The Heterogeneous Effects of Monetary Policy Under Downward Nominal Wage Rigidity*

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Abstract

This study investigates the role of downward nominal wage rigidities in the transmission of monetary policy on labor income inequality. I show that labor income inequality decreases after a contractionary monetary policy shock when wages are flexible, while it remains unchanged when wages are rigid due to downward nominal wage rigidities. To account for this stylized fact, I employ a model with capital-skill complementarity that incorporates these rigidities. The presence of capital-skill complementarity and downward nominal wage rigidity is crucial to successfully replicate the patterns observed in the data. The model shows that (i) even though the volatility of labor income inequality after a monetary policy tightening under downward nominal wage rigidity is only 25% of the volatility under flexible wages, the volatility of output is 48% higher, and (ii) under an equal degree of downward nominal wage rigidity for high and low-skilled workers, the labor income inequality is not affected by the monetary policy, regardless of the level of rigidity.

Keywords: Monetary policy, downward nominal wage rigidity, labor income inequality.

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1 Introduction

Over recent decades, labor income inequality has steadily risen across both developed and emerging economies, creating growing interest among researchers and policymakers in understanding the influence of monetary policy on labor income inequality. Studies such as Bilbiie, Känzig, and Surico (2022), Gornemann, Kuester, and Nakajima (2012), and Hohberger, Priftis, and Vogel (2020) show that monetary policy significantly impacts income inequality, especially when accounting for household heterogeneity in the analysis.

Even though this topic has received considerable attention, the main assumption of these studies is that nominal wages are flexible. Therefore, I contribute to this ongoing debate by focusing on the specific role of downward nominal wage rigidities—i.e. the resistance of nominal wages to adjust downwards—in shaping the relationship between monetary policy and labor income inequality. Differences in the degree of downward nominal wage rigidity across households can potentially affect the income distribution differently than the case in which nominal wages are flexible. Understanding the role of downward nominal wage rigidities is crucial for researchers and policymakers, as these rigidities not only influence labor income inequality but also contribute to higher output and unemployment volatility (Daly and Hobijn 2014).

To examine the effects of downward nominal wage rigidities on the transmission of monetary policy, I initially estimate a state-dependent local projections model. This model allows to calculate state-dependent empirical impulse response functions (IRFs) for various economic variables in the United States following a monetary policy shock. I show that labor income inequality decreases after a monetary policy contraction in periods of high wage flexibility. However, labor income inequality remains unchanged in periods of high wage rigidity. Additionally, the response of the unemployment rate to the monetary policy shock is more pronouncedly under nominal wage rigidity. These stylized facts suggest that wage rigidities play a critical role in determining the impact of monetary policy on labor income inequality and unemployment.

Then, to provide theoretical insights into the observed stylized facts, I augment a dynamic stochastic general equilibrium (DSGE) model with nominal rigidities (also known as New Keynesian DSGE models) with search and matching (SAM) frictions and capital-skill complementarity in the production function as in Dolado, Motyovszki, and Pappa (2021) with downward nominal wage rigidities. By accounting for these features, the model can help explain the conditions under which monetary policy is effective in reducing labor income inequality and when its impact is dampened due to wage rigidities. The model reveals two main results: First, there is a trade-off between wage flexibility and economic stability: downward nominal wage rigidity prevents a skill premium reduction but introduces higher output and unemployment rate volatility, while flexible wages facilitate skill premium adjustment, resulting in a lower output and unemployment rate volatility. Second, when both high and low-skilled workers experience an equal degree of downward nominal wage rigidity, the impact of monetary policy on labor income inequality becomes neutral, regardless of the level of rigidity in nominal wages.

Related literature The motivation of this work relies on a large literature that supports the presence of downward nominal wage rigidities in the data. Recently, Grigsby, Hurst, and Yildirmaz (2021) used microdata to provide empirical evidence that declines in nominal base wage are exceptionally rare in the data. This goes in line with earlier research exploring downward nominal wage rigidity such as Card and Hyslop (1997), Gottschalk (2005), and Daly and Hobijn (2014).

This study is related to the literature on the effects of monetary policy on inequality. As highlighted by Coibion et al. (2017), there exist several channels in an economy through which monetary policy may impact on income and wealth inequality, and the magnitude and direction of the response may also vary depending on the channel. For example, the authors mention that the *income composition channel* (heterogeneity across households in terms of their primary source of income) and the *financial segmentation channel* (agents differ in their exposure to financial markets) increase inequality after an expansionary monetary policy realization, while there are other channels such as the *savings redistribution channel* (heterogeneity across households in terms of their financial position) and the *earnings heterogeneity channel* (heterogeneity across households in terms of labor income) increase inequality after a contractionary monetary policy shock.

Dolado, Motyovszki, and Pappa (2021) look into the earnings heterogeneity channel and study the monetary policy effects on labor income inequality when considering capital-skill complementarity in production of intermediate-good firms and asymmetric SAM frictions between high and low-skilled workers and show that an unexpected accommodative monetary policy shock increases labor income inequality between these two types of workers. Giarda (2021) also investigates the labor income inequality in a New Keynesian DSGE model with both high and less-skilled workers. The author discovers that labor income inequality is countercyclical due to factors such as higher wage rigidity and marginal propensity to consume for low-skilled workers, i.e., an unexpected monetary tightening leads to an increase in labor income inequality.

This study is also related to the literature on downward nominal wage rigidity. The existing literature has not yet explored the role of this characteristic in the effect of monetary policy on labor income inequality. The reasons behind this behavior in wage adjustments have not been fully understood, but a survey conducted by Bewley (1999) sheds light on why firms avoid reducing wages during recessions. Until now, it is common in the literature to include just an ad-hoc downward nominal wage rigidity constraint, as seen in Benigno and Antonio Ricci (2011), Schmitt-Grohé and Uribe (2016), Schmitt-Grohé and Uribe (2017), and Dupraz, Nakamura, and Steinsson (2019), or introduce asymmetric wage adjustment cost to intermediate-good firms based on a linex function such as in Fahr and Smets (2010), Kim and Ruge-Murcia (2011), and Abo-Zaid (2013). Since this work is not intended to understand the sources of downward nominal wage rigidity to rationalize it in a New Keynesian DSGE model, it suffices me to use the former approach.

2 Empirical evidence

This section focuses on empirically analyzing the impact of downward nominal wage rigidity on the effect of monetary policy on labor income inequality. To accomplish this, I estimate a state-dependent local projection model. I begin by providing an overview of the data used in the analysis. Following that, I outline the methodology used in the estimation of the empirical IRFs. Finally, I discuss the results obtained from the estimated IRFs.

2.1 Data

I use monthly data from two primary sources to conduct the analysis. The key macroeconomic indicators are obtained from the Federal Reserve Economic Data (FRED), while wage data is sourced from the NBER extracts of the Current Population Survey (CPS) Merged Outgoing Rotation Group. Using the survey data, I classify workers as high or low skilled based on their educational attainment. Specifically, individuals with at least some college education are considered high-skilled workers. Next, I construct the hourly wage for both high and low-skilled workers, as well as for all workers, and apply a backward 5-month moving average following Dolado, Motyovszki, and Pappa (2021) to adjust the data for seasonality. Also, as a measure of labor income inequality, I use the hourly wage ratio between high and low-skilled workers. This ratio, referred to as the *skill premium*, captures the wage difference between these two groups, providing insight into the level of inequality in labor income. To study the effects of monetary policy on employment, I compute from the same survey data: (i) the employment rate for high and low-skilled workers, and (ii) the employment ratio, which is defined as the number of employed high-skilled workers divided by the number of employed low-skilled workers, and adjust the series applying a backward 12-month moving average to account for seasonality.

I use the identified monetary policy shocks derived from the monetary policy surprises introduced by Gertler and Karadi (2015), which are extracted from Cloyne et al. (2023). As pointed out by the latter paper, this monetary policy surprise series serves as a proxy in a proxy-VAR approach to derive and extrapolate the implied monetary policy shocks for an extended period.

Additionally, I use the excess bond premium (EBP) series from Gilchrist and Zakrajšek (2012). The EBP serves as a financial indicator that captures private investors' sentiment regarding future economic conditions.

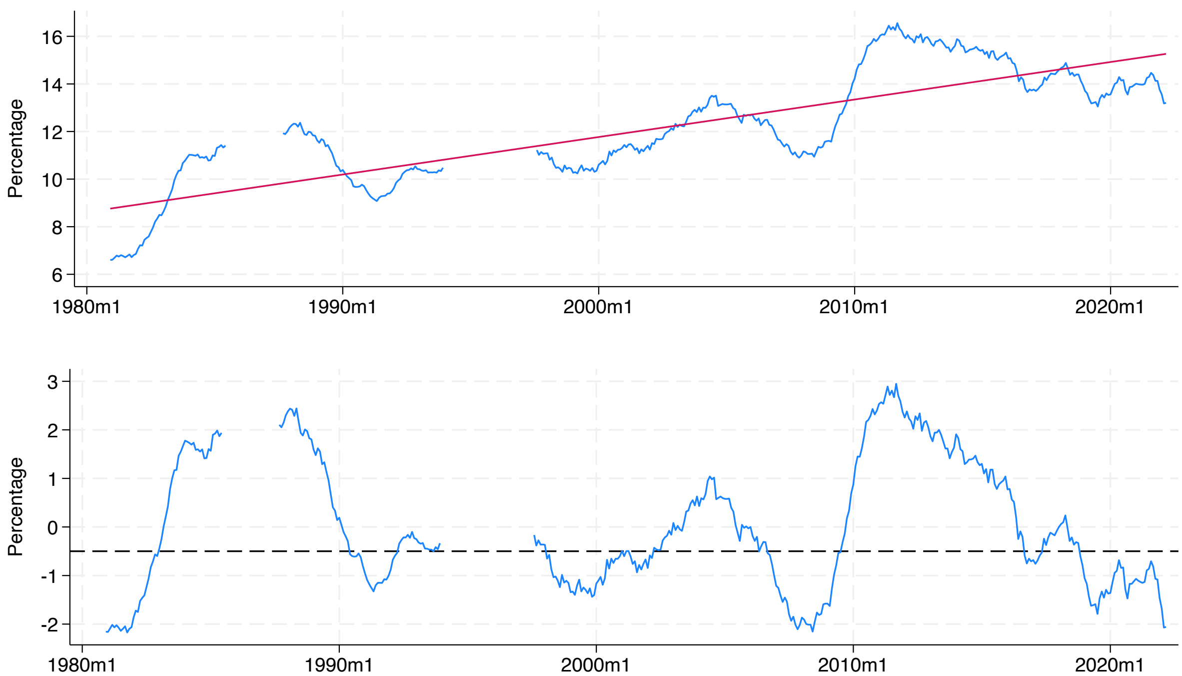
To identify periods of high and low wage rigidity in the data, I use the percentage of job-stayers—i.e. workers who remain in their jobs for at least one year—with no wage changes within one year. The complete time series can be retrieved from the Federal Reserve Bank of San Francisco, where it is known as the Wage Rigidity Meter.[1] A higher percentage indicates a larger fraction of workers who are presumed to be constrained from reducing their wages, while a lower percentage implies a greater degree of wage flexibility, as workers have the ability to adjust their wages more freely.

In Figure 1, the upper panel illustrates the percentage of job-stayers with no wage changes within a one-year period. Note that the time series exhibits non-stationarity, i.e., high values of wage rigidity in the 1980s are not equal to high values of wage rigidity in the 2010s. Therefore, to derive a stationary state variable from this series, I subtract the deterministic linear trend from the series. Thus, detrending is a solution to make comparable high values of wage rigidity across the decades. This detrending process results in the series observed in the lower panel of the figure.

An important observation to highlight from the original series is that, while it is feasible

[1] See Daly, Hobijn, and Wiles (2011), Daly, Hobijn, and Lucking (2012), and Daly and Hobijn (2014) for more details about the series.

Figure 1: Percentage of job-stayers with no wage change within one year



Note: The upper panel plots the series of nominal wage rigidity, measured as the percentage of job-stayers who experience no wage change within a one-year period. The blue line represents the time series, while the red line denotes the implied linear time trend. The lower panel shows the cyclical component of the time series described above. The black dashed line is the chosen threshold c used to identify the transition from a period of rigid wages to a period of flexible wages. Periods with no realizations are due to missing data.

to identify periods characterized by relatively high nominal wage rigidity, downward nominal wage rigidity is always present in the data (Daly and Hobijn 2014). This permanent presence of downward nominal wage rigidity makes it impossible to identify periods characterized by completely flexible nominal wages. Therefore, to study the impact of downward nominal wage rigidity on the transmission of monetary policy in the data, I compare periods of high wage rigidity with periods of low wage rigidity.

Table A.1 summarizes the data source, along with the corresponding start and end dates of the data series.

2.2 State-dependent local projections

Consider that the economy has two possible states, higher or lower wage rigidity. The response of variable y_t at horizon $h \in \{0, 1, 2, \dots, H\}$ in state $s \in \{r, f\}$[2] to a shock ε_t is estimated from the following non-linear equation:

$$y_{t+h} = I_t(z_{t-1})\Big(\alpha_h^r + \beta_h^r \varepsilon_t + \varphi_h^{r\prime}(L)\mathbf{x_t}\Big) + (1 - I_t(z_{t-1}))\Big(\alpha_h^f + \beta_h^f \varepsilon_t + \varphi_h^{f\prime}(L)\mathbf{x_t}\Big) + u_t \tag{1}$$

where $I_t(z_{t-1}) \in \{0, 1\}$ is a state indicator that depends on the state variable z_{t-1}: it takes the value 1 if the state of the economy in period t is r and 0 otherwise. The construction of the state indicator $I_t(z_{t-1})$ is explained below. $\varphi_h^s(L)$ with $s \in \{r, f\}$ is a lag operator, and $\mathbf{x_t}$ is a matrix of control variables. Under this setting, the estimated impulse response of variable y_t at horizon h in state s corresponds to the coefficient β_h^s.

The control variables included in this model are two lags of the dependent variable, the federal funds rate, the unemployment rate, and the excess bond premium. The idea behind these controls is to eliminate confounding factors in the estimation of the effect of the monetary policy shocks on the dependent variable, such as the inertia, the labor and financial market conditions, and the monetary policy stance.

The state variable z_{t-1} is assumed to capture the current state or condition of the economy. Thus, higher values of z_{t-1} indicate a higher likelihood of being in one state, while lower values of z_{t-1} suggest a higher likelihood of being in the other state. The threshold parameter c determines the transition point between these two states. Consequently, the state indicator $I_t(z_{t-1})$ is defined as

$$I_t(z_{t-1}) = \begin{cases} 1 & \text{if } z_{t-1} > c \\ 0 & \text{otherwise} \end{cases}$$

and the state variable z_{t-1} is defined as the *cyclical component* of the percentage of job-stayers with no wage changes within one year.

Note that this series contains two periods of missing data: 1985m7-1987m8 and 1994m1-1997m7. This introduces a challenge to identify the state of the economy during those periods. To address this issue, I set the threshold parameter at $c = -0.5$ to assume that any period with missing data is a period of high wage rigidity. I show in Appendix B that the results of this section remain robust even when the threshold is set at $c = 0$.

[2] States r and f stand for rigid and flexible wages.

2.3 Results

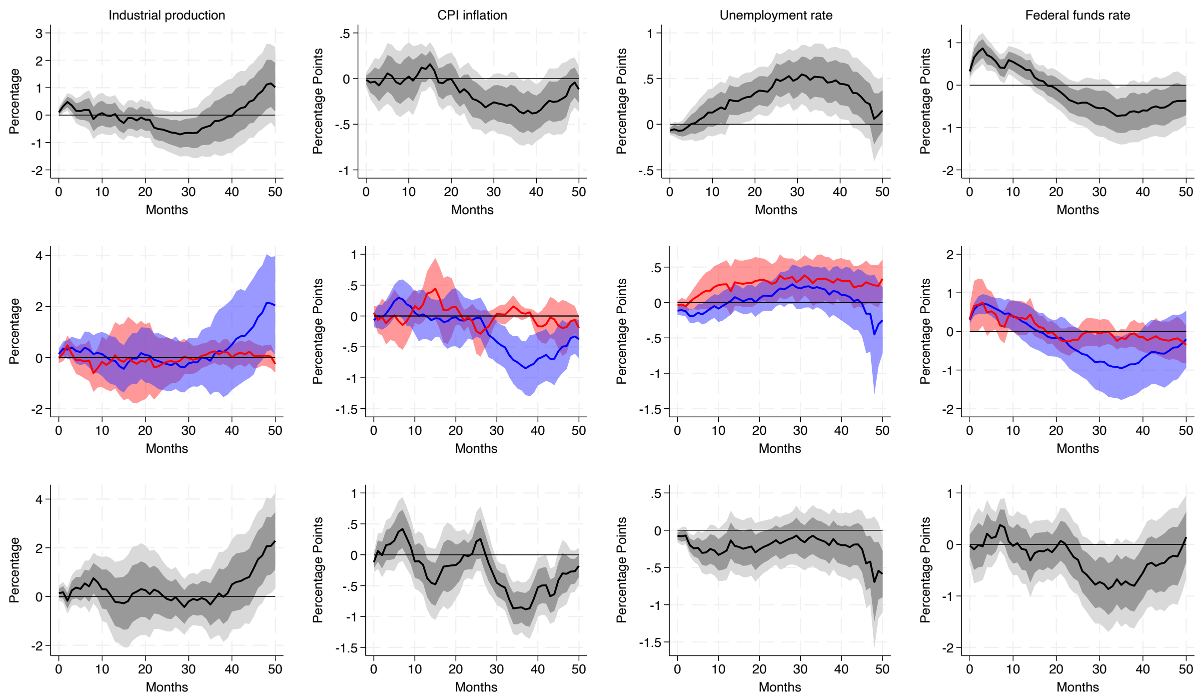
Figure 2 illustrates the IRFs of the main macroeconomic variables to an unexpected 25 bp. increase in the federal funds rate. The first row of graphs displays the IRFs from a linear model, while the second row depicts the IRFs of the state-dependent local projection model. Consistent with the predictions of the economic theory, when nominal wages are downwardly rigid, the unemployment rate response is significantly higher compared to a scenario with flexible wages. This can be observed in the graph of the third row, third column, where the line represents the difference in the IRF between states. When there is a decrease in aggregate demand, firms may experience lower revenues and profitability, leading to a need for cost-cutting measures. However, if wages are rigid and do not decrease accordingly, businesses may find it difficult to adjust their labor costs, resulting in a higher unemployment rate. Consequently, this more pronounced decline in the workforce leads to a deeper reduction in industrial production.

Figure 3 presents the IRFs of nominal wages and the skill premium. In the presence of downward wage rigidity, a contractionary monetary policy shock does not significantly impact the nominal wages of high and low-skilled workers. However, when the economy comes to a more flexible nominal wage setting, both high and low-skilled workers experience a slight decrease in nominal wages after a couple of years, though these wage declines are not statistically significant at the 90% confidence level. This pattern of response is consistent with the previous discussion that periods identified as flexible wages are actually periods of reduced wage rigidity rather than complete wage flexibility. Consequently, there may still be some reluctance in reducing nominal wages during these periods.

The response of the skill premium to the monetary policy shock when wages are flexible is also consistent with the empirical and theoretical findings of Dolado, Motyovszki, and Pappa (2021), as an increase in the federal funds rate decreases the labor income inequality. According to the authors, this result can be attributed to the concept of capital-skill complementarity in production. Following a monetary policy tightening, the reduction in investment lowers the demand for high-skilled labor, resulting in a more substantial decrease in their wages. On the other hand, as low-skilled workers serve as imperfect substitutes for high-skilled workers, the decrease in demand for high-skilled workers increases the demand for low-skilled workers. Therefore, this leads to an attenuated decline in wages for low-skilled workers and, in consequence, the skill premium decreases.

The data analysis reveals that the skill premium does not respond to the monetary policy

Figure 2: IRFs to a monetary policy shock: Main macroeconomic variables

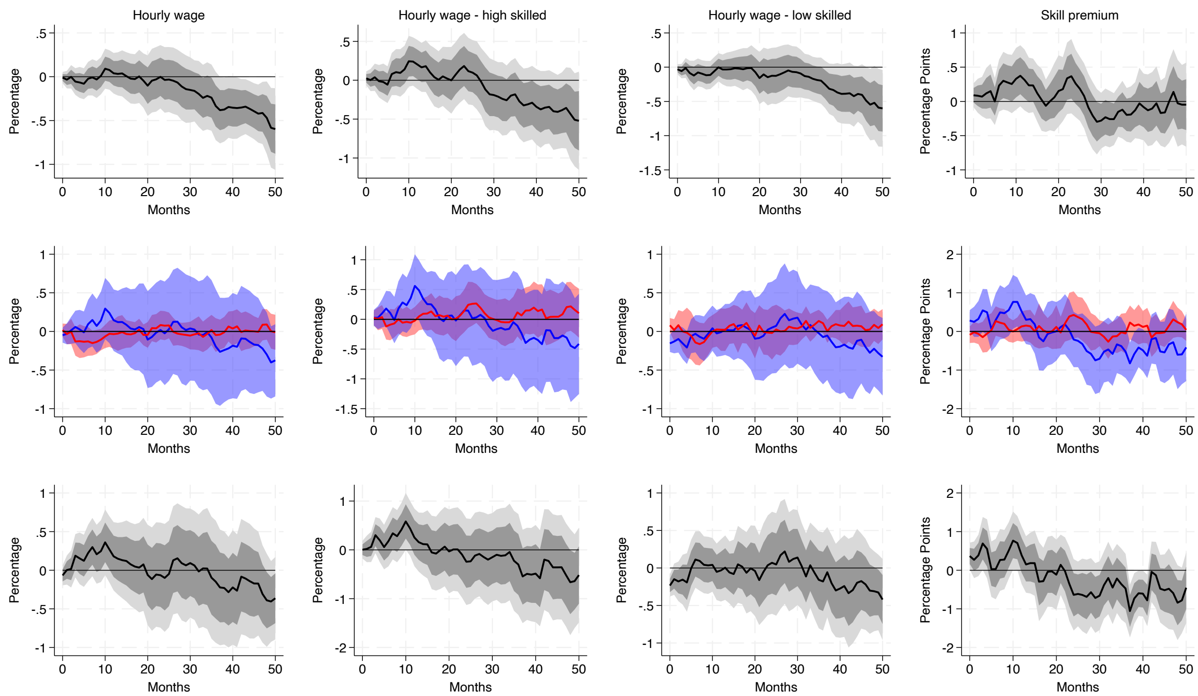


Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.

shock in the presence of downward nominal wage rigidity. Even in the presence of capital-skill complementarity, if wages of high and low-skilled workers cannot adjust downwards following a contractionary monetary policy, the skill premium remains unchanged. This finding underscores the importance of downward nominal wage rigidity in driving adjustments in the skill premium, as rigid wages hinder the transmission of monetary policy shocks to the relative compensation of different skill levels.

To gain a comprehensive understanding of the impact of monetary policy on the labor market, it is crucial to examine the employment responses of high and low-skilled workers. Figure 4 provides insights into the dynamics of employment rates for both worker groups, as well as the employment ratio, which is measured as the proportion of high-skilled workers employed relative to low-skilled workers. Regardless of whether the economy features high

Figure 3: IRFs to a monetary policy shock: Wages

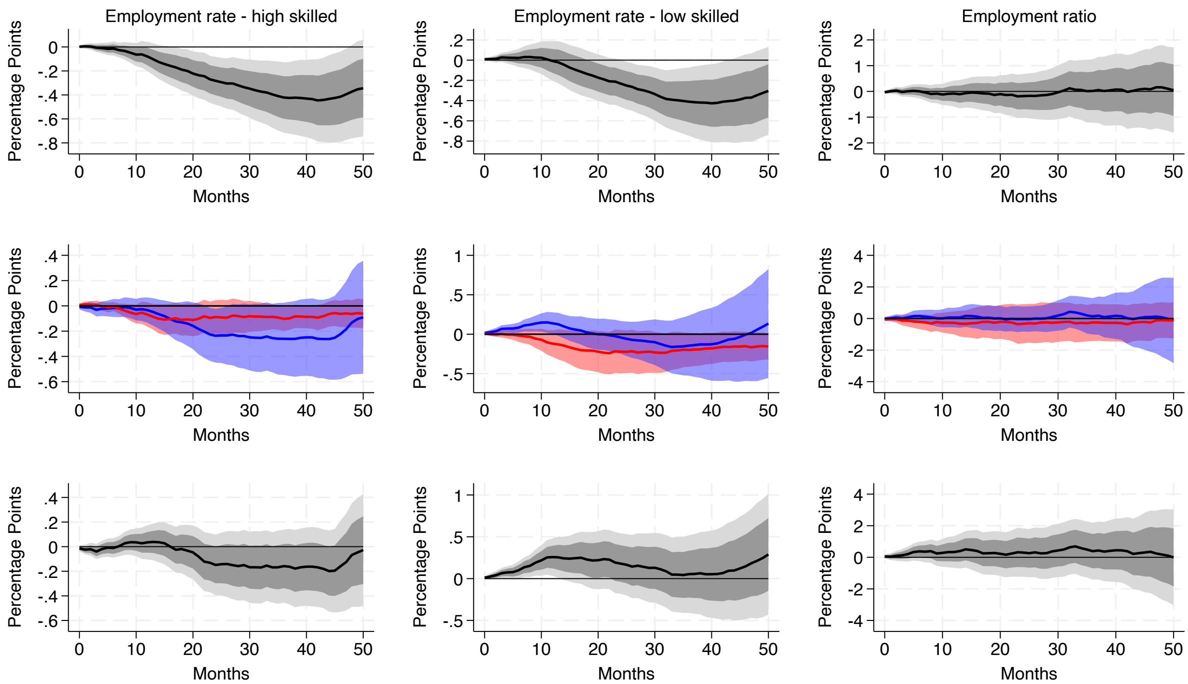


Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.

or low wage rigidity, the employment rates of both high and low-skilled workers experience a decline after a few years. However, in the case of flexible wages for low-skilled workers, their employment rate remains unchanged. This suggests that flexible wages may mitigate the negative employment effects associated with a contractionary monetary policy shock for low-skilled workers. Furthermore, the employment ratio does not exhibit any significant response to the monetary policy shock, irrespective of the wage regime. This implies that there is no evidence indicating a change in the skill composition of production following a contractionary monetary policy shock.

The employed specification used to calculate these IRFs has yielded some puzzling findings. When wages are flexible, it is intriguing to observe a significant increase in nominal wages for high-skilled workers within approximately one year. This wage increase subsequently

Figure 4: IRFs to a monetary policy shock: Employment



Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.

leads to a significant rise in the skill premium, also observed within the same timeframe. Additionally, the employment rate of low-skilled workers exhibits a significant increase within approximately one year when wages are flexible. However, upon further analysis, I discovered that these puzzling results are relatively sensitive to the threshold c, and also specific to the monetary policy shocks identified by Gertler and Karadi (2015). When using the Romer and Romer (2004) narrative series of monetary policy shocks, the IRFs of the nominal wages of high-skilled workers do not exhibit the unexpected increase. Additionally, the skill premium evolves as expected, with only a significant decrease observed after some years (Figure C.1, Figure C.2, and Figure C.3 shows the IRFs using the Romer and Romer (2004) monetary policy shocks).

The findings demonstrate that the presence of downward nominal wage rigidity significantly affects the response of the economy to a contractionary monetary policy shock. When wages are more rigid, the unemployment rate responds more pronouncedly, indicating the challenges firms face in adjusting labor costs during periods of reduced aggregate demand. Moreover, I show that downward nominal wage rigidity plays an important role in shaping the adjustments in the skill premium following monetary policy shocks. Specifically, rigid wages hinder the transmission of these shocks to the relative income compensation of different skill levels, highlighting the importance of wage flexibility in facilitating smoother labor market adjustments.

3 The New Keynesian DSGE model

This section introduces a New Keynesian DSGE model to better understand the adjustment of the economy under downward nominal wage rigidity. The model augments the model of Dolado, Motyovszki, and Pappa (2021) by including this type of rigidity.

The economy consists of heterogeneous households that can be either entrepreneurs or workers, with workers varying in skill level. Intermediate-good firms demand capital and labor from households. To reflect the substitutability of high and low-skilled workers and the complementarity between high-skilled workers and capital, intermediate-good firms produce according to a nested CES production function. The model also includes retail firms that produce final goods and a government that sets the interest rate and follows a balanced budget.

The labor market follows the Diamond-Mortensen-Pissarides framework of SAM frictions to produce frictional unemployment in the model. I extend this framework and introduce asymmetric SAM friction parameters for high and low-skilled workers. Wages are determined by a Nash bargaining model, where high and low-skilled workers have different bargaining power.

I depart from Dolado, Motyovszki, and Pappa (2021) by considering an ad-hoc downward nominal wage rigidity constraint following Schmitt-Grohé and Uribe (2016). This constraint will bind occasionally whenever the labor market clearing condition implies a reduction in nominal wages, ensuring that wages do not fall more than a fraction of the wage set in the previous period.

3.1 Households

This economy has a continuum of infinitely-lived households of mass normalized to 1. High and low-skilled workers and entrepreneurs represent a fixed fraction φ^k of the total population, with $k \in \{H, L, E\}$. Households maximize their lifetime utility, discounting future utility according to the discount factor β. Every household type pays lump sum taxes t_t^k. This economy has a set of state-contingent assets $b_{t+1}^E(s_{t+1})$ making possible a perfect risk-sharing between household types. These bonds pay one monetary unit in $t+1$ if the state of the economy in $t+1$ is s_{t+1}, and pay zero units otherwise. Thus, the gross interest rate of the economy is defined as $R_t = \left[\sum_{s_{t+1} \in \mathcal{S}} q_{t,t+1}(s_{t+1})\right]^{-1}$, where $q_{t,t+1}(s_{t+1})$ is the price of the state-contingent bond.

3.1.1 Entrepreneurs

Entrepreneurs accumulate and lease capital k_t to intermediate-good firms at a price r_t per capital unit. For simplicity, entrepreneurs do not take part in the labor market, do not receive utility for leisure, and own every firm in the economy. Given these conditions, entrepreneurs solve the following optimization problem:

$$\max_{\{c_t^E, i_t, k_{t+1}, b_{t+1}^E(s_{t+1})\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t^E\right)^{1-\eta}}{1-\eta}$$

$$\text{subject to} \quad c_t^E + i_t + t_t^E + \frac{1}{P_t} \sum_{s_{t+1} \in \ \mathcal{S}} q_{t,t+1}(s_{t+1}) b_{t+1}^E(s_{t+1}) \leq r_t k_t + \frac{b_t^E(s_t)}{P_t} + d_t$$

$$k_{t+1} = i_t + (1-\delta)k_t - \frac{\omega}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t$$

where c_t^E represents the consumption for entrepreneurs and η is the inverse of the intertemporal elasticity of substitution. P_t is the aggregate price index of the economy, i_t is the investment of each period, and d_t is the firm's profits. Capital in period $t+1$ is determined by the investment made in period t, the depreciated capital in period t (with δ representing the depreciation rate), and quadratic capital adjustment costs, where ω is the adjustment cost parameter.

3.1.2 Workers

Worker households have three options for allocating their time endowment of one unit: they can choose to be employed, unemployed, or inactive (engaged in leisure activities). The amount of time spent on each activity is denoted by n_t^k, u_t^k, and l_t^k, respectively, with $k \in \{H, L\}$. Therefore, workers must satisfy the following condition each period:

$$n_t^k + u_t^k + l_t^k = 1 \qquad k \in \{H, L\} \tag{2}$$

Workers receive a total real income of $w_t^k n_t^k$ and total unemployment benefits of $\varkappa^k u_t^k$. Thus, the problem that workers solve is

$$\max_{\{c_t^k, u_t^k, n_{t+1}^k, b_{t+1}^k(s_{t+1})\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(c_t^k\right)^{1-\eta}}{1-\eta} + \Phi^k \frac{\left(1 - n_t^k - u_t^k\right)^{1-\xi}}{1-\xi} \right] \qquad k \in \{H, L\}$$

$$\text{subject to} \quad c_t^k + t_t^k + \frac{1}{P_t} \sum_{s_{t+1} \in \mathcal{S}} q_{t,t+1}(s_{t+1}) b_{t+1}^k(s_{t+1}) \leq w_t^k n_t^k + \varkappa^k u_t^k + \frac{b_t^k(s_t)}{P_t}$$

$$n_{t+1}^k = \left(1 - \sigma^k\right) n_t^k + \mu_t^k u_t^k$$

where Φ^k is the weight of leisure on the worker's utility and ξ denotes the inverse of Frisch elasticity of substitution of labor supply. The second restriction of the optimization problem is the law of motion of employment. As will be discussed in more detail in Section 3.2, employment in the next period is determined by the fraction of job-stayers, which is represented by $\left(1 - \sigma^k\right) n_t^k$. Additionally, employment in the next period is also determined by the fraction of unemployed workers who are hired, which is represented by $\mu_t^k u_t^k$.

3.2 The labor market

Under SAM frictions, vacancies v_t^k, which are posted by intermediate-good firms, and aggregate unemployed high and low-skilled workers $U_t^k \equiv \varphi^k u_t^k$ are matched based on the following matching function:

$$m_t^k\left(v_t^k, U_t^k\right) = \psi^k \left(v_t^k\right)^{\varsigma} \left(U_t^k\right)^{1-\varsigma} \qquad k \in \{H, L\} \tag{3}$$

The matching efficiency parameter ψ^k is different between worker types, while the matching elasticity ς is constant between worker types.

Labor market tightness, vacancy filling probability, and the hiring probability are defined as $\theta_t^k = \frac{v_t^k}{U_t^k}$, $\nu^k = \frac{m_t^k}{v_t^k}$, and $\mu^k = \frac{m_t^k}{U_t^k}$, respectively, with $k \in \{H, L\}$.

The law of motion of aggregate employment $N_t^k \equiv \varphi^k n_t^k$ is defined as

$$N_{t+1}^k = \left(1 - \sigma^k\right) N_t^k + m_t^k \qquad k \in \{H, L\} \tag{4}$$

where σ^k is the separation rate, which is considered exogenous and constant, but different between worker types.

As noted, unemployment under SAM frictions is only involuntary and determined by two factors: the exogenous separation rate σ^k and the matching technology m_t^k, i.e., workers in the labor force are unemployed because (1) they are fired or (2) they do not match with an intermediate-good firm.

3.3 Firms

This economy is composed of a continuum of perfectly competitive intermediate firms that produces a homogeneous good Y_t using skilled and unskilled labor as well as capital as essential components, and a set of monopolistically competitive retail firms purchase an amount $y_t(i), i \in [0, 1]$ of this good and produce a differentiated good $y_t^r(i)$.

3.3.1 Intermediate-good firms

Intermediate firms produce according to a production function $F\left(K_t, N_t^H, N_t^L\right)$ that takes aggregate capital, defined as $K_t \equiv \varphi^E k_t$, and aggregate high and low-skilled labor N_t^k as inputs. Firms pay r_t and $w_t^k, k \in \{H, L\}$ respectively for every unit of input, and face a unit cost of κ for posting vacancies. Therefore, the intermediate-good firm's problem can be expressed as

$$\max_{\{K_t, N_{t+1}^H, N_{t+1}^L, v_t^H, v_t^L\}} \mathbb{E}_0 \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left[F\left(K_{t+s}, N_{t+s}^H, N_{t+s}^L\right) - r_{t+s} K_{t+s} - \sum_{k \in \{H,L\}} \left(w_{t+s}^k N_{t+s}^k + \kappa v_{t+s}^k\right) \right]$$
$$\text{subject to} \quad N_{t+s+1}^k = \left(1 - \sigma^k\right) N_{t+s}^k + \nu_{t+s}^k v_{t+s}^k$$

where $\Lambda_{t,t+s} = \beta^s \left(c^E_{t+s}/c^E_t\right)^{-\eta}$ is the stochastic discount factor of the entrepreneurs, which are the owners of the firms. Note that intermediate firms in this setting take N^H_t and N^L_t as predetermined variables.

The production function of intermediate firms is defined as the following nested CES function:

$$F\left(K_t, N^H_t, N^L_t\right) = A_t \left[\phi \left[\lambda K^\gamma_t + (1-\lambda)\left(N^H_t\right)^\gamma\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\left(N^L_t\right)^\alpha\right]^{\frac{1}{\alpha}} \tag{5}$$

where A_t is the aggregate TPF, ϕ is the skill intensity on production, λ is the capital intensity against skilled labor, γ is the capital-skill elasticity of substitution and α is the elasticity of substitution between the capital-skill output and low-skilled labor.

In this setting, the aggregate TFP evolves according to the following AR(1) process:

$$\ln A_t = \rho_a \ln A_{t-1} + \varepsilon^a_t \tag{6}$$

3.3.2 Wage setting

Wages are determined based on Nash bargaining theory. At each period, the surplus generated by workers from being employed $\left(V^{E,k}_t\right)$ and by intermediate firms from filling a job $\left(V^{F,k}_t\right)$ is divided between workers and intermediate firms according to their relative bargaining power ϑ^k. I include an additional ad-hoc constraint into this problem to ensure that the nominal wage $P_t w^k_t$ does not decrease by more than a fraction Ψ^k, $k \in \{H, L\}$ of the nominal wage that was set in the previous period $\left(P_{t-1} w^k_{t-1}\right)$. The wage bargaining process can be formally represented as an optimization problem as follows:

$$\begin{aligned}
&\max_{w^k_t} \ \vartheta^k \ln\left(V^{E,k}_t\right) + \left(1-\vartheta^k\right)\ln\left(V^{F,k}_t\right) && k \in \{H, L\} \\
\text{subject to } \ & V^{E,k}_t = \frac{\partial \mathcal{L}^k}{\partial n^k_t} = \lambda^{c,k}_t w^k_t - \Phi^k \left(l^k_t\right)^{-\xi} + \left(1-\sigma^k\right)\lambda^{n,k}_t && \\
& V^{F,k}_t = \frac{\partial \mathcal{L}^F}{\partial N^k_t} = F^k_{N,t} - w^k_t + \left(1-\sigma^k\right)\frac{\kappa}{\nu^k_t} && \\
& w^k_t \geq \Psi^k \frac{w^k_{t-1}}{\Pi_t} && \Psi^k \geq 0
\end{aligned}$$

where $\mathcal{L}^k$ and $\mathcal{L}^F$ are the Lagrange equations from the workers' and firms' optimization problem, respectively, $\lambda^{c,k}_t$ and $\lambda^{n,k}_t$ are the Lagrange multipliers related to the budget constraint and the law of motion of employment from the workers' problem, respectively, $F_{N,t}^k$ is the marginal product of labor k, and $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ is the gross inflation.

As the downward nominal wage rigidity constraint will bind occasionally, the solutions for w_t^k in this problem will be non-linear and equal to

$$w_t^k = \begin{cases} \vartheta^k \left[F_{N,t}^k + \left(1-\sigma^k\right) \frac{\kappa}{\nu_t^k} \right] + \frac{1-\vartheta^k}{\lambda_t^{c,k}} \left[\Phi^k \left(l_t^k\right)^{-\xi} - \left(1-\sigma^k\right) \lambda_t^{n,k} \right], & \text{if } w_t^k > \Psi^k \frac{w_{t-1}^k}{\Pi_t} \\ \Psi^k \frac{w_{t-1}^k}{\Pi_t}, & \text{otherwise} \end{cases} \tag{7}$$

3.3.3 Retail firms

Every period, a continuum of retail firms, indexed by $i \in [0,1]$, purchase a quantity $y_t(i)$ of the aggregate intermediate good Y_t to produce a final good $y_t^r(i)$. The production technology used by these retail firms is such that it requires one unit of intermediate goods to produce one unit of the final good. Final goods are then assembled into aggregate output using the following Dixit-Stiglitz aggregator:

$$Y_t^r = \left[\int_0^1 y_t^r(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}} = \left[\int_0^1 y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}} = Y_t$$

where ϵ is the elasticity of substitution between final goods. To reduce notation complexity, total output will be represented by Y_t, since the quantity of final goods Y_t^r produced is equivalent to that of intermediate goods Y_t.

Following price stickiness from Calvo (1983), a fraction $\chi \in [0,1]$ of retail firms cannot adjust prices, and the remaining fraction $1-\chi$ of firms that can adjust prices maximize their real present value of expected future profits:

$$p_t^*(i) \equiv \arg\max_{p_t(i)} \mathbb{E}_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} \left[\frac{p_t(i)}{P_{t+s}} - (1-\tau) * 1 \right] y_{t+s}(i)$$
$$\text{subject to} \quad y_{t+s}(i) = \left(\frac{p_t(i)}{P_{t+s}} \right)^{-\epsilon} Y_{t+s}$$

where $\tau \in \{0,1\}$ is a government subsidy of intermediate goods cost intended to compensate for the monopolistic behavior of retail firms. Thus, the solution to the final firm's problem is

$$p_t^* = \frac{(1-\tau)\epsilon}{\epsilon-1} \mathbb{E}_t \frac{\sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} y_{t+s}(i) P_{t+s}}{\sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} y_{t+s}(i)}.$$

3.4 Government

3.4.1 Monetary policy

Monetary policy sets the short-term nominal interest rate R_t of the economy according to the following Taylor rule:

$$\frac{R_t}{\overline{R}} = \left(\frac{\Pi_t}{\overline{\Pi}}\right)^{\zeta^\pi} \left(\frac{Y_t}{\overline{Y}}\right)^{\zeta^y} e_t \tag{8}$$

where $\overline{R}, \overline{\Pi}$, and $\overline{Y}$ represent the long-run values of nominal interest rate, inflation, and output, respectively, ζ^π and ζ^y are the parameters governing the response of inflation and output, respectively, and e_t is a monetary policy shock that evolves according to the following AR(1) process with persistence ρ_R and white noise ε_t^R:

$$\ln e_t = \rho_R \ln e_{t-1} + \varepsilon_t^R \tag{9}$$

3.4.2 Fiscal policy

The government follows a budget balance rule that is given by the following equation:

$$T_t = G_t + \tau Y_t + \sum_{k \in \{H,L\}} \varkappa^k U_t^k \tag{10}$$

Under this setting, $T_t \equiv \sum_k \varphi^k t_t^k$ represent lump sum taxes, τY_t is the total expenditure in intermediate good subsidizing, $\sum_k \varkappa^k U_t^k$ denotes the total expenditure in unemployment benefits, and G_t is the government expenditure that evolves according to the following AR(1) process:

$$\ln G_t = (1 - \rho_g) \ln \left(\Gamma \overline{Y}\right) + \rho_g \ln G_{t-1} + \varepsilon_t^g \tag{11}$$

where Γ is the long-run share of government expenditure in output.

3.5 Equilibrium

A closed economy with perfect markets implies that state-contingent asset market clears according to the following condition:

$$\sum_{k\in\{H,L,E\}} \varphi^k b_{t+1}^k(s_{t+1}) = 0 \qquad\qquad \forall s_{t+1} \in \mathcal{S} \tag{12}$$

Finally, the goods market clearing condition requires that

$$Y_t = C_t + I_t + G_t + \sum_{k\in\{H,L\}} \kappa v_t^k \tag{13}$$

3.6 Calibration

Table 1 provides an overview of the model's parameters, most of which have been extracted from the study by Dolado, Motyovszki, and Pappa (2021). These coefficients allow for a direct comparison between a model that incorporates flexible wages and SAM frictions and a model that considers downward nominal wage rigidity and SAM frictions.

In Dolado, Motyovszki, and Pappa (2021), the utility weight on leisure (Φ^k) and the bargaining power (ϑ^k) for both high and low-skilled workers were calibrated by targeting the steady-state values of the participation rates and the unemployment rates of high and low-skilled workers, based on pre-crisis average values. To better capture the heterogeneity between these two groups in the labor market, the authors employed asymmetrical parameters in the SAM framework. Specifically, they separately calculated the separation rate for high and low-skilled workers, resulting in $\sigma^H < \sigma^L$. Additionally, based on the findings of Wolcott (2021), they imposed that $\psi^H > \psi^L$ to account for the disparities between the two groups of workers to effectively match with a firm.

Downward Nominal Wage Rigidity I calibrate the degree of downward nominal wage rigidity for high and low-skilled workers by targeting the empirical impulse responses of the skill premium and the unemployment rate. To accomplish this, I employ a grid search method and construct a grid of size 25×25 with evenly distributed values of variables Ψ^H and Ψ^L within the interval $[0.9900, 0.9990]$. Subsequently, I calculate and store the theoretical IRFs to an unexpected 25 bp. increase in the interest rate. Then, I proceed to select the coefficients

Table 1: Parameter values

Parameter		Value	Parameter		Value
Households			*Labor market*		
β	personal discount factor	0.990	σ^H	separation rate – H	0.025
η	intertemporal elast. of subst.	2.000	σ^L	separation rate – L	0.056
ξ	Frisch elast. of labor supply	4.000	ψ^H	matching efficiency – H	0.720
Φ^H	weight of leisure in utility – H	0.052	ψ^L	matching efficiency – L	0.455
Φ^L	weight of leisure in utility – L	0.216	ς	matching elasticity	0.500
φ^H	share of high skilled	0.210			
φ^L	share of low skilled	0.690	*Retail firms*		
φ^E	share of entrepreneurs	0.100	ϵ	elast. of subst. between goods	6.000
ω	capital adjustment costs	4.000	χ	Calvo price rigidities	0.800
δ	depreciation rate	0.010	τ	employment subsidy	0.167
Intermediate-good firms			*Government*		
κ	vacancy costs	0.130	$\varkappa^H$	unemployment benefits – H	0.287
ϕ	skilled input intensity	0.427	$\varkappa^L$	unemployment benefits – L	0.287
λ	capital intensity	0.350	Γ	steady state government exp.	0.200
α	elasticity of subst bw N_H and N_L	0.400	ζ^R	interest rate smoothing	0.000
γ	elasticity of subst bw K and N_H	-0.490	ζ^π	monetary policy reaction to inflation	1.500
ϑ^H	bargaining power of firms – H	0.696	ζ^y	monetary policy reaction to output	0.000
ϑ^L	bargaining power of firms – L	0.374			
Ψ^H	degree of DNWR – H	0.997	*Persistence parameters*		
Ψ^L	degree of DNWR – L	0.998	ρ_a	persistence of TFP shock	0.850
			ρ_g	persistence of gov. exp. shock	0.700
			ρ_R	persistence of monetary shock	0.700

Ψ^H and Ψ^L based on the following two requirements: (1) The skill premium IRF exhibits a maximum decrease of approximately 0.3 pp. when considering downward nominal wage rigidities in the model, and (2) the unemployment rate IRF exhibits a maximum increase of approximately 0.25 pp. The coefficients that meet the criteria are $\Psi^H = 0.997125$ and $\Psi^L = 0.997875$, which implies a maximum annual decrease in the nominal wage of 1.15% and 0.85% for high and low-skilled workers, respectively. This calibration goes in line with Daly, Hobijn, and Lucking (2012), who find that workers with up to a high-school degree exhibit a higher wage rigidity on average compared to workers with at least some higher education.

4 Results

I implement the piecewise-linear Kalman filter solution proposed by Giovannini, Pfeiffer, and Ratto (2021) to compute the IRFs of the model. It is worth noting that this methodology is based on the well-known piecewise-linear solution introduced by Guerrieri and Iacoviello (2017). This specialized method is suitable for estimating DSGE models with occasionally binding constraints, such as downward nominal wage rigidity.

To make a comparison between an economy with flexible wage adjustments and an economy with downward nominal wage rigidities, I use the baseline IRFs of Dolado, Motyovszki, and Pappa (2021) as a benchmark.

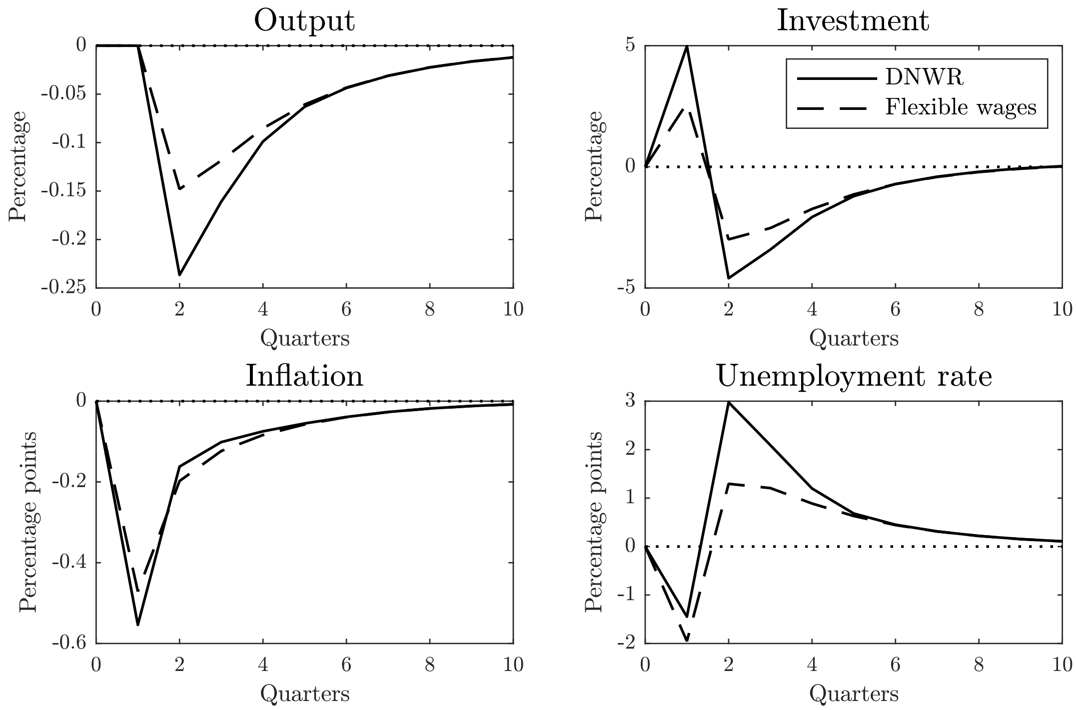
4.1 Impulse responses to a contractionary monetary policy shock

Let w_t^H/w_t^L be the measure of labor income inequality in the model, or *skill premium*. Figure 5 illustrates the IRFs to an unexpected 25 bp. increase in the interest rate for the main macroeconomic variables. An increase in the interest rate reduces aggregate demand as a result of a reduction in consumption spending. In absence of downwardly rigid wages, the decline in aggregate demand leads to a reduction in output, downward pressure on nominal and real wages for both high and low-skilled workers, and an increase in the unemployment rate. However, when downward nominal wage rigidity is present, the unemployment rate is higher compared to the scenario with flexible wages. This is because nominal wages cannot decrease by more than a certain limit per quarter, constraining firms' ability to adjust wages downward. As a result, the unemployment rate remains elevated for a longer period, leading to a more significant decrease in output. Thus, the economy experiences a stronger contraction, in line with Schmitt-Grohé and Uribe (2016).

The IRFs of the labor market variables are presented in Figure 6. As anticipated, after the monetary policy tightening, the downward nominal wage rigidity constraint becomes binding, resulting in a slow downward nominal wage adjustment for both high and low-skilled workers. Real wages, in particular, exhibit a greater reluctance to decrease and even increase initially due to the significant decrease in the price level during the same period.

Regarding the skill premium, in the scenario with flexible wages, it experiences a decrease of 1.5 percentage points on impact. As the economic downturn reduces the demand for capital, the decline in demand for high-skilled workers is more pronounced compared to the

Figure 5: IRFs to a contractionary monetary policy shock. Main macroeconomic variables



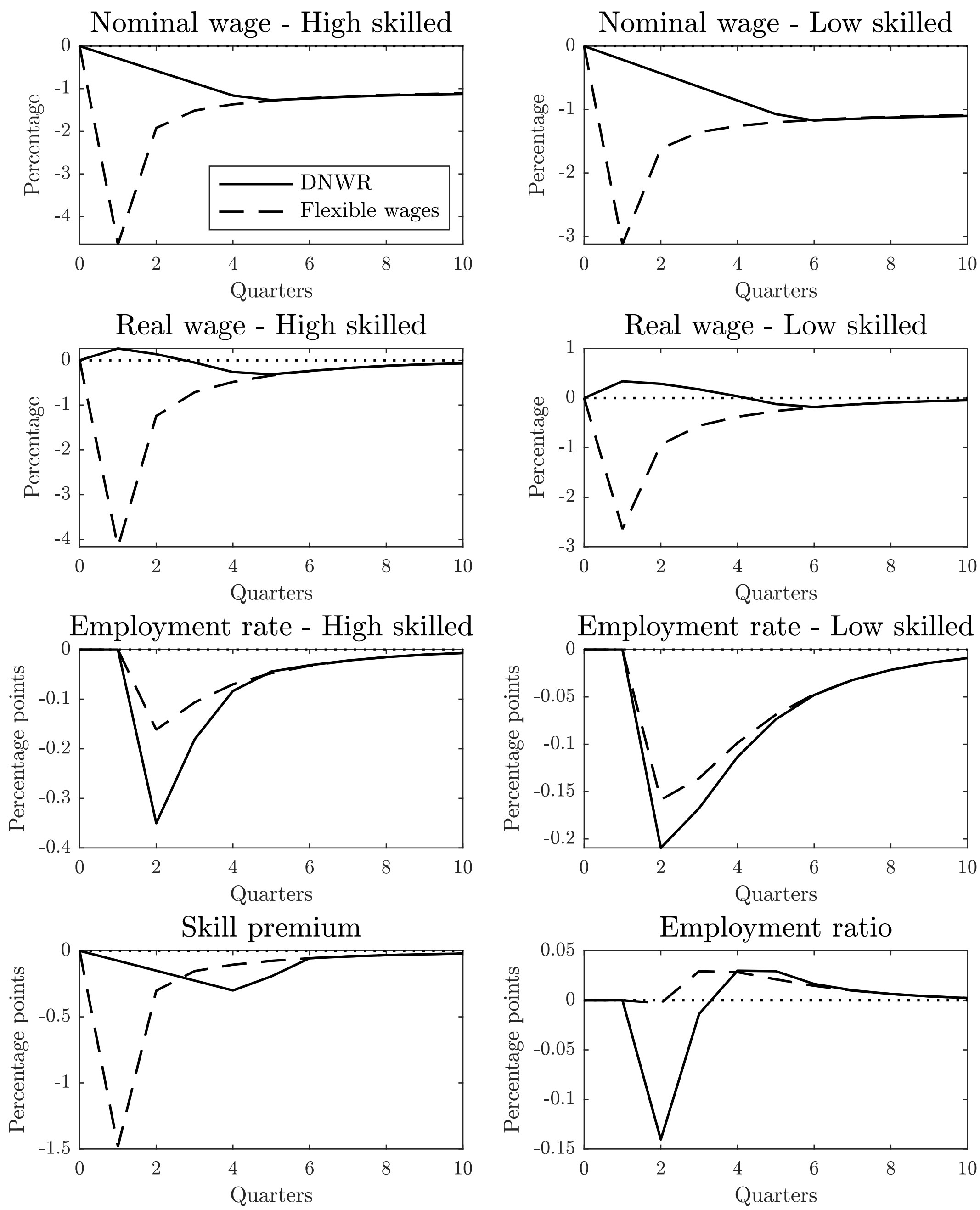
Note: The solid black lines depict the variable impulse responses of the model incorporating downward nominal wage rigidity, while the dashed black lines represent the variable responses of Dolado, Motyovszki, and Pappa (2021)'s model.

reduction in demand for low-skilled workers due to capital-skill complementarity. As a result, the nominal wage of high-skilled workers decreases more than that of low-skilled workers, leading to a reduction in the wage gap between the two groups.

On the other hand, under the presence of downward nominal wage rigidities, the skill premium only declines by approximately 0.3 percentage points after four quarters, as the nominal wage of both high and low-skilled workers is constrained from decreasing. The magnitude of the decrease in the skill premium is influenced by the difference in the degree of downward nominal wage rigidity between high and low-skilled workers. Given that high-skilled workers have a lower degree of downward nominal wage rigidity compared to low-skilled workers, they experience a relatively higher decrease in nominal wages, resulting in a reduction of the skill premium.

On the employment side, both high and low-skilled workers experience a more substantial decrease in the employment rate when downward nominal wage rigidity is present. Incorporating downward nominal wage rigidity in the model better captures the idea that, due

Figure 6: IRFs to a contractionary monetary policy shock. Labor variables



Note: The solid black lines depict the variable responses of the model incorporating downward nominal wage rigidity, while the dashed black lines represent the variable responses of Dolado, Motyovszki, and Pappa (2021)'s model.

Table 2: Maximum response and volatility to a monetary policy tightening

	Maximum response			Volatility		
Variable	**DNWR**	**Flex. wages**	**Ratio**	**DNWR**	**Flex. wages**	**Ratio**
Output (%)	-0.24	-0.15	1.60	0.07	0.05	1.48
Inflation (pp.)	-0.55	-0.47	1.18	0.14	0.12	1.14
Unemployment rate (pp.)	0.17	0.07	2.32	0.06	0.04	1.39
Skill premium (pp.)	-0.30	-1.48	0.20	0.09	0.36	0.25

Note: The maximum responses are expressed in percentage points. Volatility is expressed as standard deviations.

to capital-skill complementarity, a decrease in investment leads to a larger decrease in the employment rate of high-skilled workers compared to low-skilled workers. This pattern is not captured in the IRFs under flexible wages. Consequently, the larger decrease in the employment rate of high-skilled workers compared to low-skilled workers results in a decline in the employment ratio, measured as the number of employed high-skilled workers divided by the number of employed low-skilled workers.

The model used in this study enables the construction of a measure of gains from a fully flexible wage setting, giving valuable insights into the potential benefits of implementing such flexibility. Table 2 presents the maximum response of some economic variables and their volatility after a monetary policy tightening under two different scenarios: one with downward nominal wage rigidity and the other with flexible wages.

In the scenario with downward nominal wage rigidity, the impact on output and the unemployment rate is more severe, indicating that firms' limited ability to adjust wages may hinder their ability to adjust their workforce efficiently. Conversely, under flexible wages, the skill premium experiences a more substantial decline, suggesting that labor markets might respond more efficiently to the monetary policy shock by adjusting wage differentials between high and low-skilled workers. The impact on inflation is relatively similar under both wage settings, with only a slight difference observed. The ratios between the maximum responses under downward nominal wage rigidity and flexible wage settings reveals that the skill premium's response under the former scenario is merely 20% of the response observed under the latter one, while for output, its reduction is 60% higher. This emphasizes the significant impact of wage rigidity on both the skill premium and output levels.

Regarding volatility, the table shows that after a monetary policy tightening, downward nominal wage rigidity is associated with higher output and unemployment rate volatility.

Interestingly, the volatility of the skill premium is substantially lower under downwardly rigid wages, implying that wage differentials between high and low-skilled workers remain more stable during a monetary policy tightening. The volatility ratios shown in the table indicates that the volatility of output and the unemployment rate are 48% and 39% higher under downward nominal wage rigidity, respectively, while the volatility for the skill premium under downwardly rigid wages is only 25% of the volatility observed under flexible wages.

The main results from this analysis is that downward nominal wage rigidity prevents the reduction in the skill premium, but it also introduces higher volatility in output and the unemployment rate, potentially reflecting challenges in the labor market's adjustment process. On the other hand, flexible wages seem to facilitate a more significant adjustment in the skill premium while there is lower volatility in output and unemployment rate. Thus, there exist trade-offs between wage flexibility, economic stability, and efficiency during times of monetary policy tightening.

4.2 Impulse responses to an expansionary monetary policy shock

Occasionally binding constraints, such as the downward nominal wage rigidity constraint, can introduce non-linearities and asymmetries into DSGE models, and lead to different dynamics compared to models without such constraints (Guerrieri and Iacoviello 2017; Jacob, Smith, and Yao 2014). In the following subsection, I study this feature and analyze the IRFs to a 25 bp. decrease in the nominal interest rate. The IRFs can be found in Figure 7.

Under flexible wages, the IRFs exhibit complete symmetry between the effects of a contractionary monetary policy shock and an expansionary monetary policy shock, as the model is fully linear. However, important asymmetries arise when downward nominal wage rigidities are present.

One notable asymmetry is observed in the response of nominal wages. In the case of an expansionary monetary policy shock, the increase in aggregate demand exerts upward pressure on nominal wages. However, even though the downward nominal wage rigidity constraint is not binding on impact, firms' expectations regarding the probability that the future nominal wage will be constrained lead to a decrease in the marginal product of an additional worker. As a result, the nominal wage in the presence of downward nominal wage rigidities is lower compared to the scenario with flexible wages and the skill premium slightly increases approximately 0.5 pp. on impact.

Firms' expectations not only affect the bargained nominal wage after an increase in the aggregate demand, but also the number of high and low-skilled workers being employed. As firms expect that workers will have constrained wages—and thus wages above the optimal value—, firms will post and hire fewer workers. Consequently, an expansionary monetary policy shock leads to a relatively smaller increase in output compared to a scenario with flexible wages since there is less labor input. Additionally, the impact extends to investment and the employment ratio, where the reduced attractiveness of fewer high-skilled workers, due to capital-skill complementarity, hampers the expansion of the capital stock and decreases the skill composition of the economy, respectively.

4.3 Changes to the degree of downward nominal wage rigidity

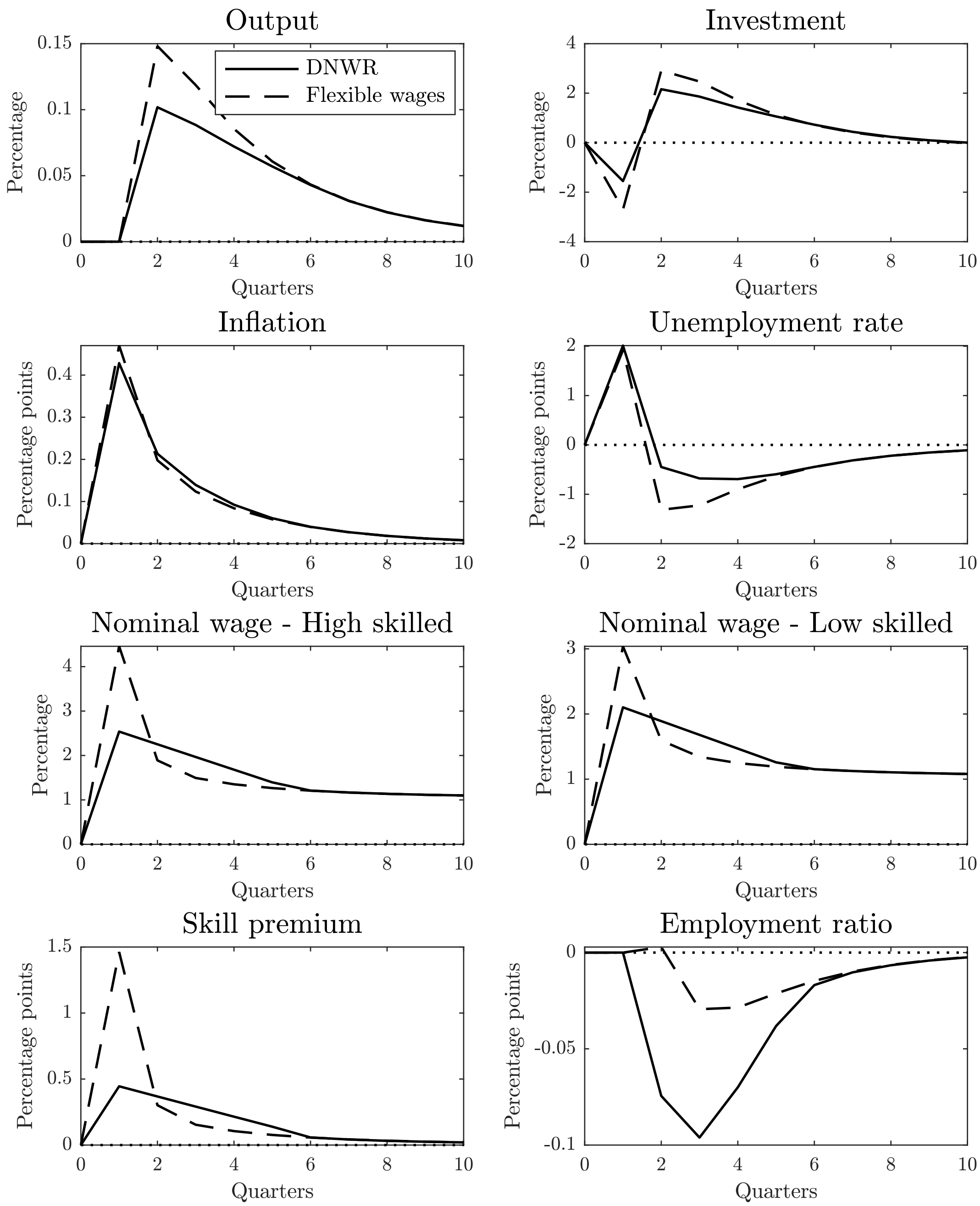
In this subsection, I examine the effects of monetary policy on the economy by considering an equal degree of downward nominal wage rigidity for both high and low-skilled workers, i.e., I impose that $\Psi^H = \Psi^L = \Psi$. In particular, I include in the analysis the following two scenarios: (1) an increase in the degree of downward nominal wage rigidity for high-skilled workers to match that of low-skilled workers, and (2) a decrease in the degree of downward nominal wage rigidity for low-skilled workers to match that of high-skilled workers. This analysis will provide a deeper understanding of the dynamics and interactions within the labor market under different wage rigidity settings.

Figure 8 illustrates the IRFs to a 25 bp. increase in the interest rate, considering two alternative degrees of nominal wage rigidity. The first scenario assumes a degree of rigidity of $\Psi = 0.9979$, which corresponds to a maximum wage cut of approximately 0.85% per year. The second scenario assumes a degree of rigidity of $\Psi = 0.9971$, representing a maximum wage cut of 1.15% per year.

It should be noted that as the degree of downward nominal wage rigidity increases, the contractionary effects of the monetary policy shock become more pronounced on variables such as output, investment, inflation, and the unemployment rate. However, as the degree of nominal wage rigidity approaches $\Psi = 0.9971$, the effects become more similar to those observed when nominal wages are flexible.

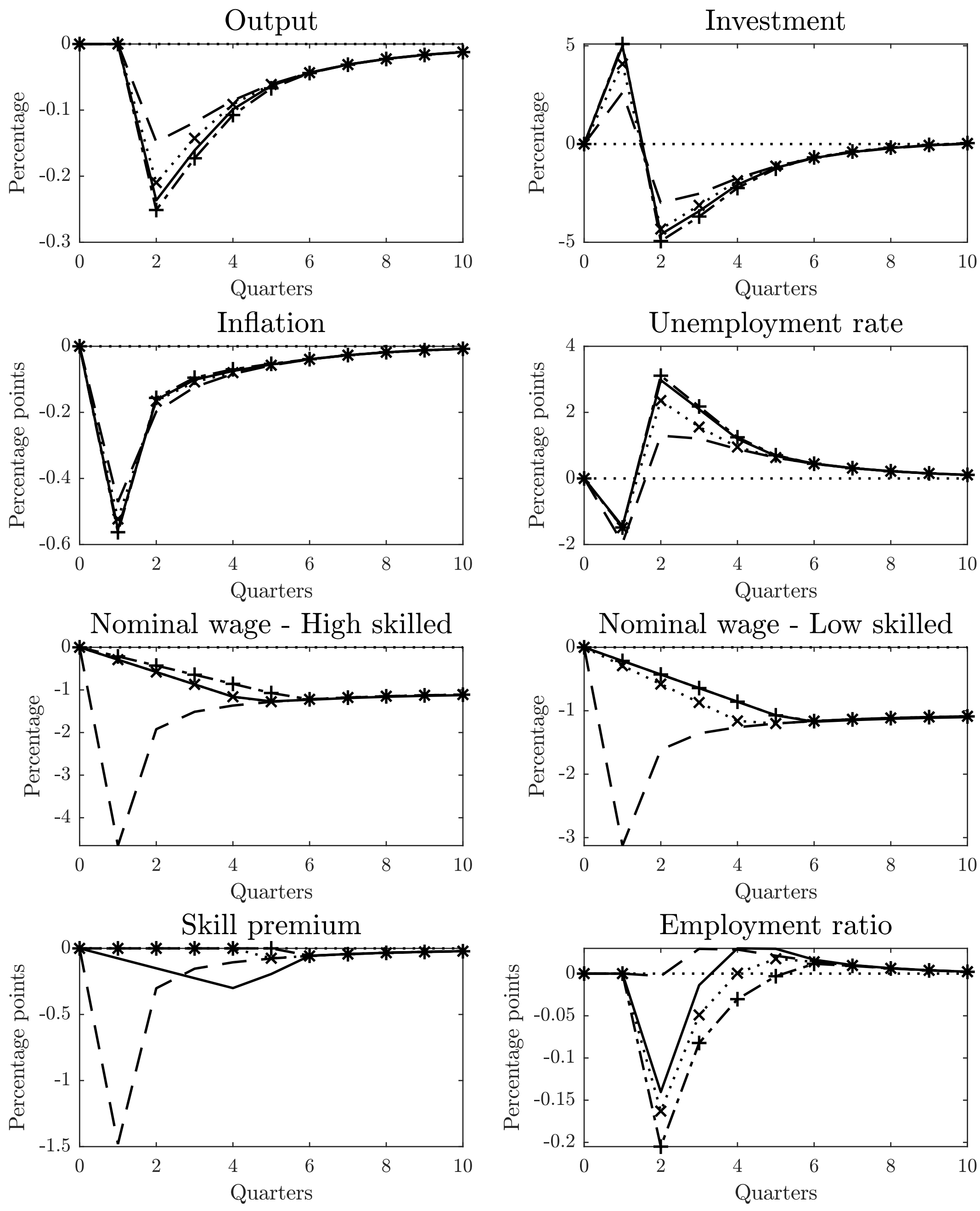
Nevertheless, the impact on nominal wages for high and low-skilled workers remains highly robust, regardless of the degree of nominal wage rigidity. Consequently, the skill premium remains virtually unchanged after the monetary policy shock.

Figure 7: IRFs to an expansionary monetary policy shock



Note: The solid black lines depict the variable responses of the model incorporating downward nominal wage rigidity, while the dashed black lines represent the variable responses of Dolado, Motyovszki, and Pappa (2021)'s model.

Figure 8: IRFs to a contractionary monetary policy shock. Sensitivity analysis



Note: The solid black lines represent the variable impulse responses under the baseline specification ($\Psi^H = 0.9971, \Psi^L = 0.9979$). The dash-dotted black lines with plus signs correspond to the variable impulse responses considering a higher degree of downward nominal wage rigidity for high-skilled workers ($\Psi^H = 0.9979, \Psi^L = 0.9979$). The dotted black lines with crosses indicate the variable impulse responses considering a lower degree of downward nominal wage rigidity for low-skilled workers ($\Psi^H = 0.9971, \Psi^L = 0.9971$). Lastly, the dashed black lines represent the variable responses when wages are fully flexible.

These findings highlight the resilience of the skill premium to changes in the degree of downward nominal wage rigidity when $\Psi^H = \Psi^L$, suggesting that labor income inequality is not significantly affected by variations in those parameters.

5 Conclusion

This paper has examined the role of downward nominal wage rigidities in the transmission of monetary policy on labor income inequality. The analysis has shown that labor income inequality decreases following a contractionary monetary policy shock when wages are flexible, while it remains unchanged when wages are rigid due to downward nominal wage rigidities. These stylized facts highlight the importance of wage rigidities in shaping the impact of monetary policy on income distribution.

To explain these findings, I augment a capital-skill complementarity model with nominal rigidities. By incorporating this element into the model, it successfully replicates the patterns observed in the data and provides theoretical insights into the relationship between monetary policy and labor income inequality.

The findings of this paper have important implications for policymakers. Understanding the role of wage rigidities in the transmission of monetary policy can help policymakers design more effective strategies to mitigate labor income inequality. Addressing downward nominal wage rigidities and promoting wage flexibility could potentially enhance the redistributive effects of monetary policy and promote more equitable income distribution.

This study also builds upon the existing literature on downward nominal wage rigidity and the effects of monetary policy on inequality. It complements previous studies that have explored different channels through which monetary policy can influence income and wealth inequality. By focusing specifically on the role of wage rigidities, this study provides a deeper understanding of the mechanisms at play and adds to the overall body of knowledge in this field.

The model implemented in this paper is limited in understanding the complexities of wage determination and the underlying reasons for downward nominal wage rigidities. To gain a more comprehensive understanding of how wage setting impacts the transmission of monetary policy, further research could focus on microfoundations and examine the specific mechanisms that give rise to wage rigidities. Additionally, exploring the potential macroeconomic consequences of addressing downward nominal wage rigidities, such as the effects on employment or productivity, could provide valuable insights for policymakers.

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A Data source

Table A.1 summarizes the data sources used in the empirical evidence.

Table A.1: Summary of data source

Data	Source	Start	End
Industrial production	FRED	1919m1	2023m4
Inflation	FRED	1947m1	2023m4
Unemployment rate	FRED	1948m1	2023m4
Federal funds rate	FRED	1954m7	2023m4
Monetary policy shock	Cloyne et al. (2023)	1980m7	2016m8
Hourly wages	Current Population Survey	1979m1	2020m12
Excess Bond Premium	Federal Reserve	1973m1	2023m4
Wage Rigidity Meter	Federal Reserve Bank of S.F.	1980m12	2022m3

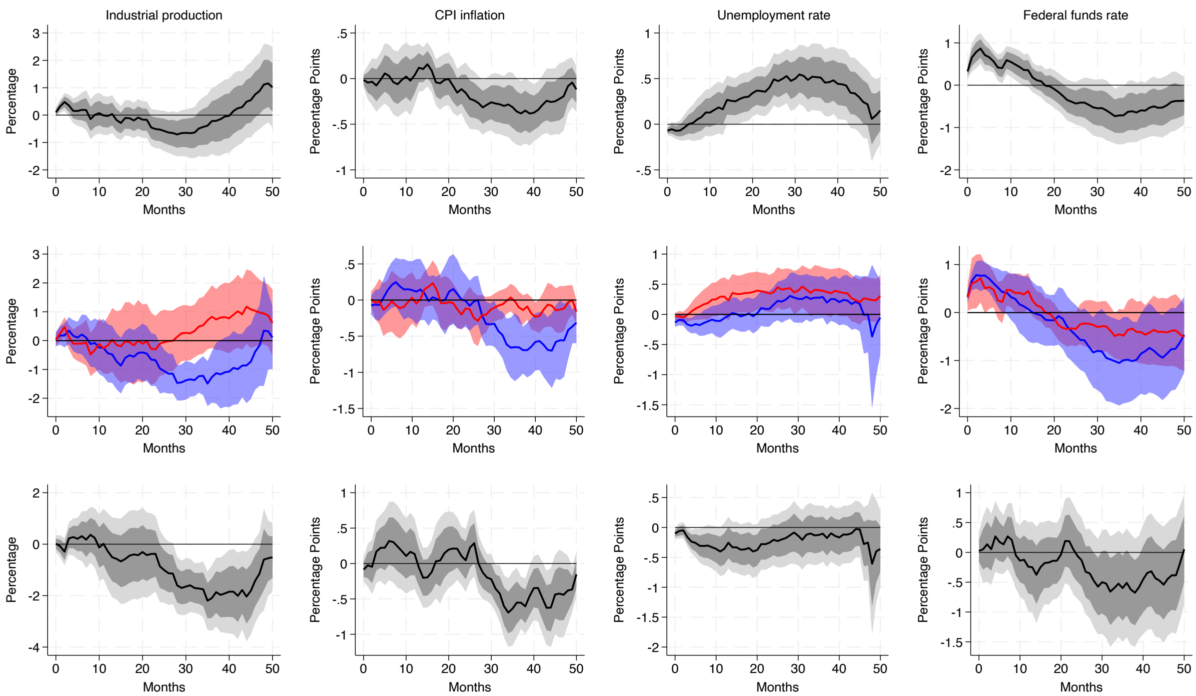
B Robustness check: Threshold parameter $(\mathbf{c = 0})$

Figure B.1, Figure B.2, and Figure B.3 show the IRFs of macroeconomic and labor variables to a monetary policy shock. In this setting, the threshold parameter c is set at 0 as a robustness check. The implied state indicator of the economy for the periods of missing data 1985m7-1987m8 and 1994m1-1997m7 is set to 1 and 0, respectively. This implies periods of high and low wage rigidity, respectively. Under this specification, the state of the economy assigned to the latter period is less innocuous. However, it is observed that the IRFs for both macroeconomic and labor variables are qualitatively robust to this specification.

C Robustness check: Romer and Romer series

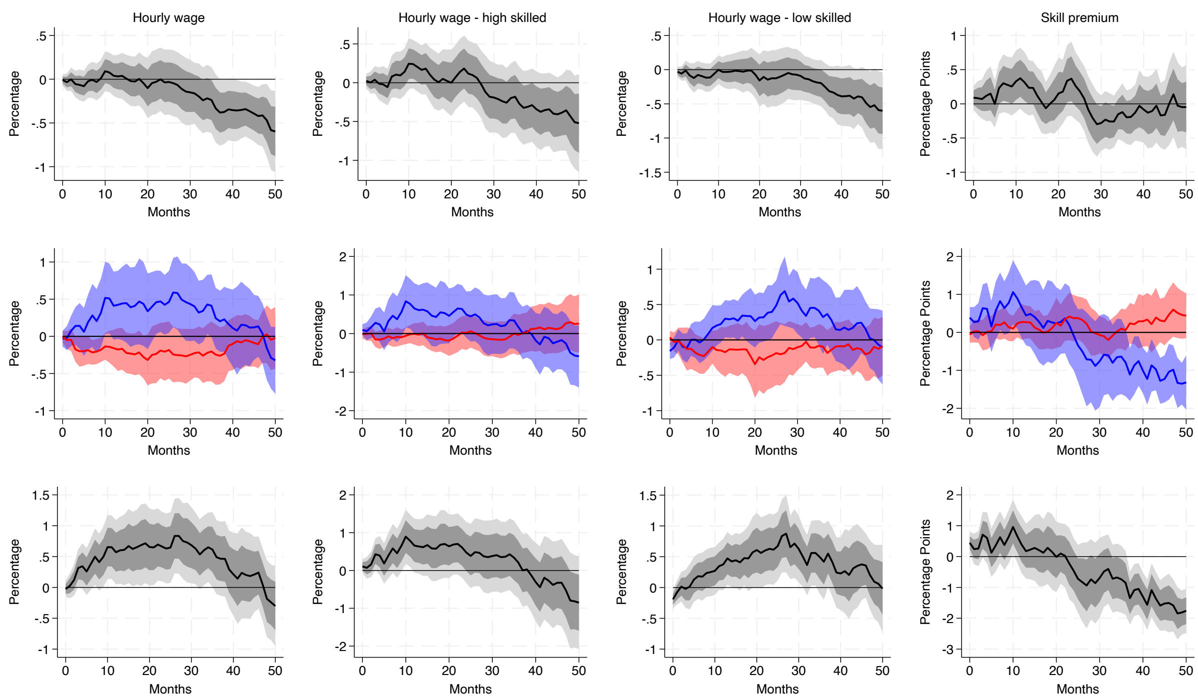
The empirical IRFs shown in the main text are computed using the identified monetary policy shocks of Gertler and Karadi (2015). In this particular section, as part of a robustness exercise, I employ the same specification but use the narrative monetary policy shocks introduced by Romer and Romer (2004). To provide a visual representation, I present Figure C.1, Figure C.2, and Figure C.3, which depict the IRFs for key macroeconomic variables, wages variables, and employment variables, respectively.

Figure B.1: IRFs to a monetary policy shock: Main macroeconomic variables



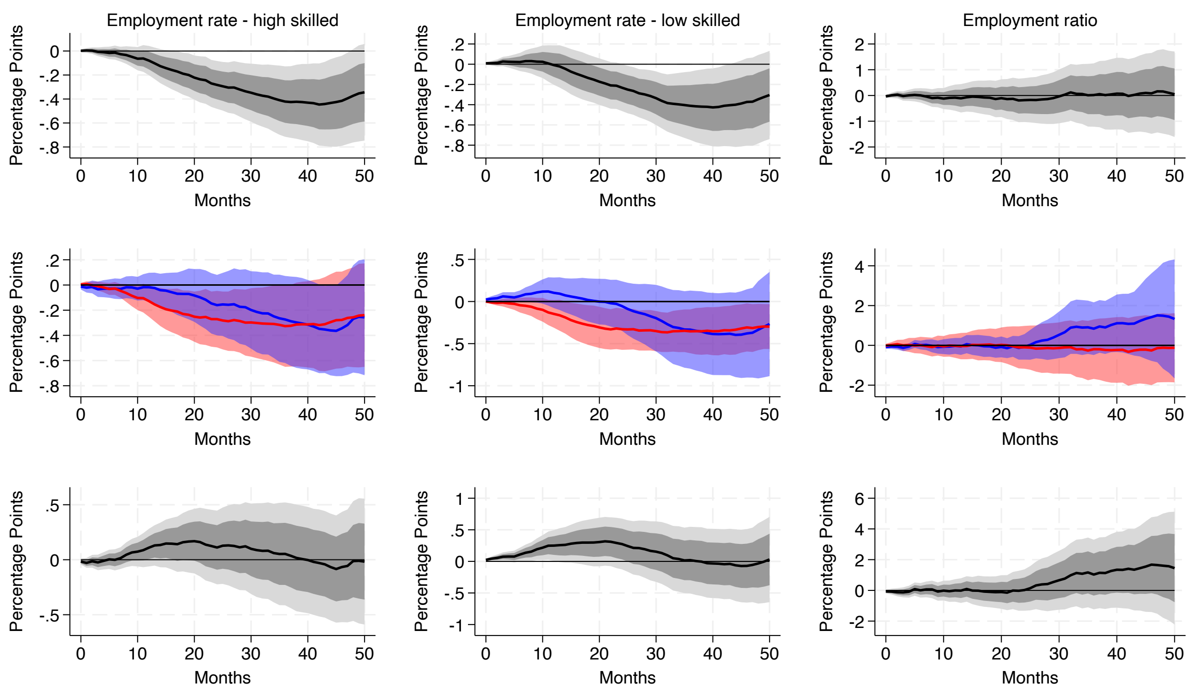
Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.

Figure B.2: IRFs to a monetary policy shock: Wages



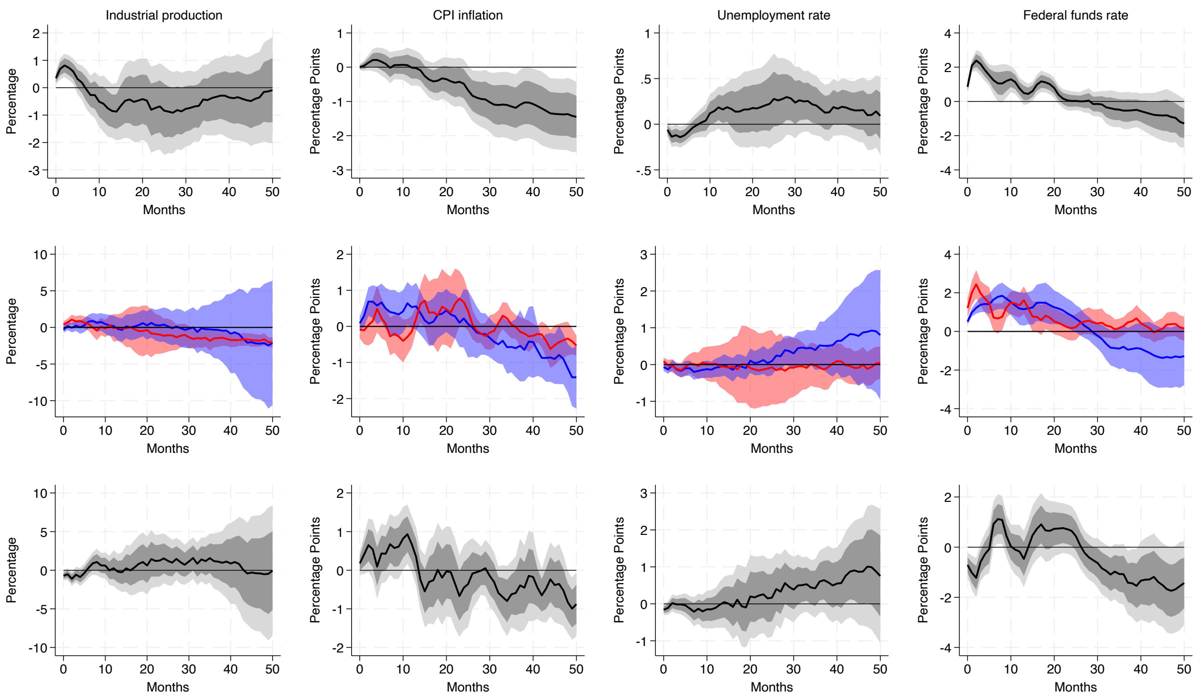
Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.

Figure B.3: IRFs to a monetary policy shock: Employment



Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.

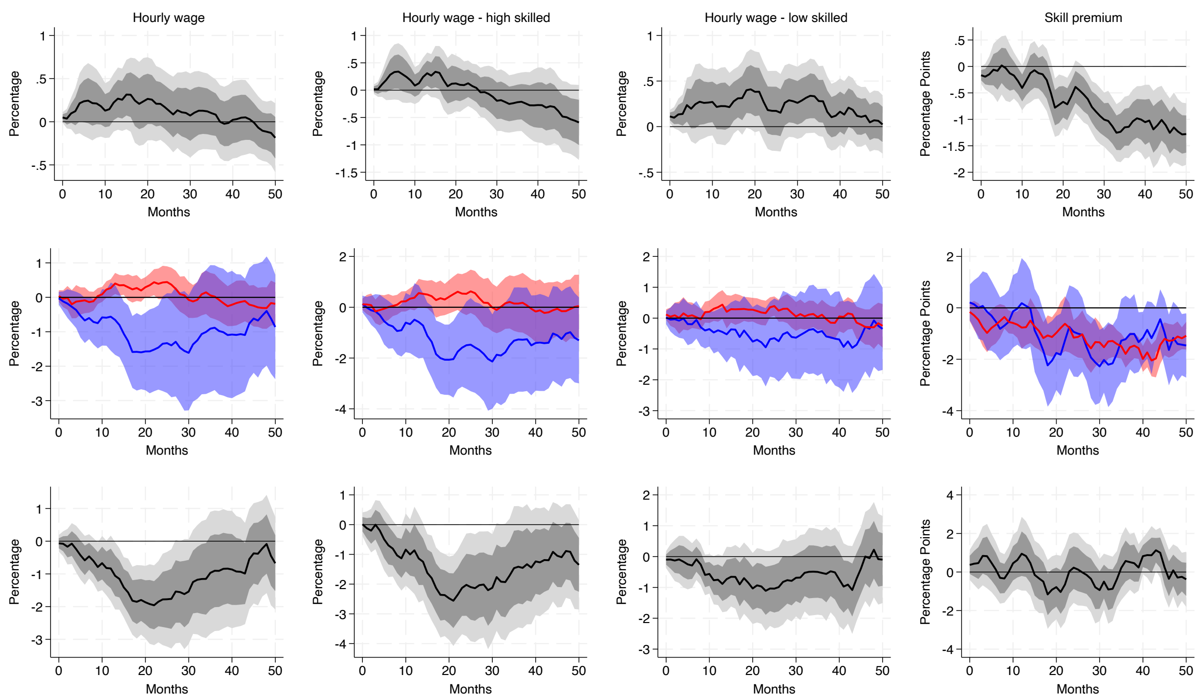
Figure C.1: IRFs to a monetary policy shock: Main macroeconomic variables



Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.

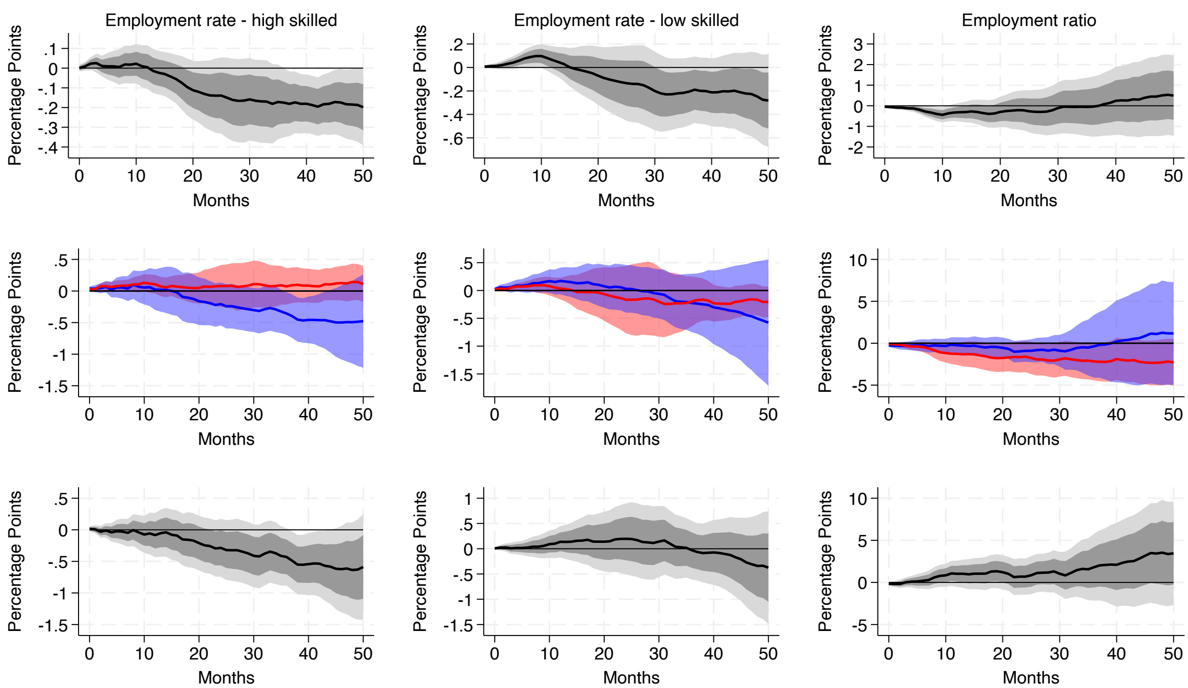
The qualitative patterns of the state-dependent local projection responses are similar compared to the baseline specification. However, the responses of industrial production and inflation in the early periods are somewhat counterintuitive. This could be attributed to potential endogeneity issues in the identification of narrative monetary policy shocks. For instance, if policymakers respond to economic conditions by modifying their narratives or adjusting their communication strategies, it can introduce endogeneity problems in the shock identification process.

Figure C.2: IRFs to a monetary policy shock: Wages



Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.

Figure C.3: IRFs to a monetary policy shock: Employment



Note: The first row of graphs depicts the impulse responses to an unexpected 25 bp. increase in the federal funds rate using a linear local projections model. The second row illustrates the impulse responses using a state-dependent local projections model, where the impulse responses vary based on whether the economy is in a period of rigid nominal wages or flexible nominal wages. The solid red lines represent the responses when the economy has rigid wages, while the solid blue lines represent the responses during a period of flexible wages. The third row represents the difference between the response estimates from the second row. The light gray, red, and blue areas indicate 90% confidence intervals, while the dark gray areas indicate 68% confidence intervals.