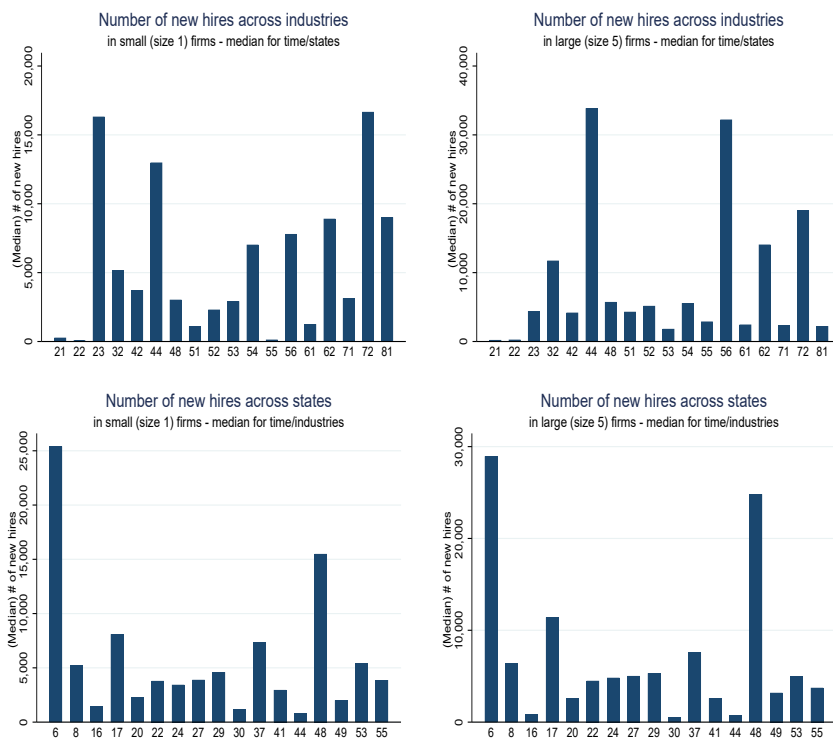


Figure A.2: Distribution of hiring across industries and states in small and large firms

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.

estimates from equation (3). From the top panel in the figure we see that employment growth of small firms increases and that of large firms decreases, and the difference between large and small firms 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 panel of Figure B.1, although weaker. Specifically, the employment growth of small firms does not respond significantly, while that of large firms decreases and the difference in the response of large and small firms loses significance in the first three quarters, in the Q1-robustness exercise.

We also perform regressions that exclude the monetary policy shocks, and resemble those of Moscarini and Postel-Vinay (2012).²⁷ Those results are presented in Figure B.2, where we see that for our specification and dataset the main message of the results of

²⁷Specifically, the regression is a fixed effects regression with clustering, similar to the benchmark regressions. However, here we do not include monetary policy shocks or their interaction with industry.

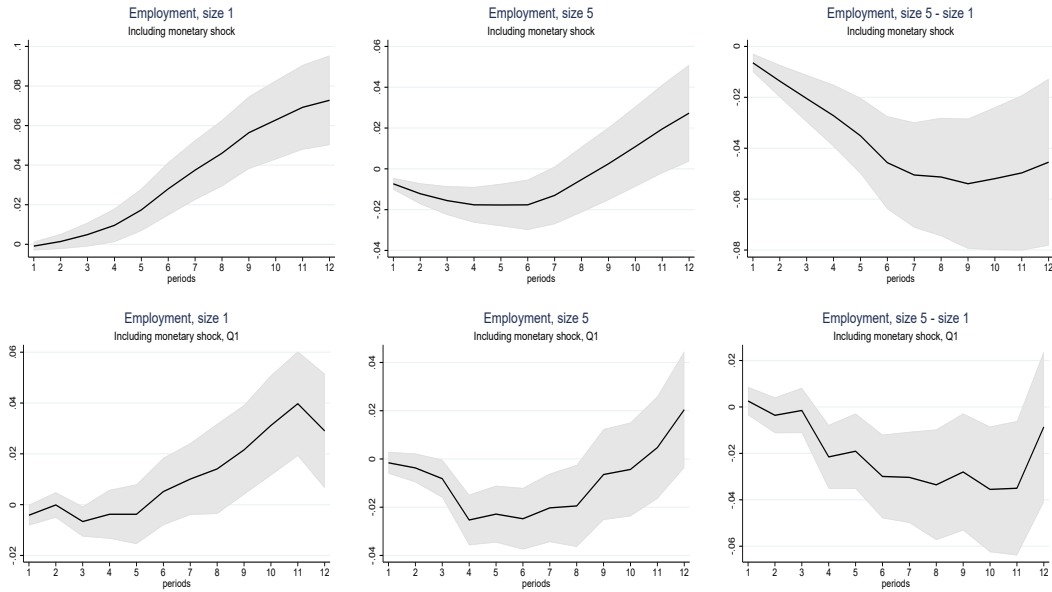


Figure B.1: Response of employment growth to state unemployment, Qs and Q1 .

Notes: The figure plots the response of employment growth to state unemployment to small (left panel) and large (middle panel) firms and the difference between them (right panel). The top panel uses shocks in all quarters and the bottom panel 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 90% confidence bands.

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 but it loses significance in the Q1-robustness exercise for the relevant three first quarters.

B.2 Excluding the Great Recession

We plot figures where the sample period is 1995:1-2007:3. Figure B.3 shows that while most of the results are qualitatively similar to the main results for monetary contraction, there are two differences in response to an expansionary target shock. First, the wage effect is negative and is homogeneous across firms. Second, the hiring and employment response is even more delayed relative to the main results.

The Q1-robustness exercise for the sample period that excludes the Great Recession is

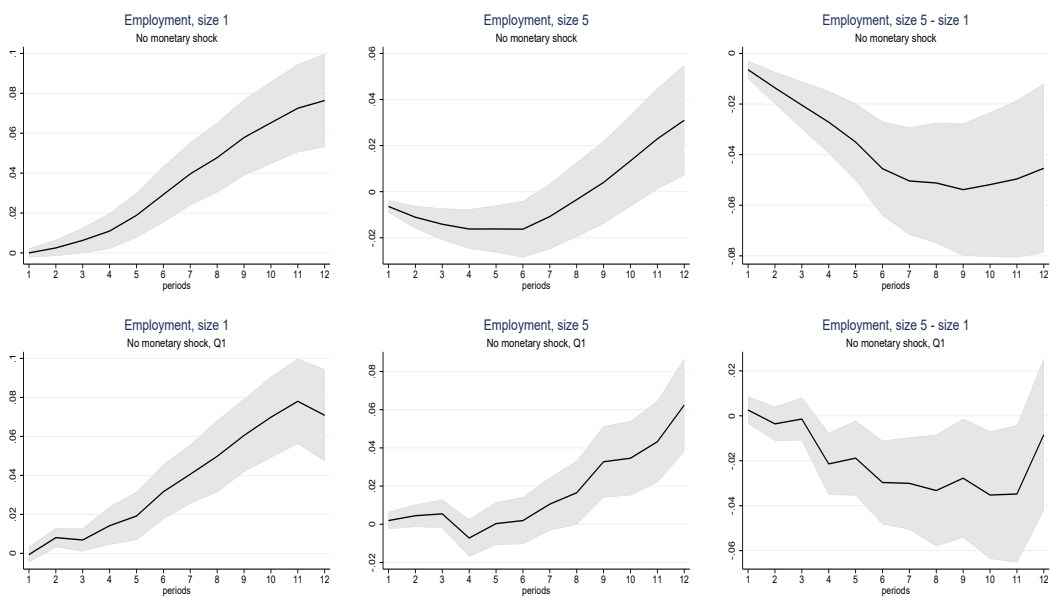


Figure B.2: Response of employment growth to state unemployment (without monetary policy shocks), Qs and Q1.

Notes: The figure plots the response of employment growth to state unemployment to small (left panel) and large (middle panel) firms and the difference between them (right panel) when monetary policy shocks are not included in the regression. The top panel uses shocks in all quarters and the bottom panel 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 90% confidence bands.

also in agreement with the results in Section 3.2 for the contractionary monetary policy shock. Examining the first three quarters, the top left panel of Figure B.4 shows that the hiring growth and employment growth of large firms decreases more than that of small firms and the difference between the firms shown in Figure B.5, is statistically significant. The bottom left panel of Figure B.4 shows that the average earnings growth decreases for both type 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 we have in Section 3.2.

The top right panel of Figure B.4 shows that the hiring growth of small firms does not respond much during the first three quarters after a monetary expansion, although that of large firms decreases. Also, the employment growth of small firms slightly increases although that of large firms slightly decreases. The difference is statistically significant for

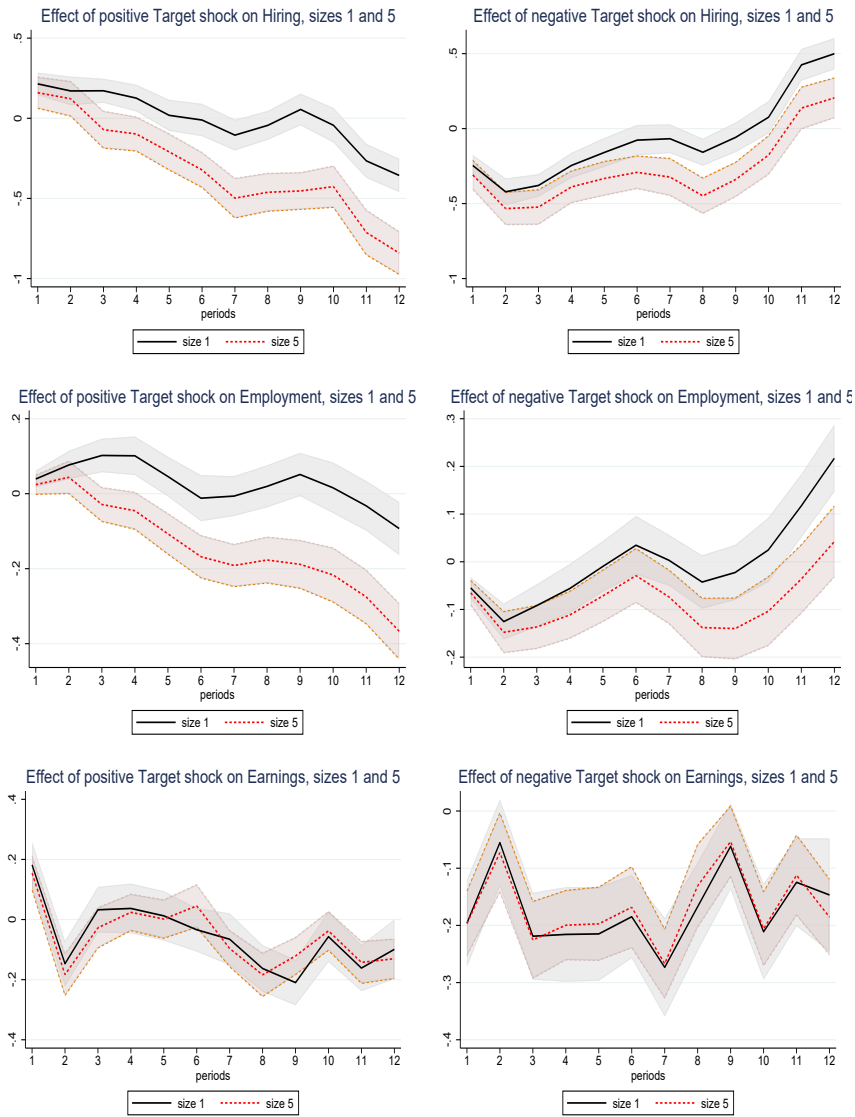


Figure B.3: Response of small and large firms, excluding the Great Recession

Notes: The top panel plots the impulse response functions for hiring growth, while the middle and bottom panels plot employment growth and earnings growth. In each of the panels, the left panel plots the impulse response function to a positive (contractionary) target shock for small (size 1-black line) and large (size 5-red dotted line) firms while the right panel plots the impulse response function to a negative (expansionary) target shock for small (size 1-black line) and large firms (size 5-red dotted line). The sample period does not include the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 90% confidence bands.

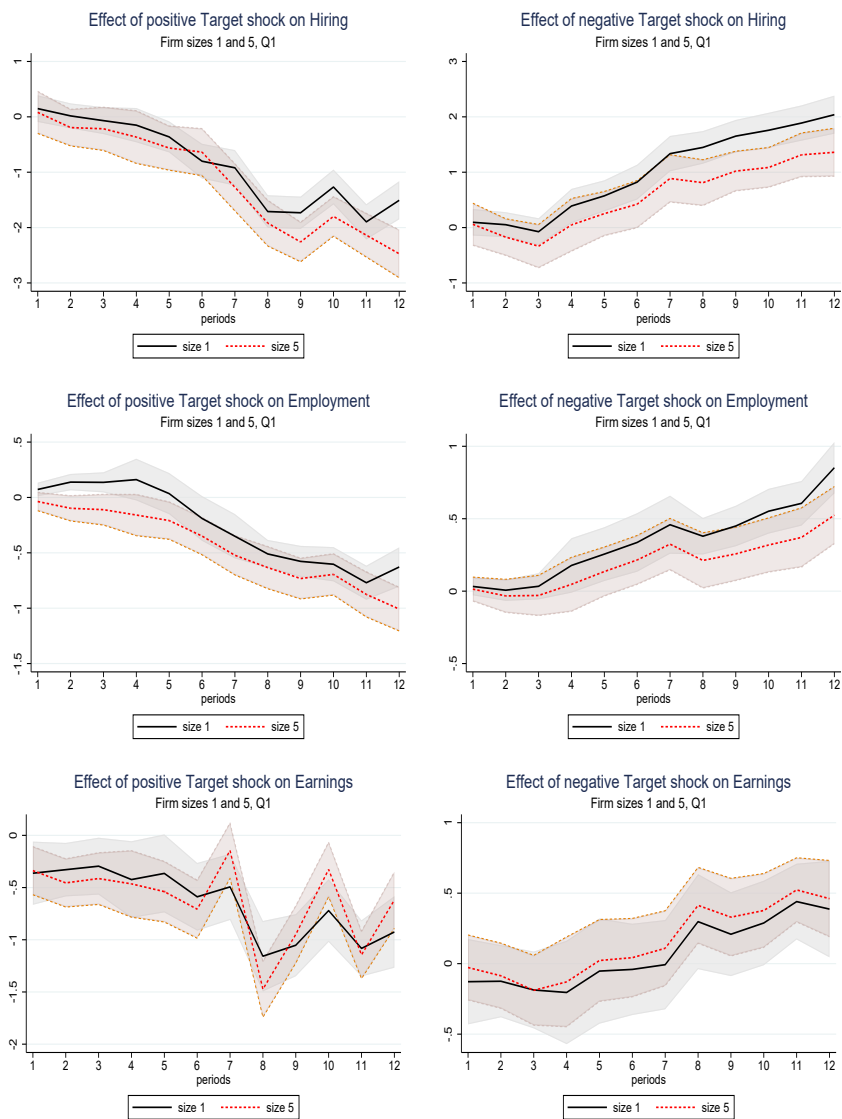


Figure B.4: Response of small and large firms, excluding the Great Recession, Q1-robustness

Notes: The top panel plots the impulse response functions for hiring growth, while the middle and bottom panels plot employment growth and earnings growth. In each of the panels, the left panel plots the impulse response function to a positive (contractionary) target shock for small (size 1-black line) and large (size 5-red dotted line) firms while the right panel plots the impulse response function to a negative (expansionary) target shock for small (size 1-black line) and large firms (size 5-red dotted line). The sample period does not include the Great Recession, and it only includes responses to first quarter monetary policy shocks (Q1-robustness). The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 90% confidence bands.

both hiring and employment growth, as shown in Figure B.5, with small firms benefiting more than large firms after the monetary expansion. The bottom right panel of Figure B.4 shows a drop in earnings growth for both small and large firms, and the difference of the two, shown in Figure B.5, is not statistically significant.

Overall, our conclusions analysing the sample before the Great Recession, and the Q1-robustness of that sample, are qualitative the same with what we conclude in our main results, when it comes to a monetary policy tightening: hiring and employment growth of large firms decreases more than that of small firms after monetary contractions; the earnings growth of both types of firms decreases, and the difference is not statistically significant. Regarding expansionary shocks, the picture is not as clear, especially for the earnings growth where we see that it decreases similarly, for both types of firms.

B.3 Price puzzle

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

$$P_{t+h} = \alpha^h + \beta^h \epsilon_t^{MP} + \Gamma^{h'} Z_t + u_{t+h}^h, \quad (\text{B.1})$$

where P_{t+h} is the logarithm of CPI in period $t+h$, ϵ_t^{MP} is the high frequency monetary policy shock in period t , and Z_t is the vector of control variables. We include lags of the HFI monetary policy shock, federal funds rate, and the log of the 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. Our findings are consistent with the literature that finds a price puzzle: following the monetary policy shock the log of CPI increases, as shown in Figure B.6.

B.4 Additional results

B.4.1 Differences between large and small firms for the Q1-robustness exercise

Figure B.7 presents the differences of the responses of large versus small firms, together with significance bands. The response of the variables are shown in Figure 9 in the main text.

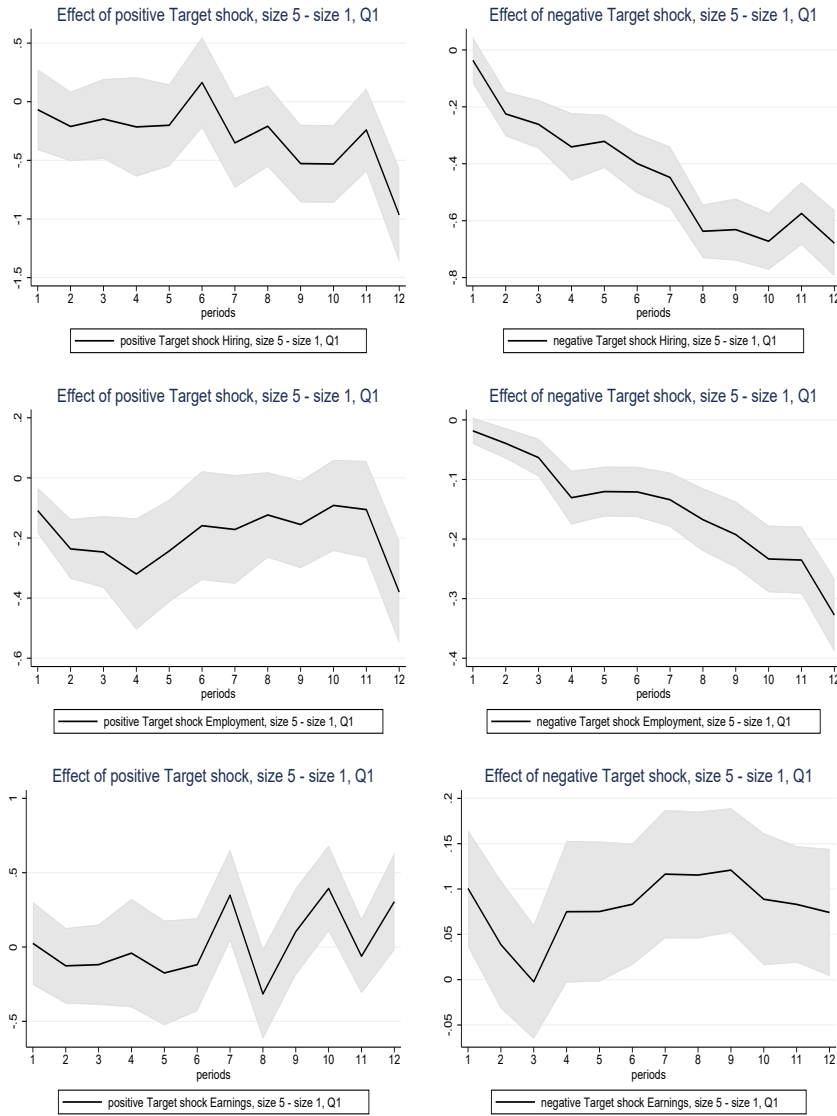


Figure B.5: Response of hiring growth, employment growth and earnings growth in small and large firms to a target shock excluding the Great Recession; Q1-robustness

Notes: The top panel plots the difference in the response of large and small firms for hiring growth, while the middle and bottom panels plot the difference for employment growth and earnings growth. In each of the panels, the left panel plots the impulse response function to a positive (contractionary) target shock after shocks in Q1 while the right panel plots the impulse response function to a negative (expansionary) target shock after shocks in Q1. The sample period does not include the Great Recession. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 90% confidence bands.

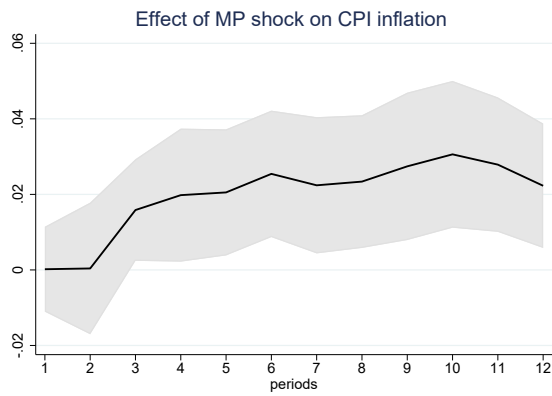


Figure B.6: The impulse response of CPI to high frequency monetary policy shock.

Notes: The figure plots the impulse responses of $\ln\text{CPI}$ following the monetary policy 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.

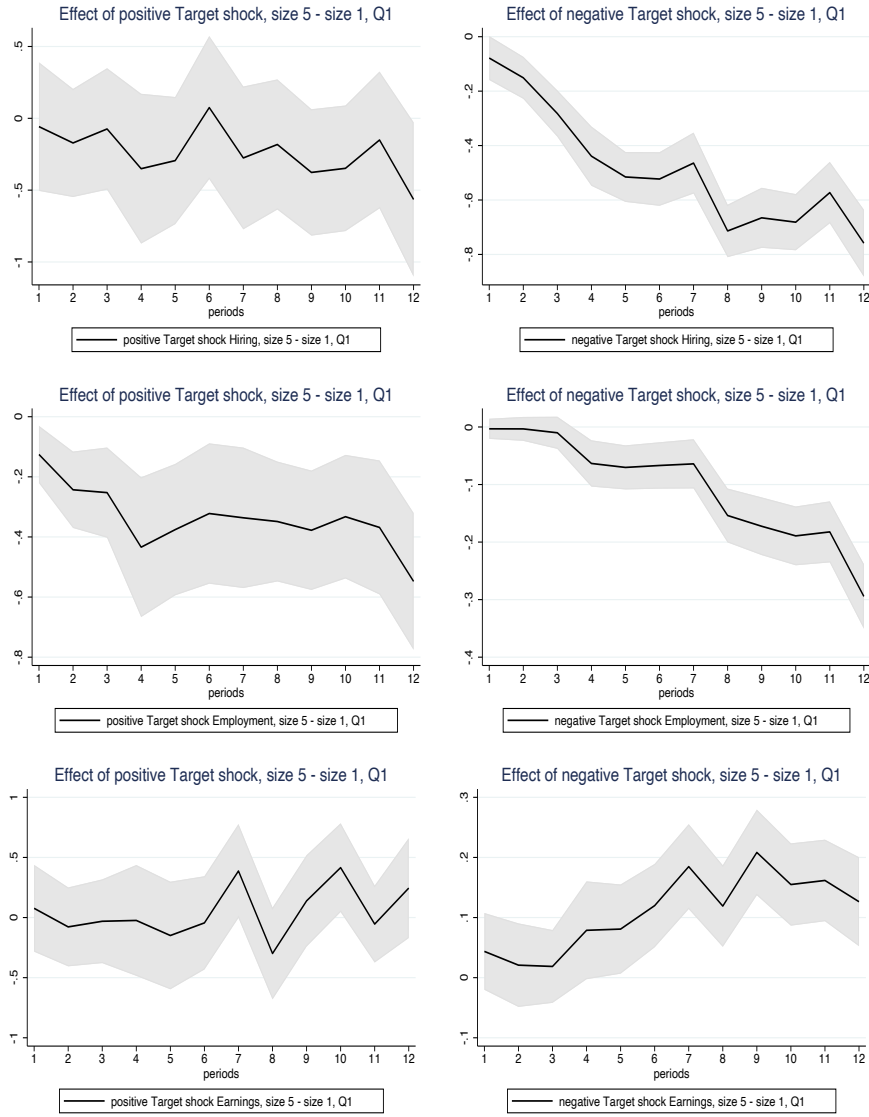


Figure B.7: Response of hiring growth, employment growth and earnings growth in small and large firms to a target shock; Q1-robustness

Notes: The top panel plots the difference in the response of large and small firms for hiring growth, while the middle and bottom panels plot the difference for employment growth and earnings growth. In each of the panels, the left panel plots the impulse response function to a positive (contractionary) target shock after shocks in Q1 while the right panel plots the impulse response function to a negative (expansionary) target shock after shocks in Q1. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent. The shaded area is the 90% confidence bands.