Downward Nominal Wage Rigidity and Asymmetric Effects of Monetary Policy

Laura Jackson*
Department of Economics
Bentley University

Ezgi Kurt†
Department of Economics
Bentley University

February 24, 2023

Abstract

This paper provides industry-level evidence on the presence of downward nominal wage rigidity and asymmetric effects of monetary policy in the US labor markets. Focusing on industry-level data from 1975q1 to 2020q4, we find strong evidence for the downward nominal wage rigidity (DNWR) channel in service-sector industries. Consistent with this channel, service-sector industries with downward-sticky (downward-flexible) wages show larger (muted) employment losses in response to monetary contractions. On the other hand, we find that the DNWR channel holds weakly in the manufacturing sector and we examine this in the context of trade integration policies of recent decades. Our results show that increasing exposure to the China shock weakens the DNWR mechanism for manufacturing industries.

JEL Classification: E52, E24, J31

Keywords: monetary policy, asymmetric effects, downward nominal wage rigidity

*Associate Professor, Bentley University, Department of Economics. E-mail: LJACKSON@bentley.edu
†Assistant Professor, Bentley University, Department of Economics. E-mail: ekurt@bentley.edu

1 Introduction

Downward nominal wage rigidity is a well-established assumption of New Keynesian (NK) DSGE models that is key in bringing asymmetric real effects of monetary policy.[1] To the extent that wages are rigid downward, a traditional NK model would predict a monetary contraction would lead to larger effects in unemployment. Despite the theoretical underpinnings, there has been little microeconomic evidence supporting downward nominal wage rigidity and its role in generating asymmetric effects of monetary policy in the context of the U.S. economy.

This paper analyzes Quarterly Census of Employment and Wages (QCEW) data from 1975q1 to 2020q4 and investigates the role of the downward nominal wage rigidity channel in understanding asymmetric effects of monetary policy. We contribute to this literature by comparing the changes in employment and compensation across major industries in response to surprise monetary innovations. Our results can be summarised as follows. First, we document that the downward nominal wage rigidity (DNWR) channel is present within service-sector industries, but less prominent in manufacturing industries. Specifically, we show that service-sector industries with downward-sticky wages show larger employment losses in response to monetary contractions. Similarly, service-sector industries with downward-flexible wages show muted employment responses to contractionary monetary policy, which is consistent with the DNWR channel. In contrast, manufacturing sectors contract both employment and wages simultaneously in response to a monetary contraction, contrary to the existence of the DNWR channel.

Next, we explore the evidence for the weak DNWR channel in manufacturing industries and show that trade integration may be a factor. Specifically, we document that the DNWR channel attenuates in the industries with larger exposure to international import competition. These results suggest that increased exposure to international trade shocks can mitigate the effectiveness of the DNWR channel, providing a basis for variation in the presence of the DNWR channel across different sectors.

The standard approach to estimating the effects of monetary policy often does not account for potential asymmetry (Christiano and Evans, 2005; Galí, 2008; Woodford, 2011). However, several studies have considered the asymmetric effects of monetary policy in terms of direction and pace of changes in the policy instrument.[2] Cover (1992) and DeLong and Summers (1988) find evidence

[1] See Christiano and Evans (2005), Schmitt-Grohé and Uribe (2016), Abbritti and Fahr (2013) and Kim and Ruge-Murcia (2009) among others.

[2] Other approaches to incorporating potential asymmetry have included smooth transition models (Weise, 1999), Markov Switching models (Garcia and Schaller, 2002; Smets and Peersman, 2001; Lo and Piger, 2005), and nonlinear VARs (Thoma, 1994).

of the Keynesian asymmetry in that expansionary monetary shocks have smaller real effects than contractionary shocks. Similarly, Tenreyro and Thwaites (2016) and Angrist et al. (2018) show that monetary expansions are much less effective than monetary contractions. Tenreyro and Thwaites (2016) also find that the source of asymmetry stems from the pace of growth in the economy, with monetary policy being less powerful in recessions. Ravn and Sola (2004) address both sign and size asymmetry, revealing that due to the importance of menu cost considerations, when using the effective federal funds rate as the policy tool, only small contractionary monetary policy shocks have real effects. Although the empirical evidence of this asymmetry is well-documented at the aggregate level, there has been little micro analysis on understanding the role of prevailing channels in producing these asymmetries.

The source of monetary asymmetry is typically argued to result from downward wage rigidity that prevents labor markets from adjusting to declining inflation. In contrast, there is no constraint on upward wage pressures that stem from the workers negotiating for raises when faced with high and rising prices. Abbritti and Fahr (2013) build a New Keynesian DSGE model with asymmetric wage adjustment costs in which wages increase relatively fast but decline slowly, thus producing an asymmetric transition of positive and negative monetary policy shocks from wages to inflation. Using a plucking model for unemployment, Dupraz et al. (2022) highlight the importance of downward nominal wage rigidity for business cycle analysis and show that increases in unemployment are followed by recoveries of a similar magnitude however the opposite is not the case. Thus, business cycle dynamics result from the economy dropping below potential output where adverse shocks lead to rising unemployment but favorable shocks lead instead to increasing wages.[3] Murray (2019) considers the channels through which downward wage rigidity produced fluctuations in employment in the U.S. during the financial crisis, finding that job destruction plays an important role.

Aggregate data for the entire economy, encompassing various industries, may mask these dynamics. We consider how disaggregate labor market data at the industry level demonstrate varying degrees of downward wage rigidity, thus helping to explain the extent to which real effects of contractionary policy are asymmetric across sectors. For example, McLaughlin (2000) analyzes asymmetry of wage distributions in the Panel Study of Income Dynamics (PSID) and finds that downward wage rigidity are observed more for low-wage, less-educated, nonwhite, hourly-wage,

[3] Jo and Zubairy (2022) looks instead at the effectiveness of fiscal policy in stabilizing business cycle fluctuations in the presence of downward nominal wage rigidity. They document that in a demand-driven recession with declining inflation, downward-rigid nominal wages can lead to rising unemployment as real wages rise above the market-clearing wage. Given the consequent crowding-out effects, the state-dependent government spending multiplier is higher when the downward wage constraint is binding.

union workers and laborers. Pischke (2018) finds that occupations with greater wage flexibility had smaller employment declines than occupations with more rigid wages during the housing market collapse in the United States after 2006. Disaggregating even further to the job level, Hazell and Taska (2020) finds that wages for new hires are rigid downward and nominal wages rarely change at the job level, falling only infrequently. They also document that when unemployment rises, wages do not fall even though wages do rise and unemployment falls during recoveries. These studies suggest that industry-specific characteristics may introduce a channel for contractionary monetary policy to have larger effects on employment when firms in some sectors are less able to cut wages due to various degrees of labor flexibility at both the intensive and extensive margin. We explore this channel by exploiting sub-sector characteristics in both manufacturing and services industries, ultimately finding that service-sector industries exhibit varying degrees of DNWR. Those facing stricter DNWR face greater job losses when monetary policy is tight.

Our approach distinguishes us from the literature in two ways. First, we document evidence for DNWR using monetary policy shocks and do not draw conclusions based on changes in the distribution of wages. For example, McLaughlin (1994) analyzes PSID data and shows that distribution of wage changes is skewed to the right, away from wage cuts. Kahn (1997) analyzes the observed distribution of wage and salary changes in different years and shows substantial stickiness of nominal wages for wage earners remaining with the same employer over the year.[4] These studies rely on distributional analysis of household self-reports to surveyers or interviewers which may be less reliable and subject to reporting errors. Moreover, different sectors might be subject to different shocks over time, so comparing distributions of different industries may not deliver the correct DNWR comparisons. In our framework, we use monetary policy shocks that are exogenous, aggregate, and uniform across different industries, serving as a benchmark tool to test how wages adjust in different sectors in response to this unique, common shock. Our framework therefore provides a novel empirical approach to assessing DNWR mechanism across U.S. industries.

Second, in contrast to the previous applied work that is constrained by short sample periods (Grigsby et al., 2021), or few industries (Pischke, 2018), we provide a more comprehensive analysis covering 95 percent of US jobs over forty-five years of panel data using employer reports. As such, we provide a more robust analysis on the wage and employment dynamics across sectors over a sufficiently long panel. This allows us to capture heterogeneity in the strength of the DNWR channel across industries as well as its implications for monetary asymmetries. We also provide

[4] Similarly, Lebow et al. (1995) shows that the shape of the wage change distribution is little affected by the rate of inflation.

additional evidence for the transmission of rising export exposure to weakening the DNWR channel heterogeneously across industries.

The rest of the paper develops as follows: Section 2 describes the data. Section 3 presents the empirical framework for exploring the asymmetric effects of monetary policy via the mechanism of downward wage rigidity. Section 4 presents the results for the the aggregate and industry-level analyses and introduces effects of globalization on reducing the extent to which downward rigidity is a binding constraint. Section 5 discusses some robustness checks. Section 6 concludes.

2 Data

In this section, we describe the datasets used in the paper. We first present the industry-level database, discuss the main variables and sample selection. Next, we present descriptive statistics and illustrate their basic properties.

2.1 Industry-level Variables

This paper uses Quarterly Census of Employment and Wages (QCEW) available from U.S. Bureau of Labor Statistics. The Quarterly Census of Employment and Wages (QCEW) publishes quarterly data on wages and count of employment reported by employers and it covers more than 95 percent of U.S. jobs, available at the industry and ownership levels.[5] The QCEW industry files are divided into two parts. The first part uses SIC categories and spans from 1975 to 2000. The second part uses NAISC categories and spans from 1990 to 2020. We first merge the two datasets using 6-digit weighted crosswalks provided by Schaller and DeCelles (2021). The final data spans 1975q1-2020q4 and consists of 181,790 observations from 1342 NAICS industries at the 6-digit level.The main variables of interest in QCEW are total nominal quarterly wages, average weekly wages for a given quarter, the employment level for the first month of a given quarter and quarterly establishment count. In addition to the industry-level data, we also employ aggregate data on log real GDP, log industrial production index, log employment and log real capital expenditures at the national level.[6]

Using QCEW data in this paper is advantageous for two reasons. First, QCEW is a long enough

[5] We only focus on private sector companies, excluding state and federal government owned establishments, as they would capture market-determined wages better. See https://www.bls.gov/opub/hom/cew/pdf/cew.pdf for detailed documentation on the dataset. The dataset is also available at size based format. However, this data is only available at annual format hence could not be employed in our analysis.

[6] Aggregate variables are FRED series GDPC1, INDPRO, PAYEMS, BOGZ1FA895050005Q, respectively. The deflator series is the Gross Value Added GDP: Business: B195RG3Q086SBEA.

panel to study industry-level variation. We analyze forty-five years of quarterly industry-level data where industries can be observed for an average of 36 years. Second, QCEW covers around 95 percent of U.S. jobs, hence it does not suffer from external validity concerns which are common concerns for analysis using firm or household level data. Last, since QCEW data relies on employer records, they are subject to less reporting errors than other datasets using self-reports in surveys.

Table 1 presents the summary statistics of key variables of interest in the industry-level data. The average number of employees is 87454 whereas the median is 27500, which suggests that the industry size has a right-skewed distribution. The mean (median) total quarterly wages paid is $994 (302) million. Relatedly, the mean average weekly wages paid is $870 and the median average weekly wages paid is $760. Based on the raw data, a positive skew for the distribution of wages suggests observational evidence of downward wage rigidity. Also, large industries seem to be more represented in the sample given the positive skew in both number of employees and establishment count.

3 Empirical Framework

This section first describes the monetary policy shocks used in the paper and discusses the identification strategy. Next, we introduce the empirical framework that explores the asymmetric effects of monetary policy and downward wage rigidity channel using industry-level data.

3.1 Monetary Policy Shocks

This paper identifies the exogenous monetary policy movement using the external instrument VAR approach of Gertler and Karadi (2015), developed by Stock and Watson (2018) and Mertens and Ravn (2013). Gertler and Karadi (2015) employs high-frequency surprises on interest rate futures around Federal Open Market Committee (FOMC) meetings as external instruments in VARs to identify the effects of monetary policy shocks. The identifying assumption of this high-frequency approach (Kuttner, 2001; Gurkaynak et al., 2011; Nakamura and Steinsson, 2018) is that the future rate surprises are measured within the 30-minute window of a FOMC meeting. The tight window helps capture monetary surprises that are due to purely exogenous policy shifts, hence leading to consistent estimates of monetary innovations.

We follow Gertler and Karadi (2015) and first estimate a monthly VAR using a one-year government bond rate, log industrial production, log consumer price index, Gilchrist and Zakrajsek

(2012) excess bond premium, employment rate, and debt to GDP.[7] The reduced form of the proxy VAR is given by

$$\mathbf{Y_t} = \sum_{j=1}^{J} \mathbf{B_j Y_{t-j}} + \mathbf{u_t} \tag{1}$$

where $u_t = \mathbf{S}\epsilon_t$ is the reduced-form shock and $\mathbf{S}$ is the structural impact matrix that maps latent structural shocks into reduced-form shocks. Data on fed funds futures are available from 1991, and the VAR data spans from 1974m1 to 2022m6. The advantage of the proxy VAR approach is that VAR can be estimated over a much longer time span than the instrument available (Cloyne et al., 2022). Next, following Cloyne et al. (2022), I extract the latent monetary policy shocks from the implied residuals of their SVAR-IV by inverting the structural VAR impact matrix.[8] This yields a time series of monetary policy innovations from 1975m1 to 2022m6. As is common in the literature, we aggregate these innovations from monthly to quarterly frequency by summing.

Before the industry-level specification, it is first useful to study whether these monetary policy shocks have an effect on real GDP. To do this, we first estimate the below local projection:

$$y_{t+h} - y_{t-1} = \beta_h \, \Delta R_t + \Omega'(L) \, Z_{j,t-1} + \epsilon_{\, j,t+h}, \tag{2}$$

where horizon is h = 0, 1,..., H, and ΔR is the change in the one-year government bond yield instrumented with the monetary policy shocks following Gertler and Karadi (2015). This specification instruments the changes in one-year treasury rate with monetary innovations and regresses on cumulative changes in log real GDP. Lag structure is 6 quarters and we only control for the lags of the dependent variable. Appendix Figure 7 plots the simple impulse response functions and shows that an initial 25bp rise in the interest rate leads to a fall in real GDP of around 0.03 % after two years.

Next, we distinguish between contractionary and expansionary monetary innovations. Following Kurt (2022), we pin down the increases and decreases in the one-year Treasury rate for each quarter and instrument them with the monetary innovations that occurred *on* these dates.[9] To test

[7] The VAR is estimated using 12 lags. We also follow Gertler and Karadi (2015) and use shocks to instrument changes in one-year Treasury rate. This is advantageous as movements in the one-year rate not only incorporate surprises in the current funds rate but also changes in expectations about the future path of the funds rate through forward guidance.

[8] Using $u_t = \mathbf{S}\epsilon_t$, we can write $E(u_t u_t') = E(\mathbf{S}\epsilon_t\epsilon_t'\mathbf{S}')$, where $E(u_t u_t') \equiv \Sigma$. $\Sigma = E(\mathbf{SS}')$ requires $\mathbf{S}$ to be identified as the Cholesky factor of Σ. Since $u_t = \mathbf{S}\epsilon_t$, $\mathbf{S}^{-1}u_t = \epsilon_t$ would yield the latent shocks.

[9] Figure 6 plots the changes in one-year treasury rate that are instrumented by the monetary policy shocks. In this framework, the monetary policy shocks instrument the increases (or decreases) in the one-year government bond yields depending on the sign of movements in that particular quarter in the one-year Treasury rate. In other words, this approach applies the sign restriction *only* to the movements of the one-year Treasury rate, and not to the monetary policy instruments. The reason is that monetary policy shocks reflect deviations from pre-FOMC meeting expectations of financial markets; hence its sign is not informative about whether the monetary policy is contractionary or expansionary. We thank Professor Òscar Jordà for this valuable suggestion.

asymmetric effects of monetary innovations, we follow Tenreyro and Thwaites (2016) and estimate the below specification:

$$y_{t+h} - y_{t-1} = \beta_h^+ \, max[0, \Delta R_t] + \beta_h^- \, min[0, \Delta R_t] + \Omega'(L) \, Z_{j,t-1} + \epsilon_{j,t+h}, \tag{3}$$

where horizon is h = 0, 1,..., H, and ΔR is the change in the one-year government bond yield instrumented with the monetary policy shocks following Gertler and Karadi (2015). Specification (3) incorporates the sign-based split of monetary innovations as described above and instruments the increases and decreases in the one-year Treasury rate for each quarter with the monetary innovations that occurred in these quarters.

Appendix Figure 8 plots the simple impulse response functions and shows that an initial 25bp rise in the interest rate leads to a fall in real GDP of around 0.4% after two years. Similarly, an initial 25bp decline in the interest rate leads to an increase in real GDP of around 0.2% after two years. That is, higher interest rates contract economic activity in the aggregate and lower interest rates expand economic activity. These results are consistent with earlier works such as Tenreyro and Thwaites (2016), Angrist et al. (2018), and Ravn and Sola (2004) which also confirm that monetary contractions are more effective at influencing economic activity than monetary expansions. In the micro analysis below, we will study industry dynamics and explore the asymmetric labor market outcomes at the sectoral-level.

3.2 Estimation Strategy

We first estimate the asymmetric effects of monetary policy shocks in the spirit of Tenreyro and Thwaites (2016) using the following local projection instrumental variable (LP-IV) (Jordà et al., 2015) specification:

$$y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \theta_q^h + \beta_h^+ \, max[0, \Delta R_t] + \beta_h^- \, min[0, \Delta R_t] + \Omega'(L) \, Z_{j,t-1} + \epsilon_{j,t+h}, \tag{4}$$

where horizon is h = 0, 1,..., H, α_j^h is industry-level fixed effects, θ_q^h are quarter fixed effects, and ΔR is the change in the one-year government bond yield instrumented with the monetary policy shocks following Gertler and Karadi (2015). The increases and decreases in the one-year Treasury rate for each quarter are instrumented with the monetary innovations that occurred in these quarters.

There are four main dependent variables: total nominal wages for a given quarter, total real wages for a given quarter, employment level, and quarterly establishment count. The dependent variable is defined as the cumulative difference to interpret the parameters as impulse responses. β_h^+ captures the effect of a 25 basis point increase in the interest rate across different horizons, and β_h^- captures the impact of a 25 basis point decrease in interest rate across different horizons. The estimation is done up to horizons of $H = 20$ quarters, and the lag structure on the control variable is 6 quarters.

Industry fixed effects, α_j^h, soak up permanent differences across industries and allow us to explore within-industry variation. We include control variables that are possibly related to industry-level responses such as lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, as well as change in the response variable and change in log real average wages at the industry level. Standard errors are two-way clustered by industry and quarter (calendar), where serial correlation adjustment is set to 2 quarters using Driscoll and Kraay (1998)'s methodology. This is a standard method to account for serial correlation at the industry level and through time (Cloyne et al., 2022; Bahaj et al., 2020). Industries with data less than 20 quarters are dropped as the impulse responses are estimated using at least five years of consecutive data.

4 Baseline Results

This section presents the impulse responses of specification (4) on employment, total nominal and real wages, and quarterly establishment count. Figure 1 plots the impulse responses to a 25 bps monetary contraction of the total sample (row 1), manufacturing (row 2) and service sectors (row 3), respectively. The shaded areas display 90 percent confidence intervals.

The first row of Figure 1 shows that, in the aggregate, monetary contractions seem to be having a stronger effect on nominal and real wages than on employment. Specifically, the number of employees falls by 0.8 percent 8 quarters following a 25 bps monetary contraction. In contrast, real and nominal wages in the total sample decline by 2.5 percent following a 25 bps monetary contraction. Consistent with a weak DNWR channel, as wages adjust, we observe a smaller decline in the number of employees. Similarly, the establishment count does not show a significant decline following a 25 bps monetary contraction. The second row reports the response of manufacturing industries to a 25 bps monetary contraction. These results show that the declines in real and nominal wages are more significant in manufacturing and almost twice as large as the aggregate response. However, despite the large declines in real and nominal wages, we simultaneously observe a significant and larger decline in manufacturing employment. Specifically, manufacturing industries lose 1.5 percent of employment two years following the monetary contraction, which suggests the absence of the DNWR channel. These results are consistent with Singh et al. (2022) which shows that employment and hiring responses to monetary policy are stronger in the manufacturing sector.[10] In the third row, we also report the responses of service sectors. Service-sector industries reduce employment by 0.4 percent and wages by 2 percent 8 quarters following a 25 bps monetary contraction, yet all responses are insignificant. These results suggest that manufacturing wages and employment are more responsive to monetary contractions than service-sector industries. In addition, we observe that the DNWR channel holds more strongly in the total sample and service-sector industries.

For comparison, Figure 2 plots the responses of the same variables for a 25 bps monetary expansion. Almost all of the responses are insignificant, except the manufacturing employment which shows 0.8 percent peak increase in employment 10 quarters following the monetary expansion. Similar to Figure 1, we observe that manufacturing wages and employment are more responsive to expansionary monetary policy than services. Comparing sectors across Figure 1 and Figure 2, we can also observe that monetary contractions are more effective than monetary expansions which is consistent with the earlier literature.[11]

Although these results serve as a benchmark, manufacturing and service sectors are vastly different in terms of organizations, labor intensiveness, output tangibility, and inventory structures. In order to trace the source of DNWR, it is more appropriate to disaggregate further to the more homogenous industry level within each sector. To do this, we estimate specification (4) at the industry level within the broader services and manufacturing sectors, respectively. Figure 3 plots the impulse responses for the four industries which have the largest employment share within the service sector: Professional Services, Accommodation and Food Services, Administrative, Support and Waste Management and Health Care Services. Since we are interested in the DNWR channel, we focus on the response of number of employees and total nominal wages. The first two columns plot the responses to a 25 bps monetary contractions. The last two columns plot the responses to a 25 bps monetary expansions. The shaded areas display 90 percent confidence intervals.

Figure 3 suggests that industries with downward-sticky wages, like accommodation and food services and health care, show a significant decline in the number of employees in response to a 25 bps monetary contraction. In contrast, industries that adjust nominal wages in response to a

[10] Howes (2021), Erceg and Levin (2006) and Barsky et al. (2007) also show similar results on investment expenditures, finding larger effects of monetary policy on durable goods.

[11] See Ravn and Sola (2004); Tenreyro and Thwaites (2016); Angrist et al. (2018); Kurt (2022).

monetary contraction, such as administrative, support and waste management industries, show a muted response in the number of employees. Professional services also seems to only respond along the wage margin, rather than the employment margin, however, their estimates are not significant. These suggest that downward nominal wage rigidity channel holds among industries within service sector. Specifically, the service sector industries with downward sticky wages show significant employment decline.[12] Similarly, industries where wages adjust the most show insignificant responses in the number of employees following a monetary contraction. Consistent with the DNWR channel, when we analyze the monetary expansions (column 3 and 4), we can not observe a similar mechanism. The employment and wage responses to monetary expansions are largely insignificant across the horizon. Overall, the DNWR channel is present within service sector industries.

Next, Figure 4 plots the impulse responses for the five main industries which have the largest employment share in the manufacturing sector: Food Manufacturing, Machinery Manufacturing, Fabricated Metal, Computer and Electronics, and Transportation Equipment Manufacturing. The first two columns plot the responses to a 25 bps monetary contractions. The last two columns plot the responses to a 25 bps monetary expansions. The shaded areas display 90 percent confidence intervals.

Figure 4 suggests that industries that adjust nominal wages in response to a monetary contraction also show large and significant responses in the number of employees. In almost all the reported industries, we observe large and significant declines in both employment and total nominal wages in response to a 25 bps monetary contraction. This suggests that manufacturing results seen in Figure 1 represent a common pattern observed in most of the main industries within the manufacturing sector. Both results confirm that the DNWR channel does not hold in the manufacturing industries and that wages and employment co-move in response to monetary contractions. In the last two columns, Figure 4 also shows that monetary expansions are also very effective in changing employment and total nominal wage with no trade-off between changing wages or the number of employees.

Overall these results suggest that the DNWR channel seems to hold in the service sector industries, but not in the manufacturing sector industries in the US. In the next section, we address one prominent mechanism that can rationalize the heterogeneous presence of DNWR across sectors.

[12] This is in line with Fallick et al. (2022) who analyzes the U.S. establishment-level data and find significant DNWR persisted during the Great Recession despite the severity of the labor market contraction. They consider variation in the wage-setting behavior of firms and find that firms facing DNWR freeze wages, if prohibited from cutting pay, resulting in worse employment outcomes.

4.1 China shock and Downward Nominal Wage Rigidity

This section explores an interesting mechanism that can explain the attenuation of DNWR channel in manufacturing industries. Specifically, we examine the implications of China's export surge on the DNWR channel in the U.S. A large body of research documented the effects of rising import exposure in reducing manufacturing employment and wages in the US (Pierce and Schott, 2016; Autor et al., 2016; Feenstra and Sasahara, 2018). Specifically, Autor et al. (2016) finds about 1 million jobs lost in manufacturing between 1999 and 2011. Feenstra and Sasahara (2018) finds the import surge to account for 1.4 million jobs in manufacturing from 1995 to 2011.

In the following exercise, we examine the effects of an industry's import exposure on the DNWR channel. As an industry switches from a closed to an open economy and is subject to rising import competition, this may contract both the wages and employment simultaneously which may dampen the presence of the DNWR mechanism. We examine the link between rising import exposure and DNWR by estimating a local projection incorporating the rising share of Chinese imports in manufacturing industries. To do this, we modify our baseline specification and estimate the following local projection:

$$y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \theta_q^h + \beta_h^+ \, max[0, \Delta R_t] + \gamma_h^+ \, max[0, \Delta R_t] \Delta IP_{j,t} + \rho_t \Delta IP_{j,t}$$
$$+ \beta_h^- \, min[0, \Delta R_t] + \gamma_h^- \, min[0, \Delta R_t] \Delta IP_{j,t} + \Omega'(L) \, Z_{j,t-1} + \epsilon_{\, j,t+h}, \tag{5}$$

where horizon is h = 0, 1,..., H, α_j^h is industry-level fixed effects, and θ_q^h is quarter fixed effects. ΔR is the change in the one-year government bond yield instrumented with the monetary policy shocks and IP is import penetration ratio a la Autor et al. (2016) that captures the variation in import competition from China. Following Autor et al. (2016), change in import exposure is defined as

$$\Delta IP_{j,t} = \frac{\Delta M_{j,t}}{Y_{j,91} + M_{j,91} - E_{j,91}}$$

where j stands for 4-digit US industry, $\Delta M_{j,t}$ is the change in imports from China over the period 1991-2011 and $Y_{j,91} + M_{j,91} - E_{j,91}$ is the US market volume in each industry (initial absorption), measured as US domestic output, $Y_{j,91}$, plus industry imports $M_{j,91}$, minus industry exports $E_{j,91}$. Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level. $\beta_h^+ (\beta_h^-)$ captures the effect of a 25 basis point increase (decrease) in the interest rate across different horizons. γ_h^+ and γ_h^- capture the marginal effects observed in industries with higher import exposure.

Figure 5 shows the impulse response functions where the shaded areas show 90% confidence intervals. The first row plots the baseline effect of a 25 bps monetary contraction. The second row plots the marginal effect of increasing China's export competition for monetary contractions. Similarly, the third row plots the baseline effect of a 25 bps monetary expansion, and the last row plots the marginal effect of increasing China's export competition for monetary expansions.

Figure 5 suggests that a one-percent increase in the exposure to Chinese exports leads contractionary monetary policy shocks to reduce an industry's employment by 0.4 percent more after two years. These results are even more significant when we analyze the response of wages. Industries with a higher exposure to the China shock show an additional 1.8 percent decline in both nominal and real wages after eight quarters. The declines in wages are also highly persistent and not transitory. The last column also reports that in the trade-exposed sectors, establishment count falls by an additional 1.9 percent 8 quarters following the monetary contraction. Similar to monetary contractions, we also show the China shock dampens the stimulating effects of monetary expansions. Specifically Figure 5 shows that the expansionary effects of monetary policy (row 3) can be offset with increasing effects of import competition (row 4).

These results provide evidence for why the DNWR channel may be weaker in the manufacturing sector, especially in the industries that are subject to large, negative effects of international competition. As the share of import competition in an industry increases, this leads to demand loss in the exposed industries which can amplify the existing financial frictions and balance-sheet channels (Gertler and Gilchrist, 1994; Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; Calomiris and Hubbard, 1990).[13] In other words, changing trade dynamics can alter the effectiveness of monetary policy via these indirect channels. Moreover, since the trade shocks put a downward pressure on wage and employment simultaneously, it also breaks the DNWR channel in the trade-exposed sectors.

We can also consider exchange rate channel of monetary policy in this context (Diamond et al., 2019; Mishkin, 1996; Georgiadis and Zhu, 2019; Kearns and Patel, 2016). As interest rate increases, this leads U.S. dollars to appreciate which would generally decrease exports and increase imports since imports now become more cheaper. This would in turn amplify the existing trade shock and dampen demand for domestic industries, leaving industries with lower wages and employment. For

[13] Lower trade volumes have also been associated with lower working capital needs, lower marginal value of investment as well as shrinking scale of firms in the literature (Djankov et al., 2010; Feenstra et al., 2011; Kohn et al., 2022).

instance, Rodriguez-Clare et al. (2020) develops a multi-sector model with DNWR and flexible exchange that highlights the changes in an economy's labor demand following the China shock. Specifically, they examine unemployment and nonemployment across U.S. states between 2000 and 2007, and document the effect of China shock to account for 0.9 percentage points of the increase in the U.S. unemployment.

These results also clarify why the DNWR channel holds strongly in the service sector (See Figure 3) which is characterized as being less tradable and not exposed to the same degree of export competition as the manufacturing sector. Overall, these results document a sizable and robust negative effect of growing Chinese import competition on the strength of the DNWR channel and a magnification of the contractionary effects of monetary policy tightening.

5 Robustness

This section shows that our main results capturing asymmetric effects of monetary policy on industry-level employment and wages are robust to a range of alternative specifications. First, we confirm that the main findings are robust to controlling for additional variables, as well as using alternative monetary policy shocks. In addition, we report results on employees per establishment which captures whether the size of establishments shrinks or expands following sign-dependent monetary shocks. Last, we explore how these results interact with business cycle dynamics.

First, we expand the control set by including changes in the unemployment rate and excess bond premium data from Gilchrist and Zakrajšek (2012). Figure 9 suggests that the employment and total nominal wages results mirror the baseline findings. Next, we examine the robustness of the main results using Wieland and Yang (2020)'s extended Romer and Romer (2004) monetary policy shocks. Figure 10 shows the baseline findings with new monetary policy shocks, which also corroborate the baseline findings on employment and total nominal wages.[14] The baseline impulse responses are also robust when we split the monetary policy shocks into pure rate shocks and central bank information shocks a la Jarociński and Karadi (2020).[15] Figure 11 plots the responses to rate and information shocks and confirms the baseline results that the rate shocks drive the main responses in employment and wages.

[14]Results in Figure 1 and 2 are also robust to excluding zero-lower bound by restricting sample to 1975q1-2008q4.

[15]Jarociński and Karadi (2020) differentiates between true monetary policy shocks and central bank information shocks by considering the behavior of financial markets in response to the policy change. Policy contractions are identified as those rate hikes which are accompanied by a decrease in the S&P 500. Expansions are identified similarly. Alternatively, information shocks exhibit a positive comovement with stock prices, capturing investor sentiment as discerned from perceptions of central bank behavior. We split our monetary policy shocks into dates which correspond with these two characteristics and condition on policy shocks separately from information shocks.

Next, we analyze the response of employees per establishment. Recall that our baseline results suggested aggregate employment fell somewhat but the decline in establishment count was small and insignificant following contraction monetary policy shocks. To reconcile these effects, we explore if employees are being shed across surviving firms, on average. Figure 12 row (1) reports the impulse response functions for the total sample which shows that industries shrink the number of employees per establishment by 0.4 percent 8 quarters following a 25 bps monetary contraction. Similarly, following expansions, industries increase the number of employees per establishment by 0.2 percent, however both effects are insignificant. Since we previously pin down the heterogeneous employment effects between manufacturing and service sectors, we also explore the employees per establishment metric for these two main sectors. According to Figure 12 row (2), most of the decline in establishment size is driven by the manufacturing sector rather than services. This is also consistent with the effects of increased trade competition observed in manufacturing.

Last, we explore the how these results interact with business cycle dynamics. To examine this, we modify our estimation as follows:

$$
\begin{aligned}
y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \theta_q^h + \beta_h^+ \, max[0, \Delta R_t] + \gamma_h^{+,+} \, max[0, \Delta R_t] \Delta GDP_{j,t}^+ + \gamma_h^{+,-} \, max[0, \Delta R_t] \Delta GDP_{j,t}^- \\
+ \beta_h^- \, min[0, \Delta R_t] + \gamma_h^{-,+} \, min[0, \Delta R_t] \Delta GDP_{j,t}^+ + \gamma_h^{-,-} \, min[0, \Delta R_t] \Delta GDP_{j,t}^- \\
+ \rho_t^+ \Delta GDP_{j,t}^+ + \rho_t^- \Delta GDP_{j,t}^- + \Omega'(L) \, Z_{j,t-1} + \epsilon_{\, j,t+h},
\end{aligned}
\tag{6}
$$

where positive and negative monetary shocks interact with changes in GDP occurring on NBER business cycle dates. These dates identify the peaks and troughs that frame economic recessions and expansions. The goal of this specification is to examine how industry responses to monetary policy interact with business cycle dynamics. Table 2 shows the responses of the number of employees and wages at horizon 8. While all of the coefficients are insignificant, the table documents that the effect of expansionary monetary policy (β^-) on employment is amplified (dampened) during economic downturns (expansions). For example, the change in employment is 1.5% (instead of 0.41%) if the monetary expansion occurs during an economic downturn. Similarly, the total employment response to monetary contractions becomes -5.25% if the monetary contraction occurs in a recession. Wages are also highly responsive to business cycle dynamics. Although, the estimates are insignificant, we can observe that monetary expansions are more effective on wages when the economy is booming than when it is contracting, consistent with upward-flexible wages and tight labor markets translating into strong wage pressures. The effects of monetary contractions on wages are also more contractionary when the economy is in a bust. These results are consistent with Lo and Piger (2005) and Garcia and Schaller (2002), documenting larger effects of monetary policy during contractions, as well as Matschke and Nie (2022), showing more significant contractions in employment for countries with higher downward wage rigidities during recessions.[16]

6 Conclusion

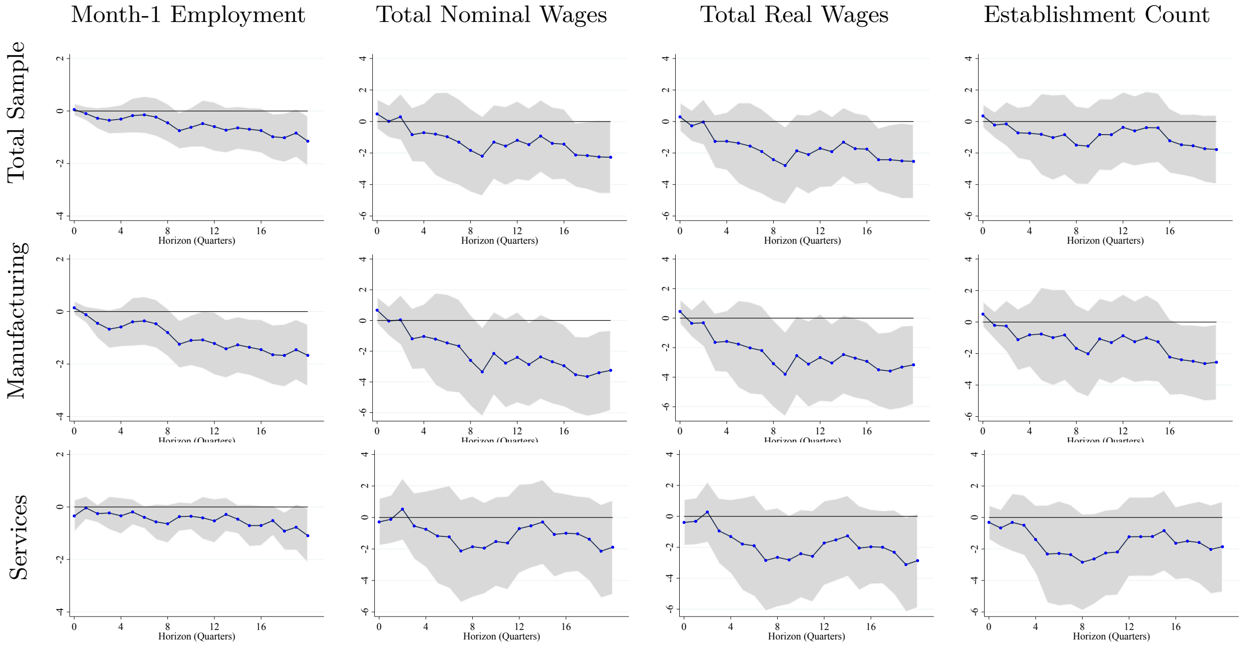
This paper provides an industry-level analysis of the DNWR channel in the US. Specifically, we analyze forty-five years of industry-level data and examine the asymmetric effects of monetary policy in labor markets outcomes. Our results find strong evidence for the DNWR channel in service-sector industries, which tend to operate in closed-economy settings with little exposure to international trade shocks. Consistent with the DNWR channel, we show that service-sector industries with downward-sticky wages show larger employment losses in response to monetary contractions. In contrast, service-sector industries with downward-flexible wages show muted employment responses to contractionary monetary policy.

On the other hand, we document that the DNWR channels holds only weakly in the manufacturing sector. We attribute this as being due to trade integration policies and the industries' increasing exposure to international import competition. As the penetration of Chinese imports increase, this puts a downward pressure on wages as well as employment of the exposed industries, hence weakening the DNWR mechanism. Overall, these results show asymmetry in the presence of the DNWR channel and suggest that exposure to trade integration policies can alter the strength of the DNWR channel and the effectiveness of monetary policy.

[16] Tenreyro and Thwaites (2016) attempts to jointly test the sign and cycle asymmetries and reports that their results are also insignificant due to low precision and lost degrees of freedom.

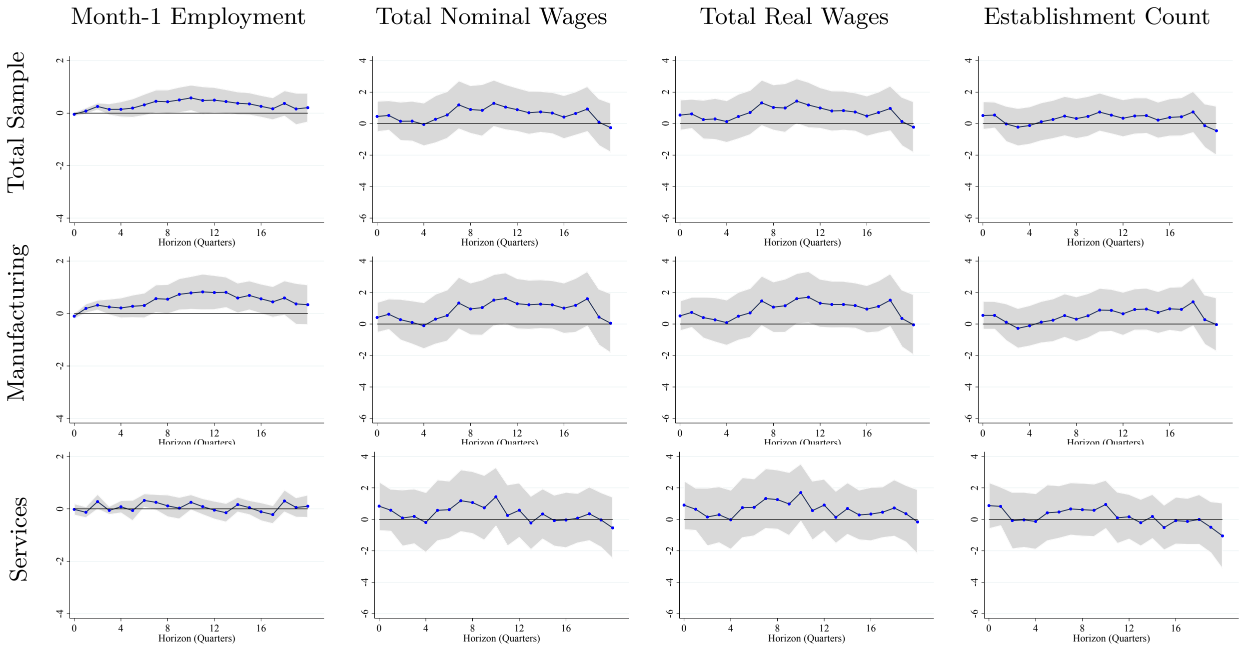
7 Figures

Figure 1: Effects of monetary contractions.



Notes: The figure shows the impulse response function following a 25bps increase in the one year interest rate. The IRFs are estimated using the local projection IV approach described in the text. Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level.

Figure 2: Effects of monetary expansions.

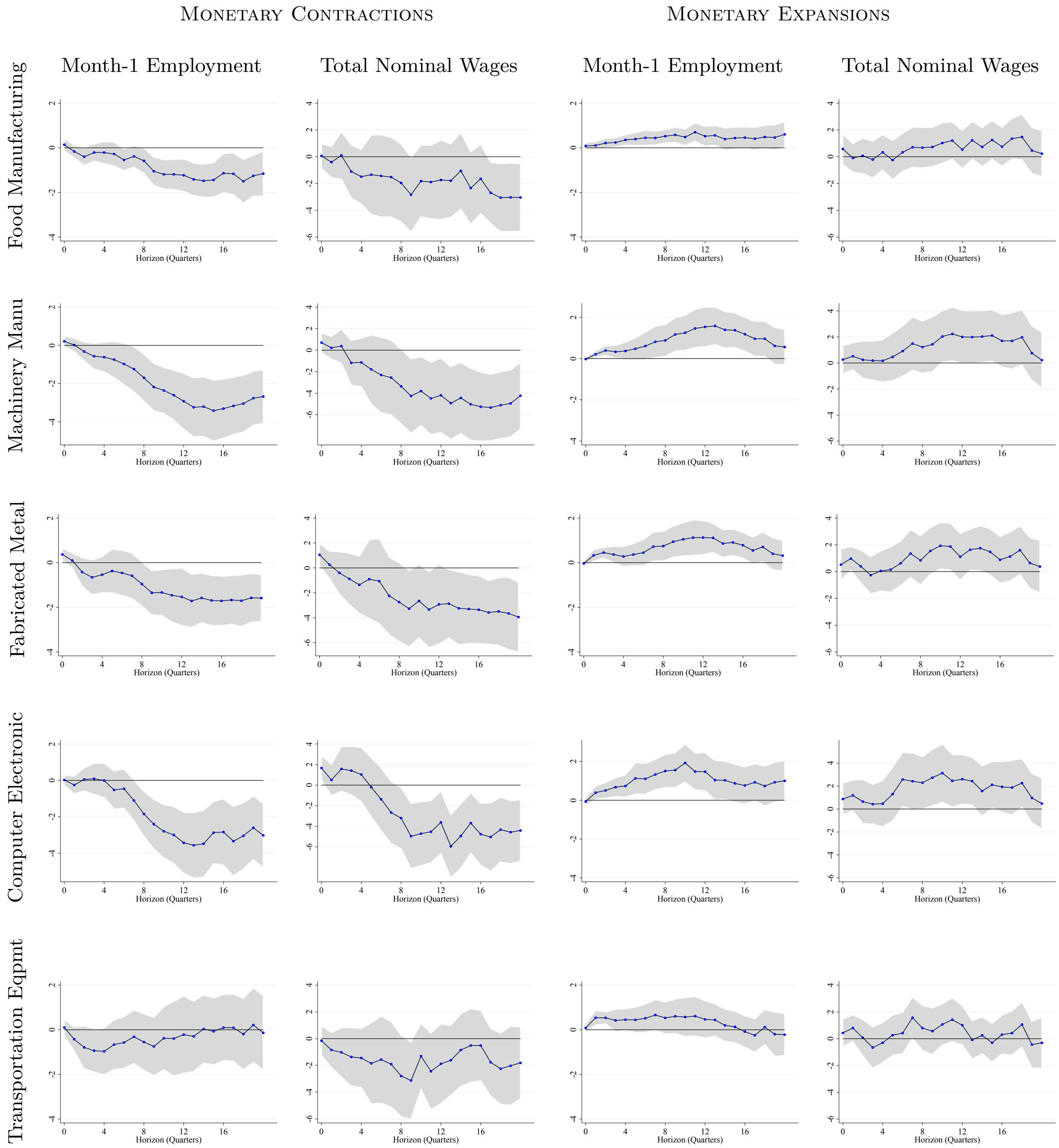


Notes: The figure shows the impulse response function following a 25bps decrease in the one year interest rate. The IRFs are estimated using the local projection IV approach described in the text. Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level.

Figure 3: Effects of monetary contractions on Services Subsectors.

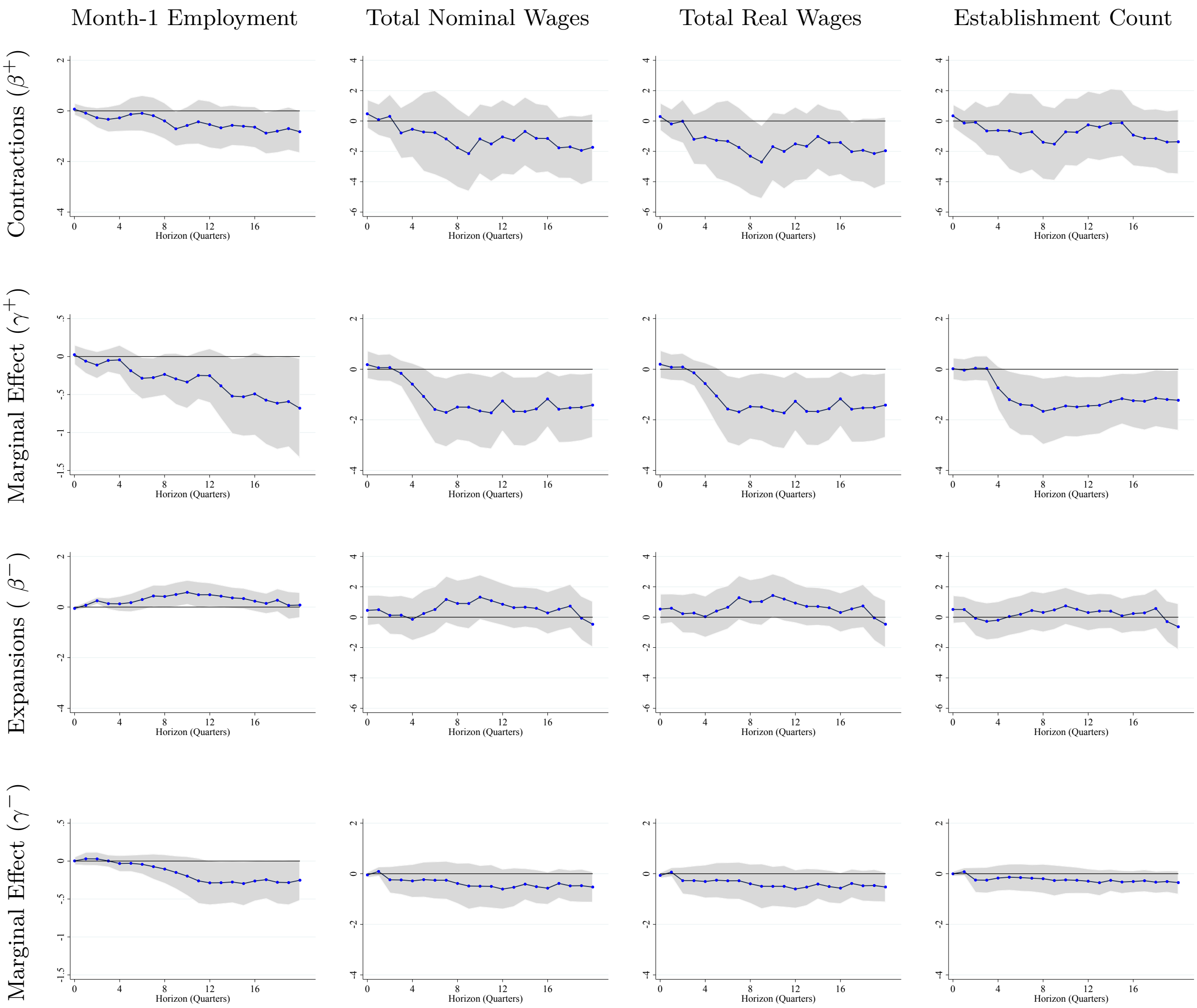
Notes: The left (right) figures show the impulse response function following a 25bps increase (decrease) in the one year interest rate. The IRFs are estimated using the local projection IV approach described in the text. Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level.

Figure 4: Effects of monetary contractions on Manufacturing Subsectors.



Notes: The left (right) figures show the impulse response function following a 25bps increase (decrease) in the one year interest rate. The IRFs are estimated using the local projection IV approach described in the text. Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level.

Figure 5: Effects of monetary contractions and expansions with China shock.



Notes: This figure shows the impulse response function following a 25bps increase (decrease) in the one year interest rate. The first and the third rows plot the baseline effect of monetary contractions and expansions, respectively. The second and forth rows plot the marginal effect of increasing exposure to China's export competition for monetary contractions and expansions, respectively. Shaded areas show 90% confidence intervals. The IRFs are estimated using the following local projection IV:

$$y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \theta_q^h + \beta_h^+ \, max[0, \Delta R_t] + \gamma_h^+ \, max[0, \Delta R_t] \Delta IP_{j,t} + \rho_t \Delta IP_{j,t}$$
$$+\beta_h^- \, min[0, \Delta R_t] + \gamma_h^- \, min[0, \Delta R_t] \Delta IP_{j,t} + \Omega'(L) \, Z_{j,t-1} + \epsilon_{\, j,t+h}, \quad (7)$$

horizon is h = 0, 1,..., H, α_j^h is industry-level fixed effects, and θ_q^h is quarter fixed effects. ΔR is the change in the one-year government bond yield instrumented with the monetary policy shocks and IP is import penetration ratio a la Autor et al. (2016). Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level.

8 Tables

Table 1: Descriptive Statistics

	Number of Employees (Month 1)	Total Quarterly Wages	Average Weekly Wages	Establishment Count
count	181790	181790	181790	181790
p5	1591	25	234	81
p50	27500	302	760	1503
mean	87454	994	870	7675
p95	322922	3787	1847	30069
sd	255902	3014	570	24428

Notes: The table reports descriptive statistics on main variables used in the paper. Total wages and average weekly wages are reported in nominal terms. Total wages is reported in million dollars.

References

Abbritti, M. and S. Fahr (2013). Downward wage rigidity and business cycle asymmetries. Journal of Monetary Economics 60(7), 871–886.

Angrist, J. D., Ò. Jordà, and G. M. Kuersteiner (2018). Semiparametric Estimates of Monetary Policy Effects: String Theory Revisited. Journal of Business and Economic Statistics.

Autor, D., D. Acemoglu, D. Dorn, G. H. Hanson, and B. Price (2016). Import competition and the great us employment sag of the 2000s. Journal of Labor Economics 34(S1), S141–S198.

Bahaj, S., G. Pinter, P. Surico, and A. Foulis (2020). Employment and the Collateral Channel of Monetary Policy. Bank of England WP No.827.

Barsky, R. B., C. L. House, and M. S. Kimball (2007, June). Sticky-price models and durable goods. American Economic Review 97(3), 984–998.

Bernanke, B. and M. Gertler (1989). Agency costs, net worth, and business fluctuations. American Economic Review 79(1), 14–31.

Calomiris, C. W. and R. G. Hubbard (1990). Firm Heterogeneity, Internal Finance, and 'Credit Rationing'. The Economic Journal.

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

Cloyne, J., F. Clodomiro, S. Paolo, and F. Maren (2022). Monetary Policy, Corporate Finance and Investment. Journal of the European Economic Association (Forthcoming).

Cover, J. P. (1992, November). Asymmetric effects of positive and negative money-supply shocks. Quarterly Journal of Economics 107(4), 1261–82.

DeLong, J. B. and L. H. Summers (1988). How does macroeconomic policy affect output? Brookings Papers on Economic Activity (2), 433–94.

Diamond, D., Y. Hu, and R. Rajan (2019, 11). The spillovers from easy liquidity and the implications for multilateralism. IMF Economic Review 68.

Djankov, S., C. Freund, and C. S. Pham (2010). Trading on time. The Review of Economics and Statistics 92(1), 166–173.

Driscoll, J. C. and A. C. Kraay (1998). Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data. Review of Economics and Statistics.

Dupraz, S., E. Nakamura, and J. Steinsson (2022). A Plucking Model of Business Cycles.

Erceg, C. and A. Levin (2006, October). Optimal monetary policy with durable consumption goods. Journal of Monetary Economics 53(7), 1341–1359.

Fallick, B., D. Villar, and W. Wascher (2022, October). Downward nominal wage rigidity in the united states in times of economic distress and low inflation. Labour Economics 78.

Feenstra, R. C., Z. Li, and M. Yu (2011, April). Exports and credit constraints under incomplete information: Theory and evidence from china. Working Paper 16940, National Bureau of Economic Research.

Feenstra, R. C. and A. Sasahara (2018). The 'china shock,'exports and us employment: A global input–output analysis. Review of International Economics 26(5), 1053–1083.

Galí, J. (2008). Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework. Princeton: Princeton University Press.

Garcia, R. and H. Schaller (2002). Are the effects of monetary policy asymmetric? Economic Inquiry 40(1), 102–119.

Georgiadis, G. and F. Zhu (2019, May). Monetary Policy Spillovers, Capital Controls and Exchange Rate Flexibility, and the Financial Channel of Exchange Rates. Globalization Institute Working Papers 363, Federal Reserve Bank of Dallas.

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

Gertler, M. and P. Karadi (2015, January). Monetary policy surprises, credit costs, and economic activity. American Economic Journal: Macroeconomics 7(1), 44–76.

Gilchrist, S. and E. Zakrajšek (2012, June). Credit spreads and business cycle fluctuations. American Economic Review 102(4), 1692–1720.

Grigsby, J., E. Hurst, and A. Yildirmaz (2021, February). Aggregate nominal wage adjustments: New evidence from administrative payroll data. American Economic Review 111(2), 428–71.

Gurkaynak, R. S., B. P. Sack, and E. T. Swanson (2011). Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. SSRN Electronic Journal.

Hazell, J. and B. Taska (2020). Downward rigidity in the wage for new hires.

Howes, C. (2021, 08). Financial constraints, sectoral heterogeneity, and the cyclicality of investment. Federal Reserve Bank of Kansas City Working Paper (No. 21-06).

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

Jo, Y. and S. Zubairy (2022, May). State dependent government spending multipliers: Downward nominal wage rigidity and sources of business cycle fluctuations. NBER Working Paper (w3025).

Jordà, Ò., M. Schularick, and A. M. Taylor (2015). Betting the house. Journal of International Economics.

Kahn, S. (1997). Evidence of nominal wage stickiness from microdata. The American Economic Review 87(5), 993–1008.

Kearns, J. and N. Patel (2016, December). Does the financial channel of exchange rates offset the trade channel? BIS Quarterly Review.

Kim, J. and F. J. Ruge-Murcia (2009). How much inflation is necessary to grease the wheels? Journal of Monetary Economics 56(3), 365–377.

Kiyotaki, N. and J. Moore (1997). Credit cycles. Journal of Political Economy.

Kohn, D., F. Leibovici, and M. Szkup (2022, February). Financial Frictions and International Trade: A Review. Working Papers 113, Red Nacional de Investigadores en Economía (RedNIE).

Kurt, E. (2022). Asymmetric Effects of Monetary Policy on Firms. Working Paper. Available at SSRN: http://dx.doi.org/10.2139/ssrn.4201754.

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

Lebow, D. E., D. J. Stockton, and W. L. Wascher (1995). Inflation, nominal wage rigidity, and the efficiency of labor markets. Technical report.

Lo, M. and J. Piger (2005). Is the response of output to monetary policy asymmetric? evidence from a regime-switching coefficients model. Journal of Money, Credit and Banking 37(5), 865–86.

Matschke, J. and J. Nie (2022). Downward wage rigidities and recession dynamics in advanced and emerging economies. Federal Reserve Bank of Kansas City Working Paper 22-10.

McLaughlin, K. J. (1994). Rigid wages? Journal of Monetary Economics 34(3), 383–414.

McLaughlin, K. J. (2000). Asymmetric Wage Changes and Downward Nominal Wage Rigidity.

Mertens, K. and M. O. Ravn (2013). The dynamic effects of personal and corporate income tax changes in the United States. American Economic Review 103(4), 1212–1247.

Mishkin, F. S. (1996, February). The channels of monetary transmission: Lessons for monetary policy. Working Paper 5464, National Bureau of Economic Research.

Murray, S. (2019). Downward nominal wage rigidity and job destruction.

Nakamura, E. and J. Steinsson (2018). Identification in macroeconomics. In Journal of Economic Perspectives.

Pierce, J. R. and P. K. Schott (2016, July). The surprisingly swift decline of us manufacturing employment. American Economic Review 106(7), 1632–62.

Pischke, J.-S. (2018). Wage flexibility and employment fluctuations: Evidence from the housing sector. Economica 85, 407–427.

Ravn, M. O. and M. Sola (2004). Asymmetric Effects of Monetary Policy in the United States. Review.

Rodriguez-Clare, A., M. Ulate, and J. P. Vasquez (2020, September). New-Keynesian Trade: Understanding the Employment and Welfare Effects of Trade Shocks. Working Papers 265, Princeton University, Department of Economics, Center for Economic Policy Studies.

Romer, C. D. and D. H. Romer (2004). A new measure of monetary shocks: Derivation and implications. American Economic Review 94(4), 1055–1084.

Schaller, Z. and P. DeCelles (2021, July). Weighted crosswalks for naics and sic industry codes. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 44–76.

Schmitt-Grohé, S. and M. Uribe (2016, 08). Downward nominal wage rigidity, currency pegs, and involuntary unemployment. Journal of Political Economy 124.

Singh, A., J. Suda, and A. Zervou (2022, May). Monetary policy, labor market, and sectoral heterogeneity. AEA Papers and Proceedings 112, 491–95.

Smets, F. and G. Peersman (2001). Are the effects of monetary policy in the euro area greater in recessions than in booms? European Central Bank Working Paper (52).

Stock, J. H. and M. W. Watson (2018). Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments. In Economic Journal.

Tenreyro, S. and G. Thwaites (2016). Pushing on a string: Us monetary policy is less powerful in recessions. American Economic Journal: Macroeconomics.

Thoma, M. A. (1994). Subsample instability and asymmetries in money-income causality. Journal of Econometrics 64(1), 279–306.

Weise, C. L. (1999). The asymmetric effects of monetary policy: A nonlinear vector autoregression approach. Journal of Money, Credit and Banking 31(1), 85–108.

Wieland, J. F. and M.-J. Yang (2020). Financial dampening. Journal of Money, Credit and Banking 52(1), 79–113.

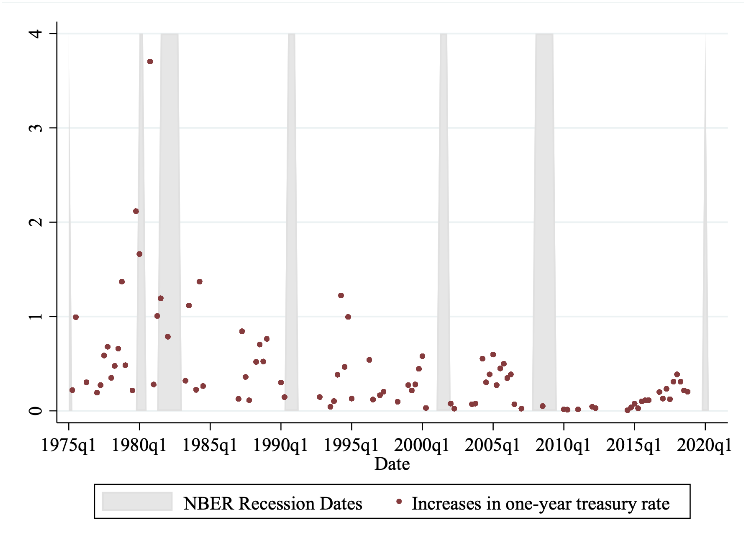
Woodford, M. (2011). Interest and Prices: Foundations of a Theory of Monetary Policy. Princeton: Princeton University Press.

9 Appendix

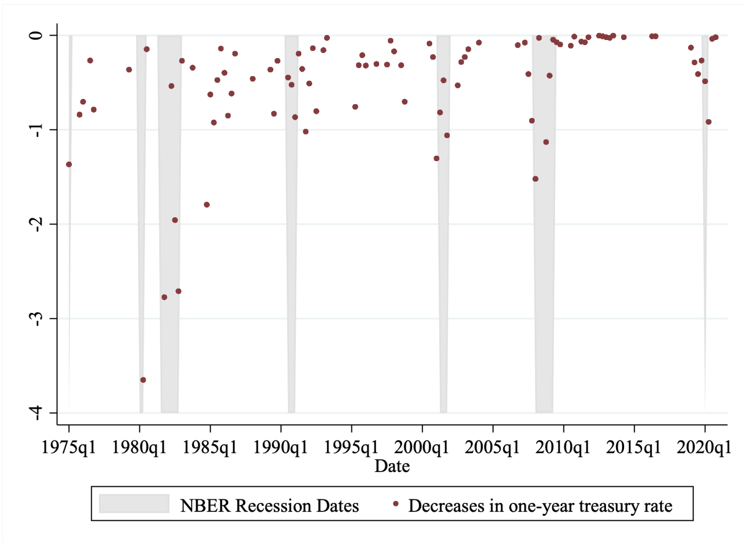
9.1 Figures

Figure 6: Changes in one-year treasury rate on the dates with monetary policy innovations.

(a) Increases in one-year treasury rate



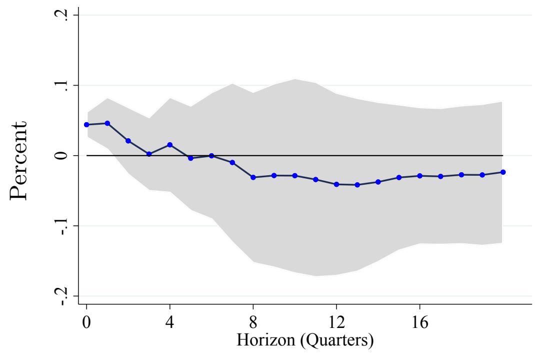
(b) Decreases in one-year treasury rate



Notes: This figure plots the increases and decreases in the one-year Treasury rate for each quarter. The positive and negative changes in one-year Treasury rate are instrumented with the monetary innovations that occurred in these quarters.

Figure 7: EFFECTS OF MONETARY INNOVATIONS ON LOG REAL GDP.

(a) WITHOUT SIGN RESTRICTION (β)



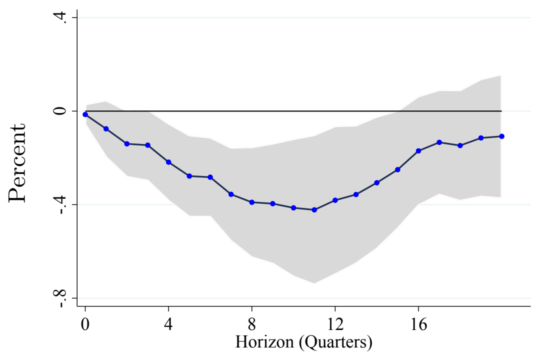
Notes: Column (a) estimates the following specification:

$$y_{j,t+h} - y_{j,t-1} = \beta_h \, \Delta R_t + \Omega'(L) \, Z_{j,t-1} + \epsilon_{\, j,t+h}, \tag{8}$$

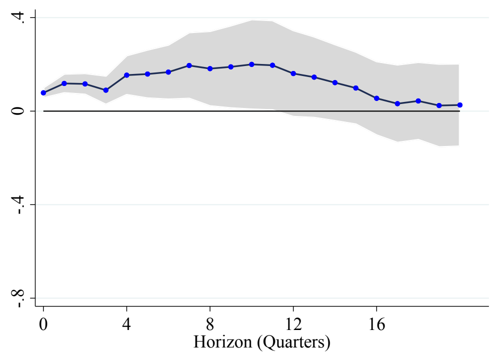
horizon is h = 0, 1,..., H, ΔR is the change in the one-year government bond yield instrumented with the monetary policy shocks. Control variables are lags of the dependent variable.

Figure 8: EFFECTS OF SIGN-DEPENDENT MONETARY INNOVATIONS ON LOG REAL GDP.

(a) CONTRACTIONS (β^+)



(b) EXPANSIONS (β^-)

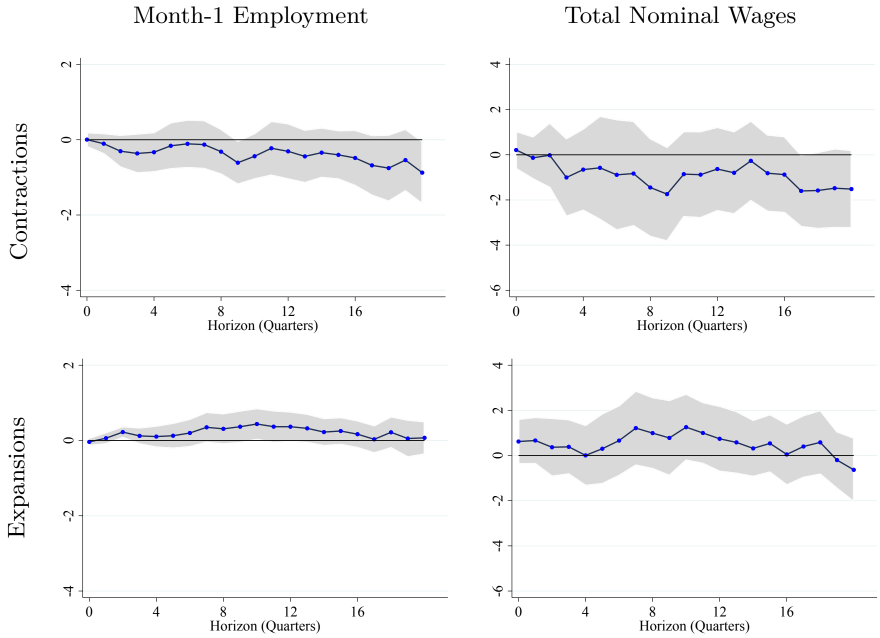


Notes: Columns (a) and (b) estimate the following specification:

$$y_{j,t+h} - y_{j,t-1} = \beta_h^+ \, max[0, \Delta R_t] + \beta_h^- \, min[0, \Delta R_t] + \Omega'(L) \, Z_{j,t-1} + \epsilon_{\, j,t+h}, \tag{9}$$

horizon is h = 0, 1,..., H, ΔR is the change in the one-year government bond yield instrumented with the monetary policy shocks. Control variables are lags of the dependent variable.

Figure 9: Effects of monetary policy using additional controls.

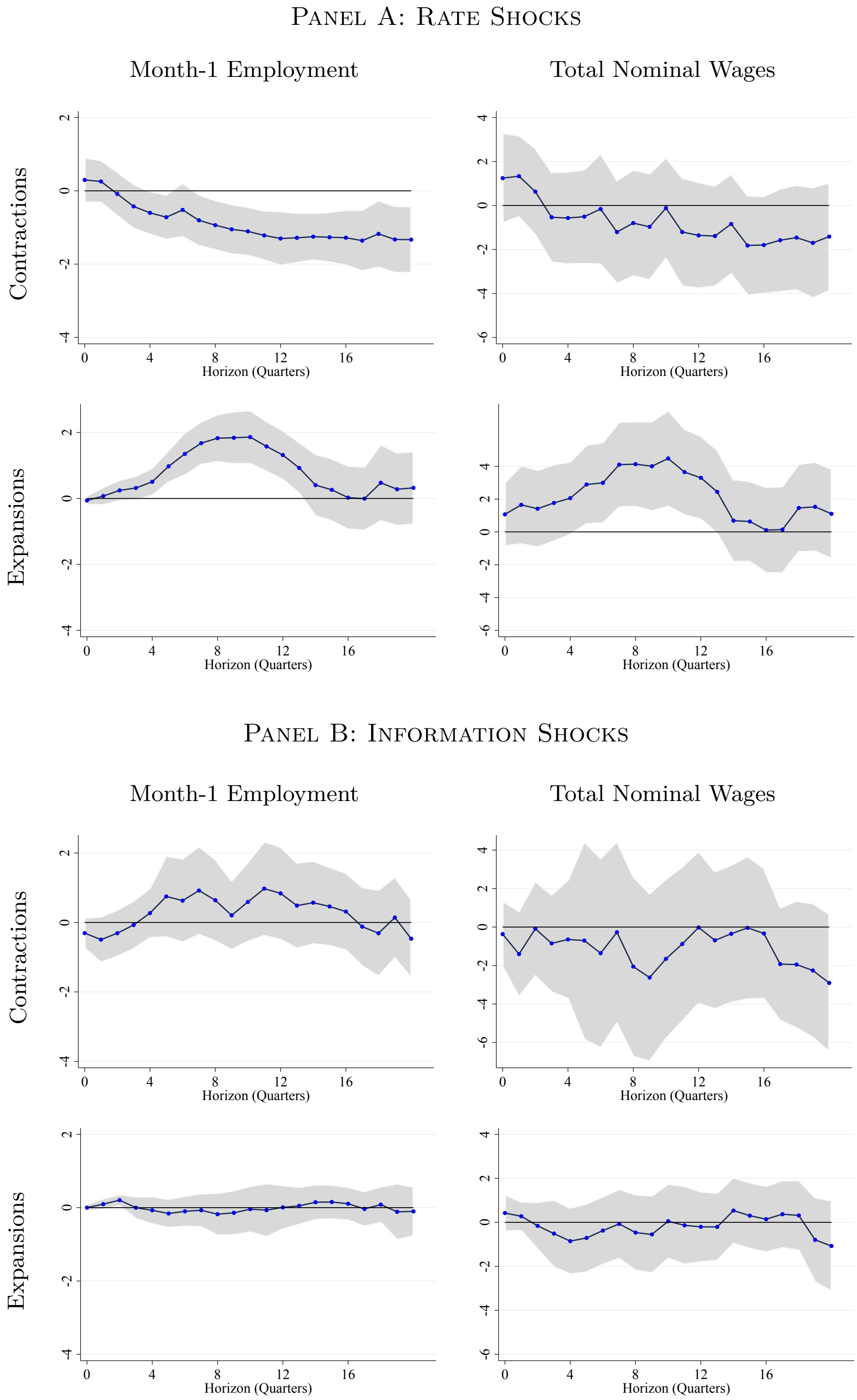


Notes: The top (bottom) figure shows the impulse response function following a 25bps increase (decrease) in the one year interest rate. The IRFs are estimated using the local projection IV approach described in the text. Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable, change in log real average wages at the industry level, change in unemployment rate and excess bond premium.

Figure 10: Effects of monetary policy using Romer shocks.

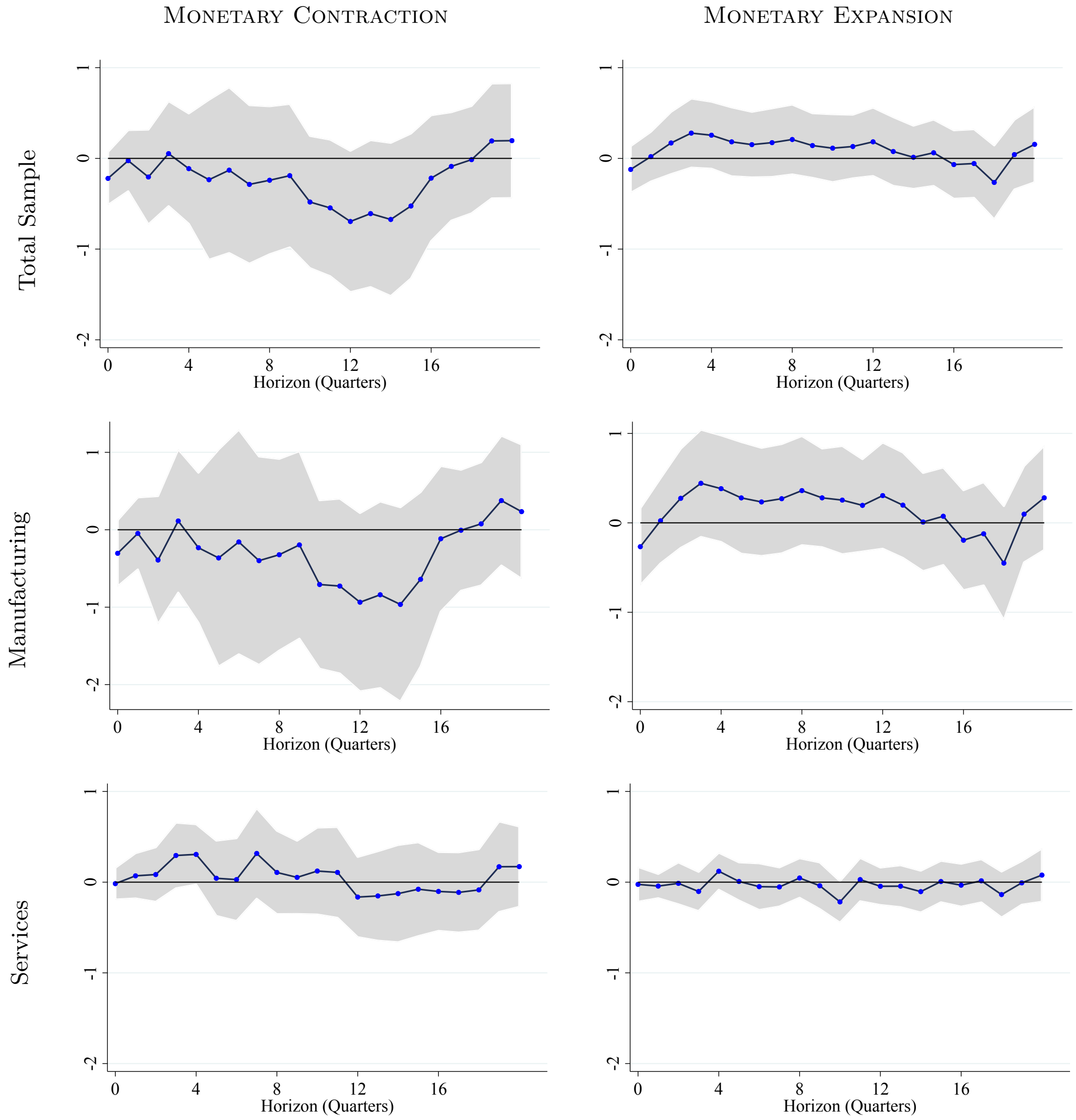
Notes: The top (bottom) figure shows the impulse response function following a 25bps increase (decrease) in the one year interest rate. The IRFs are estimated using the local projection IV approach described in the text. Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level.

Figure 11: Effects of monetary policy using rate shocks.



Notes: The top (bottom) rows in each panel shows the impulse response function following a 25bps increase (decrease) in the one year interest rate. We separate monetary policy shocks from contemporaneous information shocks by analyzing co-movement of interest rates and stock prices a la Jarociński and Karadi (2020). To generate quarterly stock price changes, we first compute monthly changes in S&P index and average these out for every quarter. Next, we split monetary policy shocks into the ones with/without an accompanying increase in S&P index. The top panel shows responses to pure rate shocks without an accompanying increase in stock prices. The bottom panel shows responses to monetary policy shocks with an accompanying increase in stock prices, which captures the central bank information shocks (Jarociński and Karadi, 2020). Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level.

Figure 12: Effects of monetary policy on employees per establishment.



Notes: The left (right) figure shows the impulse response function following a 25bps increase (decrease) in the one year interest rate. The IRFs are estimated using the local projection IV approach described in the text. Control variables are lags of the change in log real GDP, log industrial production index, log employment, log real capital expenditures, change in the response variable and change in log real average wages at the industry level.

Table 2: Business cycle interactions using NBER dates.

	β^-	$\gamma^{-,+}$	$\gamma^{-,-}$	β^+	$\gamma^{+,+}$	$\gamma^{+,-}$
Employees	0.41 (0.58)	-0.82 (8.65)	1.1 (0.67)	-0.20 (0.45)	0.86 (4.64)	-5.05 (4.01)
Employees (Baseline)	0.43 (0.28)			-0.45 (0.44)		
Total nominal wages	0.83 (1.86)	18.26 (26.8)	1.58 (2.24)	-1.52 (1.77)	-0.02 (14.25)	-15.87 (11.39)
Total nominal wages (Baseline)	0.90 (0.92)			-1.83 (1.6)		

Notes: Reported estimates are from 8 quarter following the monetary innovations. The IRFs are estimated using the following local projection IV:

$$y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \theta_q^h + \beta_h^+ \, max[0, \Delta R_t] + \gamma_h^{+,+} \, max[0, \Delta R_t] \Delta GDP_{j,t}^+ + \gamma_h^{+,-} \, max[0, \Delta R_t] \Delta GDP_{j,t}^-$$

$$+\beta_h^- \, min[0, \Delta R_t] + \gamma_h^{-,+} \, min[0, \Delta R_t] \Delta GDP_{j,t}^+ + \gamma_h^{-,-} \, min[0, \Delta R_t] \Delta GDP_{j,t}^- \quad (10)$$

$$+ \rho_t^+ \Delta GDP_{j,t}^+ + \rho_t^- \Delta GDP_{j,t}^- + \Omega'(L) \, Z_{j,t-1} + \epsilon_{\, j,t+h},$$