Temporary and Permanent Layoffs Under Financial and Monetary Policy Shocks

A thesis submitted by

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Abstract

This study examines the impact of financial and monetary policy shocks on temporary and permanent layoffs. Empirical analysis based on a structural VAR shows that both types of shocks lead to increases in temporary and permanent layoffs. However, the magnitude of their effects differs substantially, particularly within the first four quarters. To interpret the labor dynamics, I extend a standard RBC search and matching model by incorporating endogenous layoff and recall decisions, investment and collateral constraints, and nominal rigidity. The model's predictions broadly align with the empirical findings: both shocks increase layoffs, but the effects of financial shocks are notably stronger. The counterfactual experiments show that endogenous temporary and permanent layoffs play a crucial role in explaining the differential responses between the two shocks. Finally, I highlight that the differential responses arise from the different transmission channels embedded in the optimal borrowing condition.

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1 Introduction

Financial and monetary policy shocks play a crucial role in driving aggregate fluctuations (Jermann and Quadrini, 2012; Coibion, 2012). Previous studies have explored the relationship between the labor market and financial frictions (Duygan-Bump et al., 2015; Haltenhof et al., 2014; Shapiro and Olivero, 2020), as well as monetary policy (Blanchard and Galí, 2010). However, a specific yet important dimension that remains relatively underexplored is how financial and monetary policy shocks influence firms' layoffs, particularly the distinction between temporary and permanent layoffs. Moreover, there is limited understanding of how these two types of shocks differ in their transmission to the labor market.

Temporary layoffs have long been a cyclical feature of the U.S. labor market. Historically, they accounted for approximately 13% of total unemployment, but their relevance surged during the COVID-19 recession, when they temporarily made up nearly 70% of total unemployment. This dramatic increase has brought renewed attention to the dynamics of temporary layoffs (Chugh and Finkelstein Shapiro, 2025; Gallant et al., 2020; Gregory et al., 2020; Gertler et al., 2024). Despite this renewed interest, little is known about how financial and monetary policy shocks affect the composition of layoffs.

To fill this gap, I provide both empirical and theoretical analysis. Using a structural VAR approach with "GZ credit spreads" developed by Gilchrist and Zakrajšek (2012) as the measure of financial stress and monetary policy shock series constructed by Bu et al. (2021). The results show that financial and monetary policy shocks both lead to increases in temporary and permanent layoffs. However, the magnitude of their effects differs substantially, particularly within the first four quarters, which highlights the distinct transmission mechanisms through which each type of shock influences firm layoffs.

To interpret the empirical finding further, I develop a dynamic general equilibrium model that extends the standard RBC search and matching model framework along several key dimensions. Firstly, the model allows intermediate goods firms to make endogenous decisions regarding layoffs (both temporary and permanent) and recalls, following the approach Chugh and Finkelstein Shapiro (2025). Secondly, the intermediate goods firms use labor and capital to produce, and they can also borrow funds for production. However, their borrowing capacity is subject to a collateral constraint, tied to the value of their capital stock, consistent with the frameworks in (Iacoviello, 2015; Epstein et al., 2017). Thirdly, intermediate goods firms face a Rotemberg-type menu cost when choosing the optimal price (Rotemberg, 1982).

Although the model does not fully replicate the empirical impulse responses, it successfully captures the key qualitative patterns observed in the data. In particular, both financial and monetary policy shocks lead to a decline in market tightness and increases in both temporary and permanent layoffs. Most importantly, the model can reproduce the differential responses to financial versus monetary policy shocks. The difference arises from the optimal borrowing condition: financial shocks amplify layoffs by tightening borrowing constraints, which depress the firm's stochastic discount factor and directly raise the marginal cost of employment through an increase in the collateral multiplier. In contrast, monetary policy shocks affect layoffs primarily through interest rate movements. Crucially, the model captures that cyclical fluctuations in the collateral multiplier tend to be quantitatively larger than changes in the interest rate (Epstein et al., 2017), resulting in a stronger response to financial shocks.

Related Literature and Main Contributions My work is most closely related to Chugh and Finkelstein Shapiro (2025), who develop a business cycle model with labor search and matching frictions, incorporating endogenous temporary layoffs and worker recalls, as well as endogenous firm entry and exit, to explain labor market and firm dynamics, and aggregate fluctuations. Building on their framework of endogenous temporary layoffs and recalls, I abstract from firm entry and exit and instead extend the model by introducing endogenous permanent layoffs, financial frictions, and nominal rigidities.

There is a broader literature on temporary layoffs that emphasizes their important role in labor market dynamics. Fujita and Moscarini (2017) document that workers on temporary layoffs have higher recall probabilities than permanently separated workers and highlight the importance of distinguishing between the two in understanding unemployment dynamics. Gregory et al. (2020) study the role of temporary layoffs during the COVID-19 pandemic and argue that the design of unemployment insurance is crucial for shaping the recovery path. Gallant et al. (2020) build a search-and-matching framework incorporating temporary layoffs and recalls to explain labor market dynamics during the pandemic. Gertler et al. (2024) revisit the cyclical behavior of temporary layoffs, showing how they influenced labor market dynamics during the COVID-19 pandemic.

A large body of literature documents the macroeconomic effects of financial and monetary policy shocks. Jermann and Quadrini (2012) shows that financial frictions and shocks affecting firms' borrowing capacity are important drivers of macroeconomic fluctuations. Many theoretical studies have incorporated financial frictions into standard models to better explain the large-scale fluctuations in output and employment observed in the data (Petrosky-Nadeau and Wasmer, 2013; Petrosky-Nadeau, 2013, 2014; Alvarez-Cuadrado et al., 2018). Credit supply shocks and financial frictions have been shown to produce significant real effects on the economy (Jermann and Quadrini, 2012; Hombert and Matray, 2017).

The question of how monetary policy shocks affect the real economy is a classic and enduring research question, with the key challenge being the identification problem, largely due to foresight issues and the recursiveness assumption. A foundational contribution is Christiano et al. (1999), which provided estimates based on shocks identified under the recursiveness assumption. Romer and Romer (2004) introduced the narrative identification approach, using the Greenbook forecasts to eliminate information effects stemming from economic expectations. More recently, a large number of studies have employed high-frequency information methods to address potential foresight about monetary policy changes (Berentsen et al., 2011; Gertler and Karadi, 2015; Nakamura and Steinsson, 2018). Other improved identification strategies have also been proposed, such as the unified approach developed by Bu et al. (2021).

My study contributes to three strands of literature: (i) labor market search and matching with endogenous layoffs and recalls; (ii) financial frictions and labor dynamics; (iii) monetary policy and labor dynamics. The study is the first to explore firm layoffs, including both temporary and permanent layoffs under financial and monetary policy shocks, while providing a quantitative general equilibrium model that incorporates financial frictions and price stickiness into the DMP framework, along with recall and layoff decisions.

The remainder of the paper is organized as follows. Section 2 presents data and empirical evidence. Section 3 introduces the theoretical model. Section 4 conducts the quantitative analysis and discusses key findings. Section 5 concludes.

2 Data and Empirical Evidence

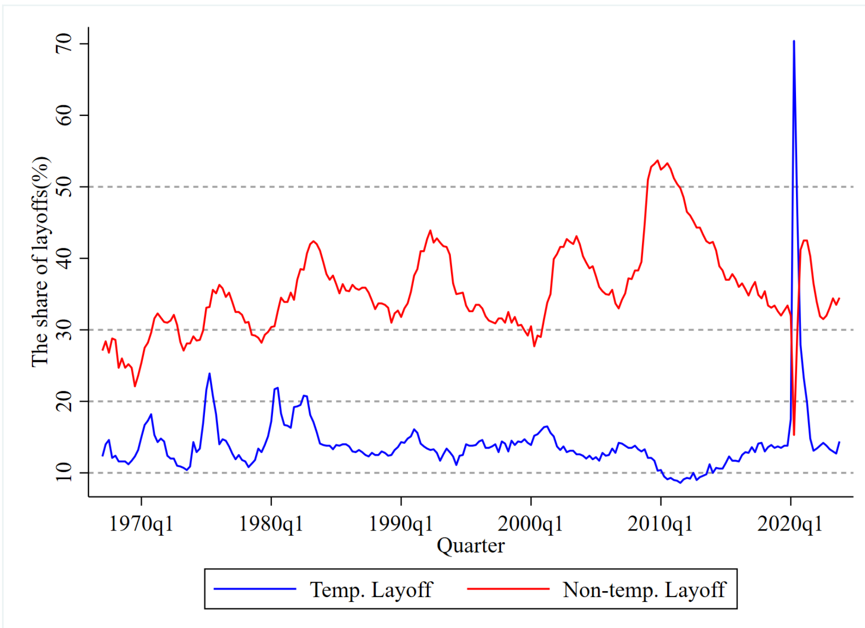
2.1 Temporary vs. Permanent Layoffs in the U.S.

According to the Bureau of Labor Statistics (BLS), unemployed individuals are categorized as job losers (including both temporary and permanent layoffs), job leavers, reentrants, and new entrants. This study focuses specifically on firms' layoff behavior, distinguishing between temporary and non-temporary (permanent) layoffs. Temporary layoffs refer to individuals who have been given a specific date of recall or expect to be recalled to their previous job within six months. In contrast, permanent layoffs describe those who do not expect to return to their prior employer and are actively seeking new employment opportunities.

Figure 1 shows the share of temporary and non-temporary layoffs as a percentage of total unemployment, from 1967q1 to 2024q4. As depicted in the figure, temporary layoffs typically account for around 15% of total unemployment, with a sharp and unprecedented spike during the COVID-19 pandemic. In contrast, non-temporary layoffs are generally fluctuating between 30% and 50% over time.

Another notable pattern observed in Figure 1 is the contrasting cyclical behavior of temporary and non-temporary layoffs during economic downturns. Specifically, during most recessions, the share of non-temporary layoffs rises, reflecting a persistent and structural response by firms to economic slack. In contrast, the share of temporary layoffs often declines, suggesting that firms are less inclined to classify separations as temporary in the face of prolonged uncertainty. This pattern reversed dramatically during the COVID-19 recession, when the share of temporary layoffs spiked sharply, which reflects firms' expectations of a short-term disruption.

Figure 1: The Percentage of Temporary and Non-Temporary Layoffs in Total Unemployment



Note: This figure illustrates the share of temporary and non-temporary layoffs as a percentage of total unemployment. The data are sourced from the FRED database and cover the period from 1967q1 to 2024q4.

2.2 Vector Autoregression (VAR) Analysis

To provide supporting empirical evidence on the link between firm layoffs, financial shock, and monetary policy shocks, following the method used by Fujita and Ramey (2007), I estimate the vector autoregression (VAR) model:

$$X_t = \alpha + \sum_{l=1}^{6} \Gamma(l) X_{t-l} + e_t,$$

where $X_t = [mps_t, cs_t, mt_t, tl_t, pl_t, y_t]'$ is the vector of endogenous variables, mps_t denotes the monetary policy shock, s_t is the credit spread, mt_t is market tightness, tl_t is temporary layoff (in logs), tl_t is non-temporary layoff (in logs), y_t is labor productivity.

The analysis uses quarterly data spanning from 1994Q1 to 2010Q4. (See Appendix A.3 for the trends in temporary and permanent layoffs over the sample period.) The time range is primarily constrained by the availability of the monetary policy shock series constructed by Bu et al. (2021), which spans from 1994Q1 to 2019Q3, and the "GZ credit spread" series from Gilchrist and Zakrajšek (2012), which spans from 1973Q1 to 2010Q4.

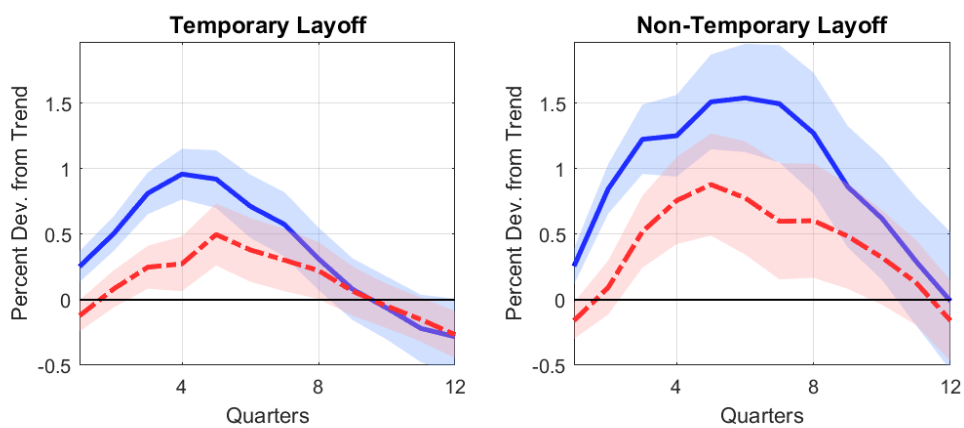
To extend the job openings series, I follow the methodology of Barnichon (2010), merging data from the Job Openings and Labor Turnover Survey (JOLTS) with the Help Wanted Index. Other variables are sourced from the U.S. Bureau of Economic Analysis (BEA), the U.S. Bureau of Labor Statistics (BLS), and the Federal Reserve Bank of St. Louis FRED database. Appendix A provides detailed variable definitions and data sources.

Cholesky decomposition Structural impulse responses are identified using a recursive identification scheme based on a Cholesky decomposition. The variable order is $X_t = [mps_t, cs_t, mt_t, tl_t, pl_t, y_t]'$, which reflects assumptions about the timing of information transmission and economic adjustment. Monetary policy shocks mps_t are placed first, under the assumption that monetary authorities do not respond contemporaneously to other macroeconomic variables within a quarter. Credit spreads cs_t, capturing financial market conditions, are ordered second, as they may respond immediately to monetary policy but not to labor market dynamics or productivity in the same quarter. This ordering allows us to identify structural financial and monetary policy shocks and trace their dynamic effects on layoff decisions.

Differential Impact on Layoffs: Financial vs. Monetary Policy Shocks Using the identification strategy described above, I examine how temporary and permanent layoffs respond to structural financial and monetary policy shocks. Figure 2 presents the impulse responses of temporary and non-temporary layoffs to 100-basis-point financial and monetary policy shocks using U.S. quarterly data. I report 68 percent confidence intervals to highlight the clearer distinctions in impulse responses across the two types of shocks. (See full results in Appendix B.)

The left panel shows that temporary layoffs respond more rapidly and strongly to financial shocks, peaking around the fourth quarter with a deviation of over 1 percent from trend. In contrast, the response to monetary policy shocks is more muted and short-lived. The right panel reveals a similar pattern for non-temporary layoffs, although the magnitude of the response is larger overall. Notably, financial shocks lead to a sustained increase in permanent layoffs, suggesting that credit conditions play a critical role in shaping firms' more permanent separation decisions. The results highlight the differential transmission mechanisms of financial and monetary shocks to the labor market, with financial disturbances producing broader and stronger effects on layoff dynamics.

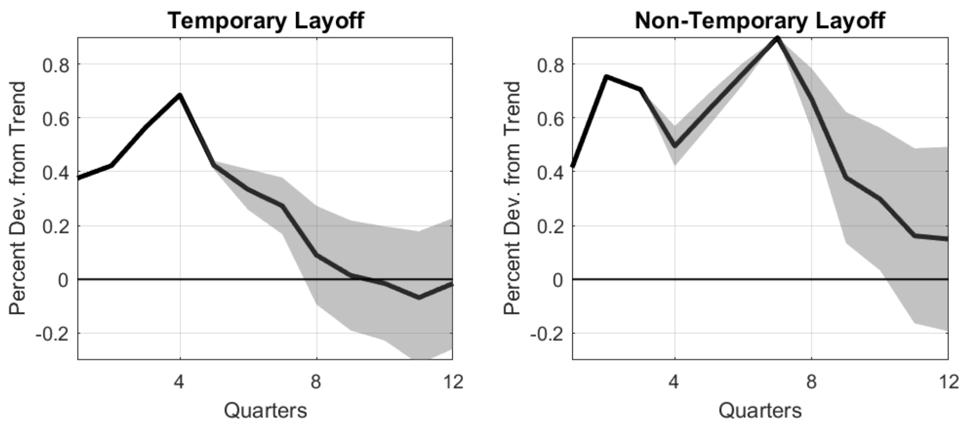
Figure 2: Impulse Responses of Temporary and Non-Temporary Layoffs to a 100-Basis-Point Financial Shock (Blue Solid Line) and Monetary Policy Shock (Red Dash-dot Line)



Note: This figure shows the impulse responses of temporary and non-temporary layoffs to a 100-basis-point financial shock (blue solid line) and monetary policy shock (red dash-dot line) in U.S. data. The cyclical components of each series are extracted using the Hodrick-Prescott (HP) filter with a smoothing parameter of 1600 for quarterly data. Shaded areas represent 68-percent confidence intervals, with light blue for the financial shock and light red for the monetary policy shock.

To further highlight the contrast between the effects of financial and monetary policy shocks, Figure 3 plots the difference in impulse responses of layoffs to the two shocks. For both temporary and non-temporary layoffs, the responses to financial shocks are consistently stronger than those to monetary shocks across the entire horizon. Shaded areas indicate the extent to which the confidence intervals of the two impulse responses overlap at each horizon. The gap is particularly pronounced in the early quarters following the shock, suggesting that financial conditions exert a more immediate and amplified influence on firms' layoffs. While both shocks eventually fade out, the effect of financial shocks peaks at a higher magnitude.

Figure 3: Difference in Layoff Responses to Financial and Monetary Policy Shocks



Note: This figure plots the difference between the impulse responses to a financial shock and a monetary policy shock for both temporary and non-temporary layoffs. The responses are measured in percent deviation from trend. Shaded areas indicate the extent to which the confidence intervals of the two impulse responses overlap at each horizon.

3 The Model

To explore the theoretical explanation behind the empirical evidence, I extend the standard RBC search and matching model by incorporating endogenous decisions of layoffs and recalls, investment and collateral constraints, and price stickiness. To be specific, firstly, compared to the standard RBC search and matching model, the intermediate goods firms can make their own decision of layoffs and recalls, as in Chugh and Finkelstein Shapiro (2025). Secondly, the intermediate goods firms use labor and capital to produce and also they are able to borrow funds for production, although the borrowing capacity is constrained by the value of their capital stock (Iacoviello, 2015; Epstein et al., 2017). Thirdly, intermediate goods firms face a Rotemberg-type menu cost when choosing the optimal price.

3.1 Final Goods Producer

The final output good is a CES aggregate of a continuum of intermediates. The production function is given by

$$y_t = \left(\int_0^1 y_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \tag{1}$$

where y_t denotes the aggregate output of the final goods and the parameter ϵ measures the elasticity of substitution between intermediate goods $y_{j,t}$.

Final goods are perfectly competitive and purchase output from intermediate goods firms. The optimal choices of intermediate inputs imply that

$$y_{j,t} = \left(\frac{P_{j,t}}{P_t} \right)^{-\epsilon} y_t \tag{2}$$

where $P_{j,t}$ and P_t denote the price of the intermediate goods and the final goods, respectively.

3.2 Intermediate Goods Firm

Investment and Collateral Constraint Intermediate producers are owned by entrepreneurs, whose aim is to maximize their discounted utility $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_j^t \mathbf{u}(c_{j,t}^i)$, where $\mathbf{u}' > 0$, $\mathbf{u}'' < 0$, $c_{j,t}^i$ is intermediate entrepreneur j's consumption at period t and β_j is the subjective discount factor for entrepreneurs of intermediate producers. Following Iacoviello (2005, 2015), to ensure the firm's collateral constraint is binding in the steady state, I assume that entrepreneurs are less patient than households, which means they discount future income more heavily than households, i.e. $0 < \beta_j < \beta$, where β is the subjective discount factor for households.

The function of a firm's production y_t is given by the constant returns-to-scale production function

$$y_t = z_t f(k_t, n_{at}), \tag{3}$$

where z_t is total factor productivity (TFP) in period t, and k_t is capital in period t.

The firm's capital accumulation follows the standard way, which is

$$k_{t+1} = (1-\delta)k_t + inv_t, \tag{4}$$

where inv_t is investment at period t, and δ denotes the depreciation rate.

The firms can finance themselves through external borrowing, but their borrowing capacity is restricted by a collateral constraint. Following Epstein et al. (2017), the total liabilities of a firm, which consist of the borrowed funds and a fraction of the wage bill, cannot exceed a set portion of the firm's capital assets. This constraint can be written as

$$R_t l_{j,t} + \eta_w w_{j,t} n_{j,t} \leq \eta_t k_{j,t+1}, \tag{5}$$

where R_t is the gross real interest rate, $l_{j,t}$ represents the amount borrowed by firm j in the current period, η_w is the fraction of the wage bill $w_{j,t}n_{j,t}$ that is included in the borrowing limit, η_t denotes the time-varying borrowing capacity, which adjusts in response to financial shocks. This constraint implies that the sum of the borrowed funds $R_t l_{j,t}$ and a fraction η_w of the wage expenses $w_{j,t}n_{j,t}$ must not exceed a fraction η_t of the firm's capital $k_{j,t+1}$.

Firms make their investment decision based on the capital Euler equation, considering the value of capital as collateral, which is given by

$$1 - \lambda_t \eta_t = \mathbb{E}_t \Xi^j_{t+1|t} \{ mc_t z_{t+1} f_k(k_{t+1}, n_{at+1}) + 1 - \delta \}, \tag{6}$$

where λ_t is the Lagrange multiplier associated with firm j's collateral constraint, indicating the binding strength of this constraint. $\Xi^j_{t+1|t}$ is the stochastic discount factor, defined as $\Xi^j_{t+1|t} = \beta \frac{u'(c_{j,t+1})}{u'(c_{j,t})}$.

Moreover, the firm's optimal borrowing decision is made at the condition where the marginal cost of borrowing (affected by the collateral constraint through λ_t) equates to the expected discounted return. That is,

$$1 - \lambda_t R_t = \mathbb{E}_t \Xi^j_{t+1|t} R_{t+1}, \tag{7}$$

These two equations imply that when the collateral constraint is binding, i.e. $\lambda_t > 0$, the firm is limited in its ability to borrow and its tendency to invest. Therefore, firms can dynamically adjust their borrowing and capital investment decisions based on external financial conditions. In essence, when financial shocks reduce borrowing capacity, firms may adjust by altering their capital investment or reducing their liabilities, thereby balancing their financial commitments in line with the available collateral.

Overall, the firm's optimal choices over capital accumulation and borrowing follow standard dynamic optimization under financial frictions and are consistent with the literature (Iacoviello, 2005; Epstein et al., 2017). The purpose is to examine how financial constraints interact with endogenous layoff and recall decisions. By linking temporary and permanent layoff to firms' investment and borrowing behavior, the model captures how financial conditions can influence labor separation dynamics through their effect on firm value and marginal costs.

Intermediate Goods Firm Profit and Value Functions Based on the information above, we can obtain the profit and value functions for the intermediate goods firm. Since the intermediate goods firm is owned by entrepreneurs, its profits are directed toward consumption. Thus, the consumption of the entrepreneurs from the intermediate goods firm j at period t, denoted as $c^i_{j,t}$, is determined by the firm's profit. That is,

$$c^i_{j,t} = \frac{P_{j,t}}{P_t} z_t f(k_{j,t}, n_{j,at}) - w_{j,t} n_{j,at} - \gamma v_{j,t} - \chi_i n_{j,it} - i_{j,t} + l_{j,t} - R_t l_{j,t-1} - \int_0^{\widetilde{e}_{j,t}} edF(e)$$
$$+ q_{j,bt} n_{j,at-1} \left(\int_0^{\widetilde{a}_{j,t}} adH(a) \right) - q_{j,bt} n_{j,it-1} \left(\int_0^{\widetilde{\zeta}_{j,t}} \zeta dR(\zeta) \right) + (n_{j,at-1} + n_{j,it-1}) \left(\int_0^{\widetilde{b}_{j,t}} bdG(b) \right)$$
$$- \frac{\psi}{2} (\frac{P_{j,t}}{P_t} - 1)^2. \tag{8}$$

The value of having an active worker $\mathbf{J}_{at}$ is given by

$$\mathbf{J}_{at} = -\lambda_t \eta_w w_t + mc_t z_t f_n(k_t, n_{at}) - w_t + \mathbb{E}_t \Xi^j_{t+1|t} \{ \left[q_{bt+1} \left(\int_0^{\widetilde{a}_{t+1}} adH(a) \right) - \int_0^{\widetilde{b}_{t+1}} bdG(b) \right]$$
$$+ (q_{bt+1} q_{at+1} + (1 - q_{bt+1})) \mathbf{J}_{vt+1} + q_{bt+1} \left[(1 - q_{at+1}) \mathbf{J}_{at+1} + q_{at+1} \mathbf{J}_{it+1} \right] \}. \tag{9}$$

The expression has three main components. The first component, for the current period, is the marginal benefit of having an active worker, represented by the marginal productivity $z_t f_n(k_t, n_{at})$, minus the marginal cost of having an active worker, given by the real wage adjusted for collateral constraints, $(1 + \lambda_t \eta_w) w_t$. The second component includes the marginal cost of firing a worker with probability q_{bt+1} and the marginal benefit of doing so, $\int_0^{\widetilde{b}_{t+1}} b \, dG(b)$. The third component is the expected value of the next period.

The value of having a worker on temporary layoff $\mathbf{J}_{at}$ is given by

$$\mathbf{J}_{it} = -\chi_i + \mathbb{E}_t \Xi^j_{t+1|t} \{ -q_{bt+1} \left(\int_0^{\widetilde{\zeta}_{t+1}} \zeta dR(\zeta) \right) - \int_0^{\widetilde{b}_{t+1}} bdG(b) + q_{bt+1} q_{rt+1} \mathbf{J}_{at+1}$$
$$+ q_{bt+1} (1 - q_{rt+1}) \mathbf{J}_{it+1} \} \tag{10}$$

It includes the flow cost χ_i for the current period. The continuation value of keeping the worker on temporary layoff for the next period is given by $\mathbb{E}_t \Xi^j_{t+1|t} \mathbf{J}_{it+1}$, which occurs with probability $q_{bt+1}(1 - q_{rt+1})$. Additionally, there is the value of recalling a worker from temporary layoff to active status, represented by $\mathbb{E}_t \Xi^j_{t+1|t} \mathbf{J}_{at+1}$, which occurs with probability $q_{bt+1} q_{rt+1}$ and involves a resource cost of $\int_0^{\widetilde{\zeta}_{t+1}} \zeta \, dR(\zeta)$.

The value of having a vacancy $\mathbf{J}_{vt}$ is given by

$$\mathbf{J}_{vt} = -\gamma + q_t \mathbf{J}_{at} + (1-\rho_v)(1-q_t)\mathbb{E}_t \Xi^j_{t+1|t} \mathbf{J}_{vt+1}. \tag{11}$$

Posting a vacancy incurs a flow cost γ in the current period. If the vacancy is filled in the current period with the probability q_t, then the firm receives the value of having an active worker $\mathbf{J}_{at}$. Otherwise, the firm receives the continuation value of having a vacancy.

Layoffs, Recalls, and Job Creation This section introduces the firm's decisions regarding layoffs, recalls, and job creation, following the framework developed by Chugh and Finkelstein Shapiro (2025). The intermediate producers make decisions on layoff and recall, as well as job vacancy posting at the beginning of the period t. They can adjust their workforce by (1) placing an active worker on temporary layoff (2) recalling a worker on temporary layoff back to active status (3) firing a worker permanently from either active workers or workers on temporary layoff (4) posting a new vacancy (5) hiring a new worker through matching. Table 1 summarizes the layoff and recall choices of the intermediate firms.

Table 1: Layoff and Recall Choices

Choices	Status	Saving	Distr.	Thre.	Prob.
Temporary Layoff	E $\rightarrow$ TL	saving a	$a \sim H(a)$	$\widetilde{a}_t$	$q_{at} = H(\widetilde{a}_t)$
Recall	TL $\rightarrow$ E	cost ζ	$\zeta \sim R(\zeta)$	$\widetilde{\zeta}_t$	$q_{rt} = R(\widetilde{\zeta}_t)$
Permanent Layoff	E, TL $\rightarrow$ PL	cost b	$b \sim G(b)$	$\widetilde{b}_t$	$q_{bt} = G(\widetilde{b}_t)$
Vacancy Posting		cost e	$e \sim F(e)$	$\widetilde{e}_t$	$v_{nt} = F(\widetilde{e}_t)$

Note: This table summarizes the layoff and recall choices available to intermediate firms prior to production. In the "Status" column, E, TL, and PL denote workers who are employed, on temporary layoff, and on permanent layoff, respectively.

In particular, placing an active worker on temporary layoff allows the firm to save an amount of resources a in units of consumption goods and it is drawn from the i.i.d distribution $H(a)$. A firm chooses to place an active worker on temporary layoff if and only if the saving of placing the worker is greater than the cost. For any given cost of placing an active worker on temporary layoff, there exists an endogenous threshold $\widetilde{a}_t$ below which the firm decides to place an active worker on temporary layoff. Depending on the net value of having an active worker $\mathbf{J}_{at}$ relative to having a worker on temporary layoff $\mathbf{J}_{it}$, and the value of having a vacancy $\mathbf{J}_{vt}$, the threshold is given by

$$\widetilde{a}_t = \mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}. \tag{12}$$

The probability of placing an active worker on temporary layoff is given by the cumulative density of the savings evaluated at $\widetilde{a}_t$, which is

$$q_{at} = G(\widetilde{a}_t),\ \frac{\partial q_{at}}{\partial \widetilde{a}_t} > 0. \tag{13}$$

In turn, recalling a worker from temporary layoff back to active status requires a fixed cost ζ, which is drawn from i.i.d distribution $R(\zeta)$. Defining $\widetilde{\zeta}_t$ as the endogenous threshold below which the firm decides to recall a worker on temporary layoff back to active status. The threshold depends on the difference between the value of having an active worker $\mathbf{J}_{at}$ and the value of having a worker on temporary layoff $\mathbf{J}_{it}$, which means

$$\widetilde{\zeta}_t = \mathbf{J}_{at} - \mathbf{J}_{it}. \tag{14}$$

The endogenous probability of recalling a worker on temporary layoff is given by

$$q_{rt} = R(\widetilde{\zeta}_t),\ \frac{\partial q_{rt}}{\partial \widetilde{\zeta}_t} > 0. \tag{15}$$

Similarly, maintaining matches with active workers and workers on temporary layoff incurs a cost b, which is drawn from an i.i.d. distribution $G(b)$. Defining $\widetilde{b}_t$ as the endogenous threshold amount of cost below which a firm decides to keep the worker. The threshold is given by

$$\widetilde{b}_t = \left[(1-q_{at})(\mathbf{J}_{at}-\mathbf{J}_{it}-\mathbf{J}_{vt}) + \left(\frac{\eta_a}{1+\eta_a}\right) q_{at}\widetilde{a}_t\right]\left(\frac{n_{at-1}}{n_{at-1}+n_{it-1}}\right) + \left[q_{rt}(\mathbf{J}_{at}-\mathbf{J}_{it}) - \left(\frac{\eta_r}{1+\eta_r}\right) q_{rt}\widetilde{\zeta}_t\right]\left(\frac{n_{it-1}}{n_{at-1}+n_{it-1}}\right) + \mathbf{J}_{it}. \tag{16}$$

The endogenous probability of keeping a worker is given

$$q_{bt} = R(\widetilde{b}_t),\ \frac{\partial q_{bt}}{\partial \widetilde{b}_t} > 0. \tag{17}$$

The intuition behind the thresholds lies in the fact that the probability of layoffs or recalls is determined by endogenous cutoff values, which are based on the firm's value under different states. The threshold for permanent layoffs is more complex and less intuitive, as permanent separations occur prior to temporary layoffs and recall decisions. However, in the special case where temporary layoffs are not existed, the threshold $\widetilde{b}_t$ simplifies to $\mathbf{J}_{at} - \mathbf{J}_{vt}$, which has a more straightforward interpretation: it reflects the difference in firm value between having a employed worker and having a vacancy.

Following Leduc and Liu (2020, 2023), posting a new vacancy incurs an entry cost e, which is drawn from an i.i.d distribution $F(e)$. Defining $\widetilde{e}_t$ as the endogenous threshold below which the firm decides to post a new vacancy. The firm will keep posting vacancies as long as the net value of entry is non-negative, which means in equilibrium,

$$\widetilde{e}_t = \mathbf{J}_{vt}. \tag{18}$$

The new vacancy posting v_{nt} is given by

$$v_{nt} = F(\widetilde{e}_t),\ \frac{\partial v_{nt}}{\partial \widetilde{e}_t} > 0. \tag{19}$$

Therefore, placing an active worker on temporary layoff allows the firm to save $\int_0^{\widetilde{a}_t} a\, dH(a)$

in resources. The total resource savings from placing active workers on temporary layoff is given by $q_{bt}n_{at-1}(\int_0^{\widetilde{a}_t} a\,dH(a))$. Recalling a worker back from temporary layoff to active status requires $\int_0^{\widetilde{\zeta}_t} \zeta\,dR(\zeta)$ in resources. Thus, the total resource cost of recalling workers on temporary layoff is $q_{bt}n_{it-1}(\int_0^{\widetilde{\zeta}_t} \zeta\,dR(\zeta))$. Keeping a work incurs a cost of $\int_0^{\widetilde{b}_t} b\,dG(b)$ in resources, resulting in total cost of $(n_{at-1}+n_{it-1})(\int_0^{\widetilde{b}_t} b\,dG(b))$. Finally, $\int_0^{\widetilde{e}_t} e\,dF(e)$ represents the total fixed cost of posting vacancies.

In addition, I assume each worker placed on temporary layoff incurs a per-period cost $\chi_i \geq 0$ for the firm. This cost represents ongoing expenses associated with providing certain job-related benefits that temporarily laid-off employees continue to receive throughout the layoff period (such as employer-sponsored health insurance). Additionally, in addition to the entry cost, posting a vacancy incurs a fixed cost $\gamma \geq 0$ per period.

Meanwhile, in the labor market, new job matching between job searchers s_t and vacancies v_t is determined by a matching function $m(s_t, v_t)$. We can define job-finding rate f_t, job-filling rate q_t, and market tightness θ_t, respectively, as

$$f_t = \frac{m(s_t, v_t)}{s_t}, \tag{20}$$

$$q_t = \frac{m(s_t, v_t)}{v_t}, \tag{21}$$

$$\theta_t = \frac{v_t}{s_t}. \tag{22}$$

Unemployment is workers under non-active status, which is given by

$$u_t = 1 - n_{at}. \tag{23}$$

At the beginning of the period t, there are n_{at-1} active workers and n_{it-1} workers on temporary layoff. Thus, the measure of job searchers is given by

$$s_t = 1 - q_{bt}(n_{it-1} + n_{at-1}). \tag{24}$$

The evolution of total vacancies v_t can be given by

$$v_t = (1 - \rho_v)(1 - q_{t-1})v_{t-1} + (q_{bt}q_{at} + (1 - q_{bt}))n_{at-1} + v_{nt}, \tag{25}$$

where $0 < \rho_v < 1$ is the exogenous decay rate of unfilled vacancies.

Based on the intermediate producers' layoffs, recalls, and job creation decisions, the law of motion for active workers n_{at} and workers on temporary layoff n_{it} can be given by

$$n_{at} = q_{bt}(1 - q_{at})n_{at-1} + q_{bt}q_{rt}n_{it-1} + m(s_t, v_t), \tag{26}$$

$$n_{it} = (1 - q_{rt})q_{bt}n_{it-1} + q_{at}q_{bt}n_{at-1}. \tag{27}$$

At the end of the period t, the job searchers who fail to find a job remain on permanent layoff. Thus, the measure of permanent layoff n_{pt} is given by

$$n_{pt} = s_t - m(s_t, v_t) = 1 - n_{at} - n_{it}. \tag{28}$$

Price Stickiness and Monetary Policy Intermediate producers can choose their optimal price $P_{j,t}$. To introduce nominal rigidity, I assume there will be a quadratic adjustment cost given by $\frac{\psi}{2}(\frac{P_{j,t}}{P_{j,t-1}} - 1)^2$ while choosing prices. After choosing the optimal price and imposing symmetry across firms, we can obtain the New Keynesian Phillips Curve. That is,

$$(1 - \epsilon + \epsilon mc_t)\, y_t - \psi\,(1 + \pi_t)\,\pi_t + \mathbb{E}_t \Xi^j_{t+1|t}\,\psi\,(1 + \pi_{t+1})\,\pi_{t+1} = 0 \tag{29}$$

where mc_t denotes the marginal cost at period t, and $\pi_t = \frac{P_t}{P_{t-1}} - 1$ denotes the inflation rate at period t. Linearizing around the steady state yields the familiar forward-looking New

Keynesian Phillips Curve:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \frac{\epsilon - 1}{\psi} \cdot \widehat{m}c_t,$$

where $\widehat{m}c_t$ represents the log-deviation of marginal cost from its steady-state value.

I make use of the Fisher equation to relate nominal and real interest rates

$$i_t = \mathbb{E}_t R_t \pi_{t+1}. \tag{30}$$

The monetary policy follows the Taylor rule, which is

$$\frac{i_t}{i} = \left(\frac{i_{t-1}}{i}\right)^{\rho_m} \left[\left(\frac{1+\pi_t}{1+\pi}\right)^{\delta_\pi} \left(\frac{y_t}{y}\right)^{\delta_y}\right]^{1-\rho_m} \varepsilon_t^i, \tag{31}$$

where R_t denotes the real interest rate at period t, i_t denotes the nominal interest rate at period t, and ε_t^i is a monetary policy shock. i, π, y is the interest rate, inflation rate, and output level in the steady state.

3.3 Household

The representative household chooses consumption c_t and asset a_t to maximize the expected lifetime discounted utility with habit formation $E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$, where $u(c_t) = ln(c_t - \phi_c c_{t-1})$, subject to the sequence of budget constraints

$$P_t c_t + a_t + T_t = w_t n_{at} + \chi_u (1 - n_{at}) + \chi_i n_{it} + R_{t-1} a_{t-1} + \Pi_t^f, \tag{32}$$

where T_t denotes lump-sum taxes, Π_t^f is the profit from the final goods producer, and the parameter χ_u measures the flow benefits of unemployment.

The household's optimizing consumption-asset decision leads to the intertemporal Euler equation

$$1 = \beta R_t E_t \frac{\mu_{t+1}}{\mu_t} \frac{P_t}{P_{t+1}}. \tag{33}$$

The multiplier of the budget constraint μ_t is given by

$$\mu_t = \frac{1}{c_t - \phi_c c_{t-1}} + \beta \phi_c E_t \frac{1}{c_{t+1} - \phi_c c_t}. \tag{34}$$

Denote by $V_t(n_{at-1}, n_{it-1}, a_{t-1})$ the value function for the representative household. The household's optimizing problem can be written in the recursive form

$$V_t(n_{at-1}, n_{it-1}, a_{t-1}) = \max \left[u(c_t) + \beta E_t V_{t+1}(n_{at}, n_{it}, a_t) \right], \tag{35}$$

subject to the budget constraint (32), the measure of job searchers (24), the law of motion for active workers (26), and the law of motion for workers on temporary layoff (27).

Define the value of being an active worker relative to permanent layoff status as $\mathbf{W}_{at} \equiv \frac{\mu_{at}}{\mu_t}$, and the value of being a worker on temporary layoff relative to permanent layoff status as $\mathbf{W}_{it} \equiv \frac{\mu_{it}}{\mu_t}$, where μ_t, μ_{at}, and μ_{it} denote the Lagrange multipliers for constraints (32), (26), and (27), respectively. Thus, the value of being an active worker and a worker on temporary layoff relative to permanent layoff status is given by, respectively,

$$\mathbf{W}_{at} = w_t - \chi_u + E_t \Xi_{t+1|t}\, q_{bt+1} \left\{ (1 - q_{at+1} - f_{t+1}) \mathbf{W}_{at+1} + q_{at+1} \mathbf{W}_{it+1} \right\}, \tag{36}$$

$$\mathbf{W}_{it} = \chi_i + E_t \Xi_{t+1|t}\, q_{bt+1} \{ (q_{rt+1} - f_{t+1}) \mathbf{W}_{at+1} + (1 - q_{rt+1}) \mathbf{W}_{it+1} \}, \tag{37}$$

where $\Xi_{t+1|t} = \beta \frac{\mu_{t+1}}{\mu_t}$ is the stochastic discount factor for household. The economic intuition for the net value of being an active worker and a worker on temporary layoff is easy to interpret, which is the net gains in the current period plus the expected net value in the next period.

3.4 Nash Bargaining Wage

The wage rate is determined by the Nash bargaining process, following the approach in Chugh and Finkelstein Shapiro (2025), which splits the combined surplus from the job match between the employee and the employer. The surplus associated with the worker's employment is represented by $\mathbf{W}_{at}$, while the employer's surplus is denoted by $\mathbf{J}_{at} - \mathbf{J}_{vt}$. In particular, the Nash bargaining wage solves the following problem:

$$\max_{w_t} (\mathbf{W}_{at})^{\phi} (\mathbf{J}_{at} - \mathbf{J}_{vt})^{1-\phi}, \tag{38}$$

where $0 < \phi < 0$ indicates the worker's bargaining power.

Thus, the Nash bargaining wage w_t is given by

$$\begin{aligned} w_t - \chi_u + E_t \Xi_{t+1|t}\, q_{bt+1} \left\{ (1 - q_{at+1} - f_{t+1}) \left(\frac{\phi}{1-\phi} \right) (\mathbf{J}_{at+1} - \mathbf{J}_{vt+1}) + q_{at+1} \mathbf{W}_{it+1} \right\} \\ = \left(\frac{\phi}{1-\phi} \right) (\mathbf{J}_{at} - \mathbf{J}_{vt}) \end{aligned} \tag{39}$$

3.5 Government

The government provides unemployment benefits χ_u to workers who are not employed, including workers on temporary and permanent layoffs. These benefits are funded through lump-sum taxes imposed on the representative household. Thus, the government maintains a balanced budget each period, ensuring that

$$\chi_u(1 - n_{at}) = T_t. \tag{40}$$

3.6 Symmetric Equilibrium and Market Clearing

After imposing symmetry, we can obtain the symmetric equilibrium, under which the markets for assets, bonds, and goods are all clear. Since the aggregate asset supply and bond supply are zero, the asset and bond market clearing implies that $a_t = 0$ and $l_t = 0$.

The goods market clearing implies that total production is used for consumption, investment, vacancy posting cost, vacancy creation cost, the net temporary-layoff storage cost (i.e., worker-recalling cost plus permanent worker-layoff cost minus temporary worker-layoff saving), and the price adjustment cost. Thus, the aggregate resource constraint is given by

$$\begin{aligned} y_t = c_t + i_t + \gamma v_t + \int_0^{\widetilde{e}_t} edF(e) + q_{bt} n_{it-1} \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) \right) \\ - q_{bt} n_{at-1} \left(\int_0^{\widetilde{a}_t} adH(a) \right) + (n_{at-1} + n_{it-1}) \left(\int_0^{\widetilde{b}_t} bdG(b) \right) + \frac{\psi}{2} \pi_t^2. \end{aligned} \tag{41}$$

4 Quantitative Analysis

4.1 Parameter Calibration

To solve the model quantitatively, I select suitable functional forms and calibrate a subset of parameters based on the existing literature. The remaining parameters are calibrated to align with the steady-state values observed in the data.

Function Forms I assume that the production function for the intermediate goods firm follows a Cobb-Douglas form, represented as $f(k_t, n_{at}) = k_t^{\alpha} n_{at}^{1-\alpha}$, where k_t and n_{at} denote capital and active worker at time t, respectively. Following Chugh and Finkelstein Shapiro (2025), and the matching function is $m(s_t, v_t) = M s_t^{\xi} v_t^{1-\xi}$, where $0 < \xi < 1$ is the elasticity of matching function and $M > 0$ is a matching efficiency parameter.

Recall that intermediate goods firms pay a fixed cost e as part of the worker recruiting process, drawn from an *i.i.d.* distribution $F(e)$, and a fixed cost ζ to recall workers on temporary layoff, drawn from an *i.i.d.* distribution $R(\zeta)$. In addition, when firms place a worker on temporary layoff, they save an amount of resources a drawn from an *i.i.d.* distribution $H(a)$. And when firms keep a match with a worker, they spend an amount of cost b drawn from an *i.i.d.* distribution $G(b)$. Following Leduc and Liu (2023) , we adopt power distributions for $F(e) = (e/\bar{e})^{\eta_e}$, $R(\zeta) = \left(\zeta/\bar{\zeta}\right)^{\eta_r}$ $H(a) = (a/\bar{a})^{\eta_a}$, and $G(b) = \left(b/\bar{b}\right)^{\eta_b}$, where $\eta_a > 0,\ \eta_b > 0,\ \eta_e > 0,\ \eta_r > 0$ and $\bar{a} > 0,\ \bar{b} > 0,\ \bar{e} > 0,\ \bar{\zeta} > 0$ are scaling parameters.

Finally, the productivity z_t and the borrowing capacity η_t follow the AR(1) processes, respectively,

$$ln\, z_t = (1-\rho_z)\, ln(\bar{z}) + \rho_z\, ln(z_{t-1}) + \varepsilon_t^z, \tag{42}$$

$$ln\, \eta_t = (1-\rho_\eta)\, ln(\bar{\eta}) + \rho_\eta\, ln(\eta_{t-1}) + \varepsilon_t^\eta, \tag{43}$$

The parameters $0 < \rho_z, \rho_\eta < 1$ measure the persistence of the shocks. The terms $\bar{z}, \bar{\eta}$ represent the steady-state levels of the shocks, while $\varepsilon_t^z, \varepsilon_t^\eta$ are normally distributed with a zero mean and finite variance $\sigma_z^2, \sigma_\eta^2$, respectively. Additionally, the monetary policy shock ε_t^i in Equation (31) is also assumed to be normally distributed with zero mean and finite variance σ_i^2.

Calibrated Parameters Table 2 shows the calibrated parameter values. The model is quarterly. I set the capital share $\alpha = 0.32$, the capital depreciation rate $\delta = 0.025$, and the consumption habit parameter $\phi_c = 0.7$, which is consistent with U.S. empirical estimates. Following Arseneau et al. (2015), I set the elasticity of substitution among intermediate goods firms $\epsilon = 5.0$ and the price adjustment cost $\psi = 18.52$. Following Chugh and Finkelstein Shapiro (2025), I set the exogenous decay rate of unfilled vacancies $\rho_v = 0.10$, the matching elasticity $\xi = 0.5$, and the worker bargaining power $\phi = 0.5$. Following Epstein et al. (2017), I set the household's discount factor $\beta = 0.99$ and the intermediate entrepreneurs' discount factor $\beta^j = 0.97$. The fraction of the wage bill that intermediate goods firms need to finance with borrowed funds is $\eta_w = 1$. Following Leduc and Liu (2023), I set the shape parameters $\eta_a = \eta_b = \eta_r = \eta_w = 1$, which implies $F(e) = (e/\bar{e})$, $R(\zeta) = \left(\zeta/\bar{\zeta}\right)$ $H(a) = (a/\bar{a})$, and $G(b) = \left(b/\bar{b}\right)$. Following Smets and Wouters (2007), I calibrate the Taylor rule parameters to $\delta_y = 1.5$ for the output gap, $\delta_\pi = 0.125$ for inflation, and $\rho_m = 0.8$ for interest rate smoothing. Finally, I normalize the total factor productive $\bar{z} = 1$ and set $\rho_z = \rho_\eta = 0.95, \sigma_z = \sigma_\eta = \sigma_i = 0.01$ as a baseline.

To calibrate the parameters $\bar{\eta}$, γ, χ_u, χ_i, M, $\bar{a}$, $\bar{b}$, $\bar{\zeta}$, $\bar{e}$, we align them with key U.S. data statistics from 1994Q1 to 2010Q4. Specifically, I target the average unemployment insurance replacement rate to 50% of wages and the average benefit for temporarily laid-off workers to 7.5% of total compensation. The average unemployment rate is 6.0%, while the average ratio of workers on temporary layoff is 13.2% of total unemployment. The average quarterly net job creation rate is set to the target of 0.32%. The total separation rate from active workers is 10%, and the average quarterly job-filling probability is 70%. Additionally, I calibrate to match the average ratio of debt to GDP of 3.16 (Epstein et al., 2017) and the fixed cost of posting vacancies to GDP of 3.2%, which is roughly in line with the 3% used in (Arseneau and Chugh, 2012).

The calibrated parameter values are $\bar{\eta} = 0.6163$, $\gamma = 0.5311$, $\chi_u = 0.5297$, $\chi_i = 0.0794$, $M = 0.6680$, $\bar{a} = 185.3361$, $\bar{b} = 1.4390$, $\bar{\zeta} = 3.1120$, $\bar{e} = 242.1896$.

Table 2: Calibrated Parameters

Parameter	**Value**	**Description**
Parameters from Existing Literature		
α	0.32	Capital share
β	0.99	Subjective discount factor for households
β^j	0.97	Subjective discount factor for intermediate entrepreneurs
δ	0.025	Capital depreciation rate
ϕ_c	0.7	Consumption habit parameter
ξ	0.5	Matching elasticity
ϕ	0.5	Worker bargaining power
ϵ	5.0	Substitution elasticity
ψ	18.52	Price adjustment cost parameter
ρ_v	0.1	Exogenous decay rate of unfilled vacancies
ρ_i	0.1	Exogenous probability of temporary layoff separations
δ_y	1.5	The parameter of response to output gap
δ_π	0.125	The parameter of response to inflation
η_w	1	Fraction of wage bill that firms need to pay
$\eta_a, \eta_b, \eta_r, \eta_w$	1	Uniform Distribution for H, G, R, F
$\bar{z}$	1	Mean value of total factor productivity shock
ρ_z	0.95	Persistence parameter of TFP shock
ρ_η	0.95	Persistence parameter of financial shock
ρ_m	0.8	Persistence parameter of nominal interest rate
σ_z	0.01	Standard deviation of TFP shock
σ_η	0.01	Standard deviation of financial shock
σ_i	0.01	Standard deviation of monetary policy shock
Parameters Calibrated with U.S. Data		
$\bar{\eta}$	0.6163	Mean value of financial shock
γ	0.5311	Flow cost of vacancy posting
χ_u	0.5297	Unemployment insurance benefits
χ_i	0.0794	Benefits provided by firms to workers on temporary layoff
M	0.6680	Matching efficiency parameter
$\bar{a}$	185.3361	Scaling parameter, H distribution
$\bar{b}$	1.4390	Scaling parameter, G distribution
$\bar{\zeta}$	3.1120	Scaling parameter, R distribution
$\bar{e}$	242.1896	Scaling parameter, F distribution

4.2 Model Implications

Based on the calibrated and estimated parameters, I examine the model's quantitative performance in capturing labor market dynamics. First, following a negative TFP shock, the impulse responses replicate key features of the labor market, highlighting the amplification effects via endogenous separations. Second, the model successfully accounts for the distinct responses to financial and monetary policy shocks, with the differences in impulse responses broadly consistent with theoretical expectations.

4.2.1 Impulse Responses to TFP Shock

Figure 4 shows the impulse responses of several key variables to a one-standaed-deviation adverse TFP shock in the benchmark model (black solid lines), the counterfactual with no endogenous permanent layoffs (blue dash lines), and the counterfactual with no endogenous both permanent and temporary layoffs (red dash lines).

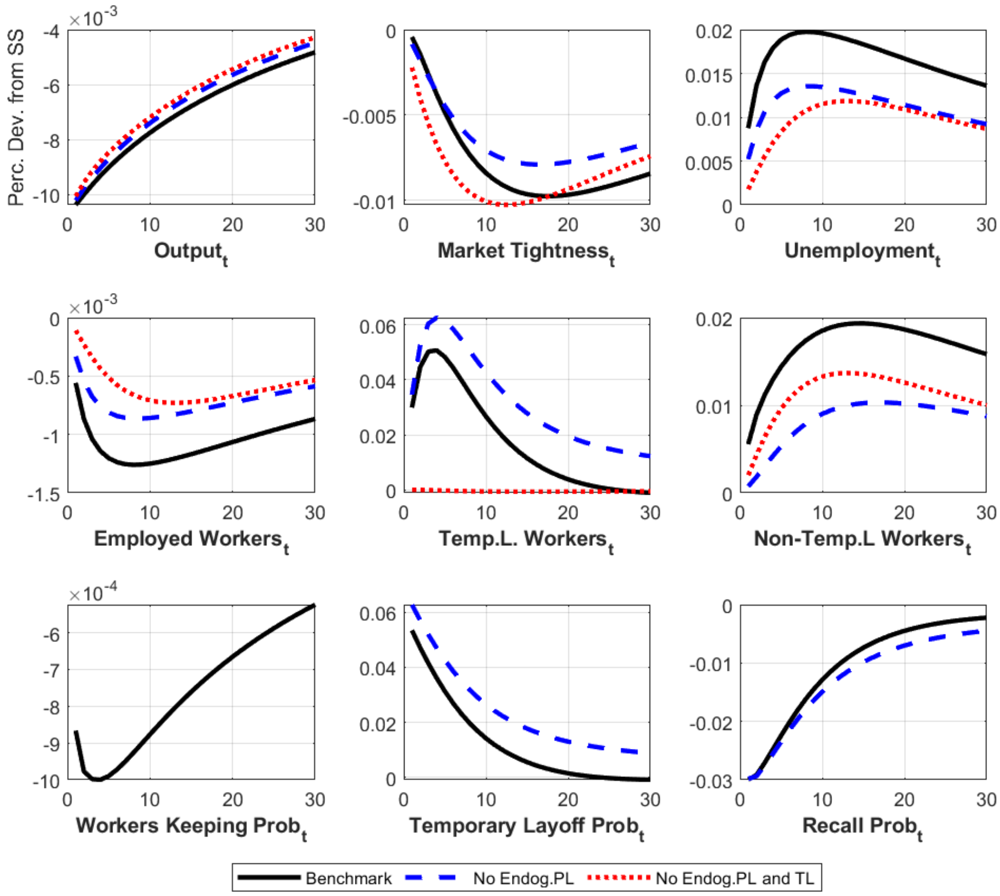
A negative productivity shock leads to a persistent contraction in output and market tightness, along with a gradual rise in unemployment. Our focus is on how the shock affects the composition of workers across employment states. The cyclical dynamics reveal that the probabilities of retaining an active worker and recalling a temporarily laid-off worker are procyclical, while the probability of placing a worker on temporary layoff is countercyclical. Following the shock, the probability of keeping a worker in active employment declines, the probability of placing a worker on temporary layoff increases, and the probability of recalling a worker from temporary layoff falls. As a result, both workers on temporary and non-temporary layoff rise, while the employed workers decrease.

Amplification via Endogenous Separations The presence of endogenous separation in the benchmark model amplifies the propagation of TFP shocks. As shown in Figures 4, the black solid lines, which represent the model with endogenous temporary and permanent layoffs, exhibit more pronounced responses across key labor market variables compared to the counterfactual models with only exogenous temporary and permanent layoffs. In particular, output declines more sharply, while unemployment rises more strongly under the benchmark specification.

This amplification arises from the firms' ability to adjust along both temporary and non-temporary layoff margins in response to changing economic conditions. In particular, the probabilities of layoffs and recalls are functions of endogenous thresholds, which in turn depend on the firm's value in different states. Therefore, these additional adjustment margins intensify separations in the short run, reduce employment, thereby reinforcing the effects of the initial shock.

Another notable result is that both the number of temporary layoff workers and the temporary layoff probability are less responsive in the benchmark model compared to the version without endogenous permanent layoffs. This occurs because, when permanent layoffs are endogenous, an adverse productivity shock reduces the probability of keeping workers, which in turn lowers the firm value. As a result, the threshold for placing a worker on temporary layoff becomes less responsive, leading to a less responsive adjustment in the temporary layoff probability and, consequently, in the number of temporary layoffs. The underlying intuition is that when firms cannot endogenously lay off workers permanently, they are forced to rely more heavily on temporary layoffs in response to negative productivity shocks.

Figure 4: Impulse Responses to a One-Standard-Deviation Adverse TFP Shock, Benchmark Model (Black Solid Line) vs. Exogenous Permanent Layoff (Blue Dash Line) vs. Exogenous Temporary Layoff and Permanent Layoff (Red Dot Line)

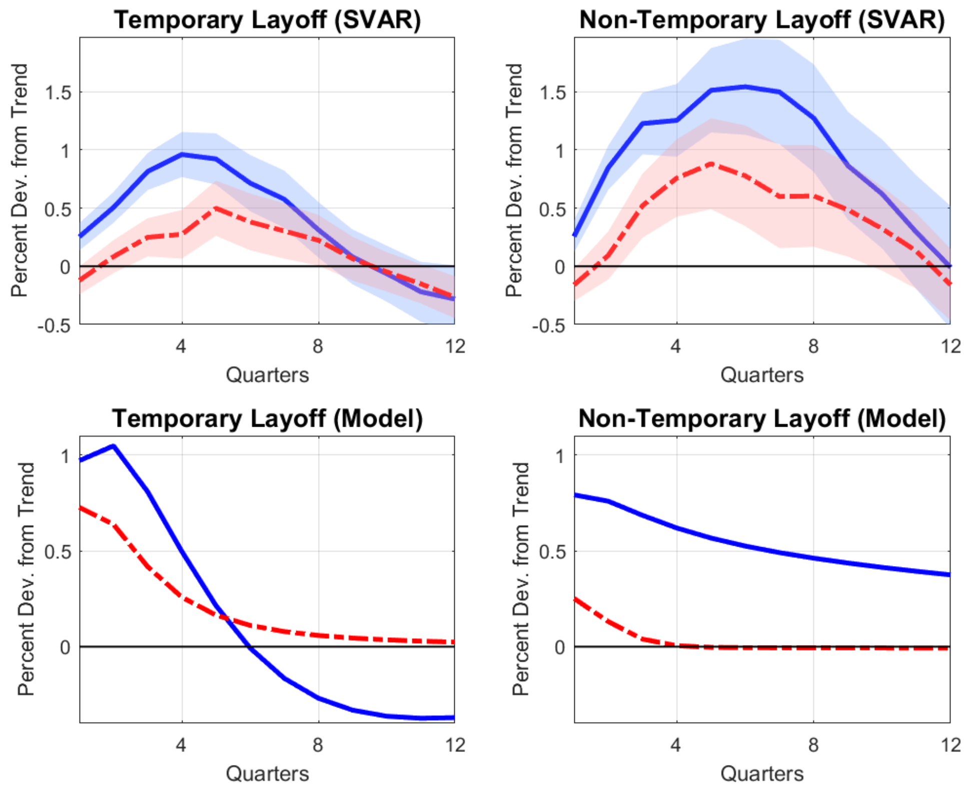


Note: This figure presents the impulse responses of output, market tightness, unemployment, employed workers, temporarily laid-off workers, permanently laid-off workers, workers keeping probability, temporary layoff probability, and recalling probability following an adverse one-standard-deviation TFP shock.

4.2.2 Differential Responses to Financial and Monetary Policy Shocks

Recall that the empirical results shown in Figure 2 and 3 present the differential impact of financial and monetary policy shocks on layoffs. The temporary and non-temporary layoffs respond more rapidly and strongly to financial shocks, while the response to monetary policy shocks is more muted and short-lived.

Figure 5: Impulse Responses of Temporary and Non-Temporary Layoffs to Financial Shock (Blue Solid Line) and Monetary Policy Shock (Red Dash-dot Line), SVAR (Top Panels) vs. Model (Bottom Panels)

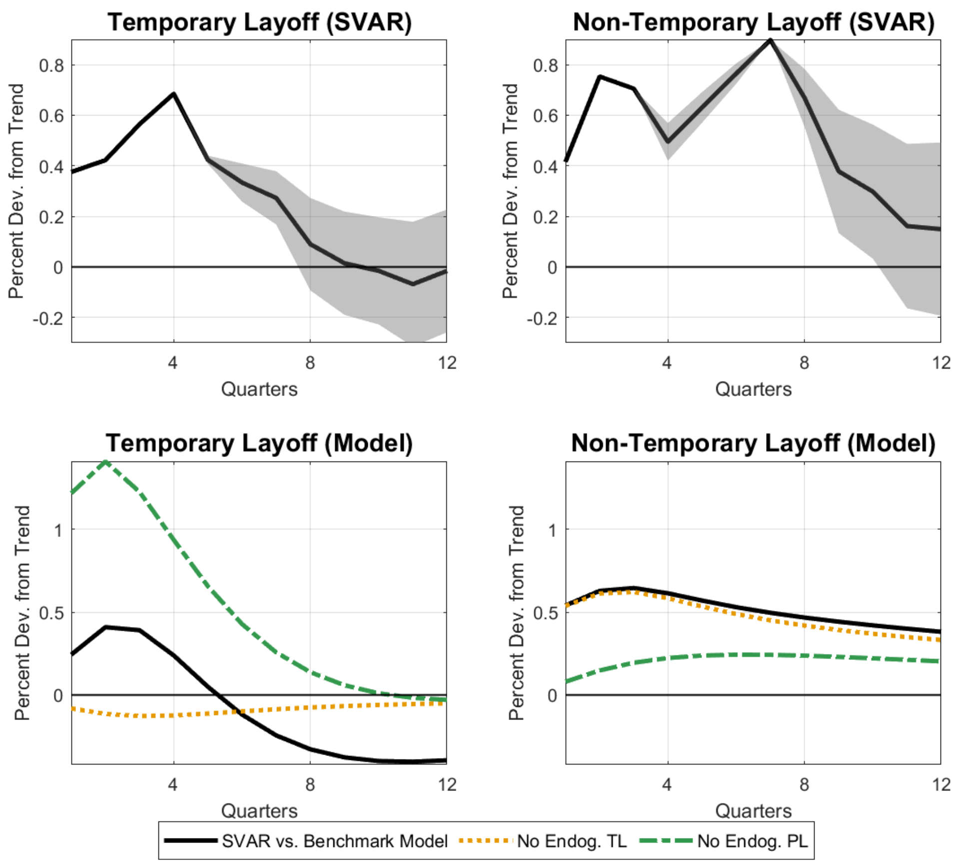


Note: This figure compares impulse responses of temporary and non-temporary layoffs to an adverse financial shock (blue solid line) and monetary policy shock (red dash-dot line). The top panels display responses estimated from the structural VAR model, while the bottom panels show those generated by the structural model. Shaded areas in the top panels represent 68-percent confidence intervals.

Figure 5 compares the impulse responses of temporary and non-temporary layoffs generated by the structural VAR and the model following financial and monetary policy shocks. (See full results in Appendix B.)

Consistent with the empirical SVAR results, the model captures the key qualitative pattern: both types of layoffs increase in response to financial and monetary policy shocks, with financial shocks generating significantly larger effects. In particular, temporary layoffs exhibit a sharper initial rise, while non-temporary layoffs respond more gradually and persistently, mirroring the empirical dynamics. Quantitatively, however, the model responses tend to be smaller in magnitude and more monotonic, lacking the hump-shaped pattern observed in the data. This discrepancy suggests that the model captures the relative strength of financial versus monetary policy shocks.

Figure 6: Difference in Layoff Responses to Financial Shock and Monetary Policy Shocks, SVAR (Top Panels) vs. Benchmark Model (Black Solid Line) vs. Model without Endogenous Temporary Layoff (Orange Dot Line) vs. Model without Endogenous Permanent Layoff (Green Dash-dot Line)



Note: This figure compares the differences in the impulse responses of temporary and non-temporary layoffs to financial and monetary policy shocks generated by the structural VAR and the model. The top panels display responses estimated from the structural VAR model, while the bottom panels show those generated by the structural model. Shaded areas in the top panels represent the extent to which the confidence intervals of the two impulse responses overlap at each horizon.

Figure 6 compares the differences in the impulse responses of temporary and non-temporary layoffs to financial and monetary policy shocks, as generated by the structural VAR and the model. Consistent with Figure 5, although the magnitude of the differences generated by the model is smaller than those generated by the structural VAR, the model successfully captures the overall shape of the responses, particularly during the first four quarters.

The orange dot line and green dash-dot lines represent counterfactual experiments from the model without endogenous permanent and temporary layoffs, respectively. As shown, the response of temporary layoffs is significantly muted when endogenous temporary layoffs are removed, while the response of permanent layoffs is also muted in the absence of endogenous permanent layoffs. Thus, endogenous temporary and permanent layoffs play a crucial role in explaining the differential responses to financial and monetary policy shocks.

Optimal Borrowing Euler Equation: Financial vs. Monetary Policy Shocks The differential responses of layoffs to financial and monetary policy shocks stem from the distinct transmission channels. The central mechanism in the model is captured by Equation (7), the optimal borrowing Euler equation:

$$1 - \lambda_t R_t = \mathbb{E}_t \Xi^j_{t+1|t} R_t.$$

This equation reflects the idea that the marginal benefit of borrowing today must equal the expected marginal cost of repaying that borrowing in the future, discounted by the entrepreneur's stochastic discount factor.

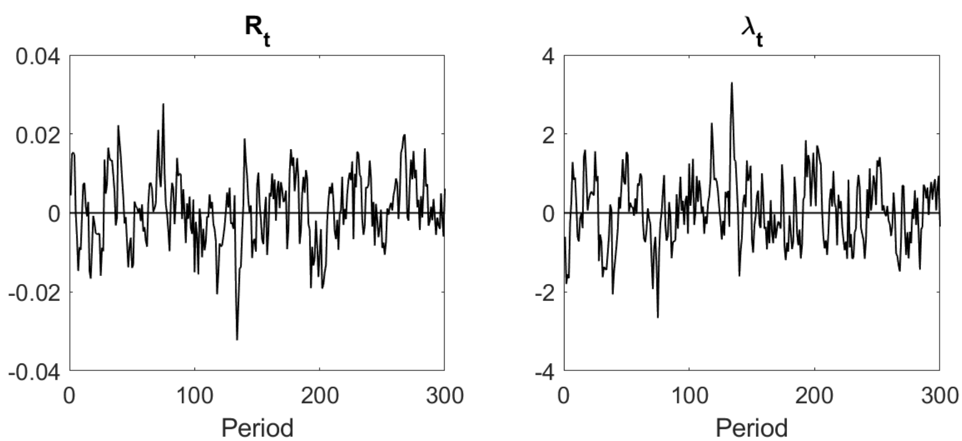
To better understand the different layoff responses following financial and monetary policy shocks, we can rearrange the equation as:

$$R_t^{-1} - \lambda_t = \mathbb{E}_t \Xi^j_{t+1|t}.$$

An adverse financial shock tightens the firm's borrowing capacity, lowering the borrowing limit parameter η_t. This tightening raises the firm's collateral multiplier λ_t, which in turn depresses the entrepreneur's stochastic discount factor $\mathbb{E}_t \Xi^j_{t+1|t}$. A lower discount factor reduces the firm values of all labor-related positions, which include having an employed worker, having a worker on temporary layoff, or having a vacancy. As firm values fall, the thresholds for retaining and recalling workers also fall, while the threshold for placing a worker on temporary layoff rises. These shifts translate into higher probabilities of both temporary and permanent layoffs. Additionally, an increase in the collateral multiplier raises the marginal cost of employing a worker, given by $(1 + \lambda_t \eta_w) w_t$, further reducing the value of having an employed worker.

Monetary policy shocks operate through a similar channel but with important differences in magnitude. A tightening of monetary policy raises the interest rate R_t, which, via the optimal borrowing equation, reduces the entrepreneur's stochastic discount factor $\mathbb{E}_t \Xi^j_{t+1|t}$. This initiates the same logic of declining firm values and rising layoff probabilities.

Figure 7: Simulated Time Paths of Real Interest Rate and Collateral Multiplier



Note: This figure presents the simulated time paths of the real interest rate and the collateral multiplier. The dynamics are generated by the model and the cyclical components of each series are extracted using the Hodrick-Prescott (HP) filter with a smoothing parameter of 1600.

However, the key difference lies in the relative size of the effects: cyclical fluctuations in the collateral multiplier λ_t tend to be quantitatively larger than changes in the interest rate R_t (Epstein et al., 2017). As shown in Figure 7, the collateral multiplier exhibits much greater volatility than the real interest rate. Furthermore, only financial shocks directly increase the marginal cost of employment through the collateral channel, introducing an additional amplification mechanism that is absent under monetary policy shocks.

5 Conclusion

This study investigates how financial and monetary policy shocks affect firm-level layoff decisions, with a particular focus on the distinction between temporary and permanent layoffs. Using a structural VAR framework and U.S. quarterly data, the empirical analysis shows that both types of shocks increase layoffs. However, financial shocks produce more immediate and stronger effects, especially within the first four quarters following the shocks.

To interpret these findings, I develop a dynamic general equilibrium model that extends the standard RBC search and matching framework. The model incorporates endogenous layoff and recall decisions, investment under collateral constraints, and price stickiness. It successfully reproduces the key qualitative features observed in the data: both financial and monetary policy shocks raise layoffs, with financial shocks generating significantly larger responses.

The model explains this asymmetry through differences in the transmission channels embedded in the optimal borrowing condition. Financial shocks tighten collateral constraints, raising the collateral multiplier, which both lowers firms' valuation of employment relationships and increases the marginal cost of keeping workers. In contrast, monetary policy shocks operate primarily through interest rate adjustments and have a relatively muted effect on firm behavior. Importantly, the model captures that cyclical fluctuations in the collateral multiplier are quantitatively larger than those in the interest rate, reinforcing the differential layoff responses observed empirically.

These findings underscore the importance of credit conditions in shaping labor market dynamics and highlight the need to distinguish between financial and monetary sources of macroeconomic fluctuations. Future research may extend the analysis by incorporating other features to better match the empirical evidence.

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APPENDIX

A Variable Definitions and Data Details

A.1 Variables Definitions

Table 3: Variables and their definitions

Variable	Definition/Notes
GZ credit spread	The credit spread index constructed by Gilchrist and Zakrajšek (2012)
monetary policy shocks	U.S. monetary policy shock series developed by Bu et al. (2021)
market tightness	Vacancy rate/Unemployment rate
temporary layoff	Job losers on Layoff (in logs)
non-temporary layoff	Job losers minus job losers on Layoff (in logs)
labor productivity	Real GDP divided by the number of employed

A.2 Data Details

Time span used: 1994Q1-2010Q4.

Job Vacancies I merge the JOLTS data with the Barnichon (2010) Help Wanted Index to obtain a longer time series for job openings.

Real GDP Real Gross Domestic Product, Billions of Chained 2017 Dollars, Quarterly, Seasonally Adjusted Annual Rate. Source: U.S. Bureau of Economic Analysis.

Temporary Layoffs (Level) Unemployment Level - Job Losers on Layoff, Thousands of Persons, Quarterly, Seasonally Adjusted. Source: U.S. Bureau of Labor Statistics.

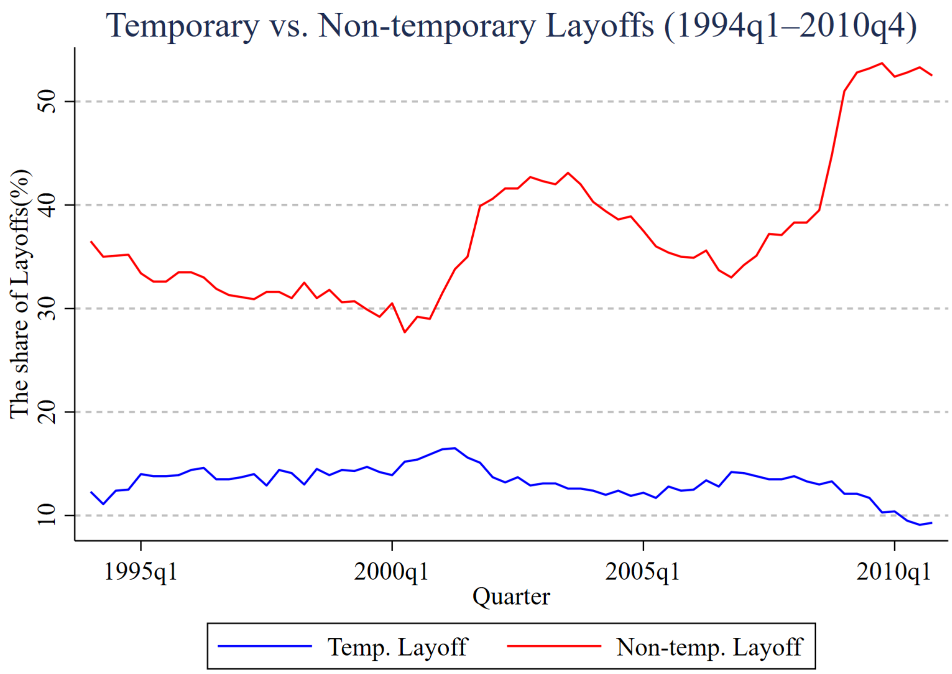
Job Losers (Level) Unemployment Level - Job Losers, Thousands of Persons, Quarterly, Seasonally Adjusted. Source: U.S. Bureau of Labor Statistics.

Number of the employed (Level) Employment Level, Thousands of Persons, Quarterly, Seasonally Adjusted. Source: U.S. Bureau of Labor Statistics.

Unemployment rate Civilian Unemployment Rate, Percent, Quarterly, Seasonally Adjusted. Source: U.S. Bureau of Labor Statistics.

A.3 Supporting Figures

Figure 8: The Percentage of Temporary and Non-Temporary Layoffs in Total Unemployment (1994q1-2010q4)

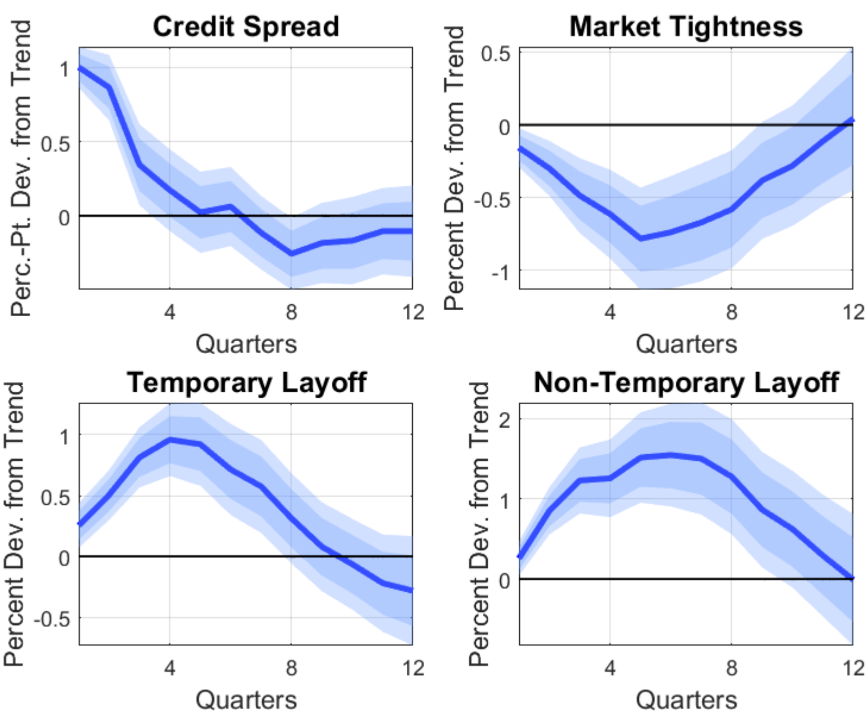


Note: This figure illustrates the share of temporary and non-temporary layoffs as a percentage of total unemployment. The data are sourced from the FRED database and cover the period from 1994q1 to 2010q4.

B Additional Results

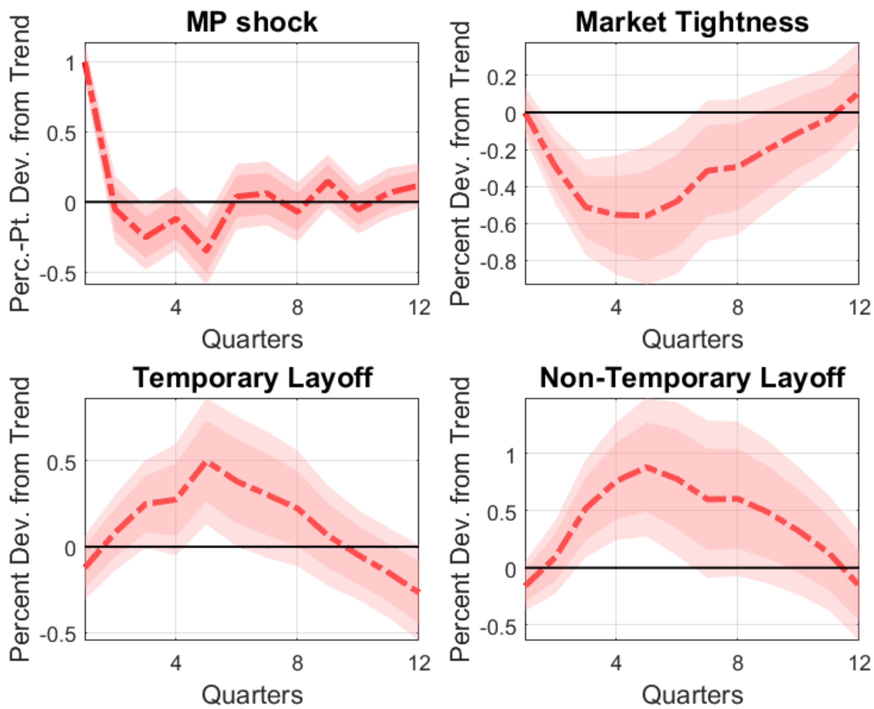
B.1 Empirical Results

Figure 9: Responses of Temporary Layoffs, Non-temporary Layoffs, and Market Tightness to a Positive 100-Basis-Point Financial Shock



Note: This figure illustrates the responses of temporary layoffs, non-temporary layoffs, and market tightness to a positive 100-basis-point financial shock in U.S. data. The cyclical components of each series are extracted by the HP filter with smoothing parameter 1600 for the quarterly series. 68% and 90% confidence intervals are shown in light blue. The variables ordering are credit spread, market tightness, temporary layoff, non-temporary layoff, and labor productivity.

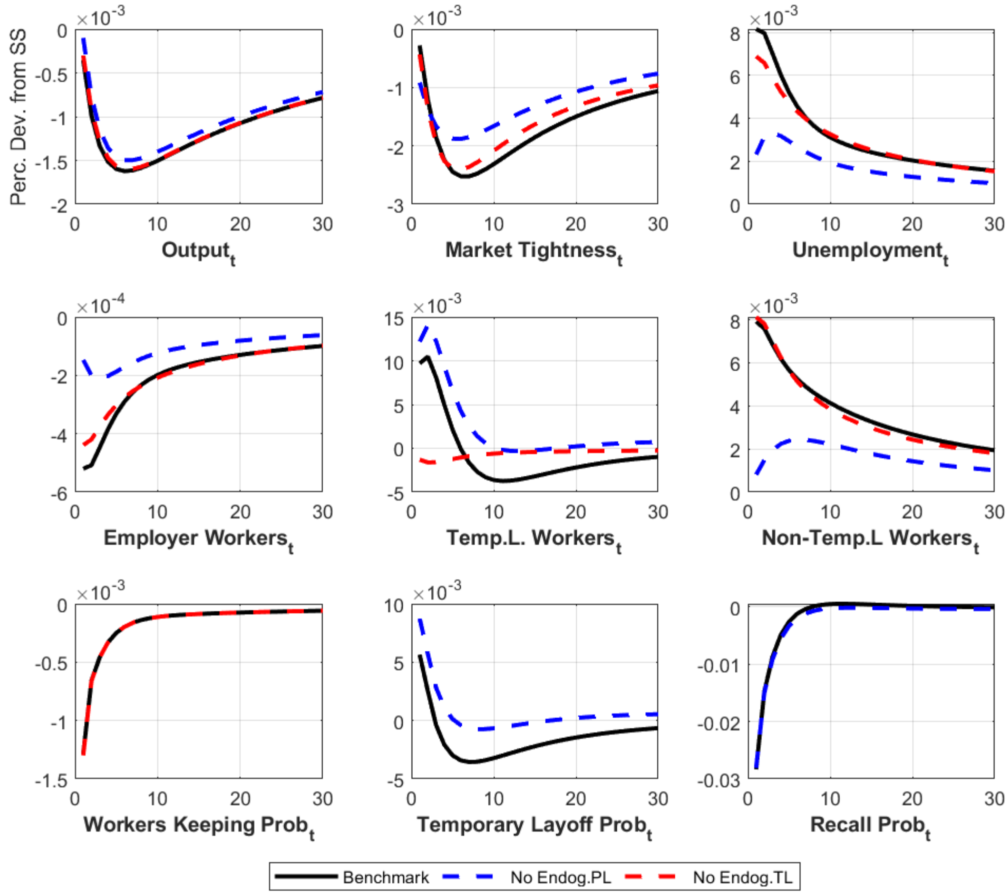
Figure 10: Responses of Temporary Layoffs, Non-temporary Layoffs, and Market Tightness to a Positive 100-Basis-Point Monetary Policy Shock



Note: This figure illustrates the responses of temporary layoffs, non-temporary layoffs, and market tightness to a positive 100-basis-point monetary policy shock in U.S. data. The cyclical components of each series are extracted by the HP filter with smoothing parameter 1600 for the quarterly series. 68% and 90% confidence intervals are shown in light red. The variables ordering are credit spread, market tightness, temporary layoff, non-temporary layoff, and labor productivity.

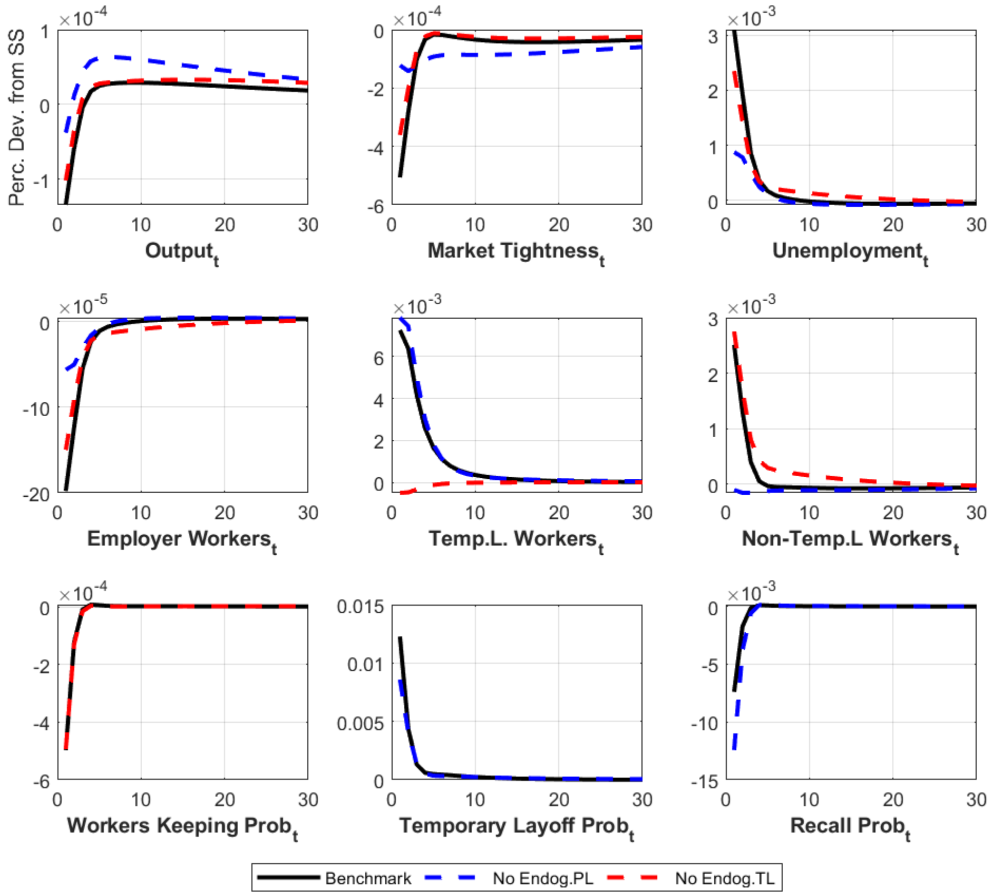
B.2 Model-Generated Impulse Responses

Figure 11: Impulse Responses to a One-Standard-Deviation Adverse Financial Shock, Benchmark vs. Exogenous Permanent Layoff vs. Exogenous Temporary Layoff and Permanent Layoff



Note: This figure presents the impulse responses of output, market tightness, unemployment, employed workers, temporarily laid-off workers, permanently laid-off workers, workers keeping probability, temporary layoff probability, and recalling probability following an adverse one-standard-deviation financial shock.

Figure 12: Impulse Responses to a One-Standard-Deviation Adverse Monetary Policy Shock, Benchmark vs. Exogenous Permanent Layoff vs. Exogenous Temporary Layoff and Permanent Layoff



Note: This figure presents the impulse responses of output, market tightness, unemployment, employed workers, temporarily laid-off workers, permanently laid-off workers, workers keeping probability, temporary layoff probability, and recalling probability following an adverse one-standard-deviation monetary policy shock.

C Derivation for Equilibrium Conditions

C.1 Final Goods Producer

Final goods firms are perfectly competitive and purchase output from intermediate goods firms. The representative final goods firm solves the following problem:

$$\max_{y_{j,t}} \; P_t\, y_t - \int_0^1 P_{j,t}\, y_{j,t}\, dj \quad \text{s.t.} \quad \left[\int_0^1 y_{j,t}^{\frac{\epsilon-1}{\epsilon}}\, dj\right]^{\frac{\epsilon}{\epsilon-1}} \geq y_t$$

The optimality condition yields the final goods firm's demand for each differentiated good:

$$y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon} y_t$$

C.2 Intermediate Goods Firm

Intermediate good firms are owned by entrepreneurs j, who choose consumption $c^i_{j,t}$, vacancies $v_{j,t}$, active workers $n_{j,at}$, inactive workers placed to temporary layoff $n_{j,it}$, endogenous threshold $\widetilde{a}_{j,t}$, $\widetilde{b}_{j,t}$, $\widetilde{\zeta}_{j,t}$, price $P_{j,t}$, next period capital stock $k_{j,t+1}$, and borrowed funds $l_{j,t}$ to maximize $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_j^t\, \mathbf{u}(c_{j,t})$, where $\mathbf{u}' > 0$, $\mathbf{u}'' < 0$, and $0 < \beta_j < \beta$.

The problem is subject to

$$c^i_{j,t} = \frac{P_{j,t}}{P_t} y_{j,t} - w_{j,t} n_{j,at} - \gamma v_{j,t} - \chi_i n_{j,it} - i_{j,t} + l_{j,t} - R_t l_{j,t-1} - \int_0^{\widetilde{e}_{j,t}} e dF(e) - \frac{\psi}{2}\left(\frac{P_{j,t}}{P_{j,t-1}} - 1\right)^2$$
$$+ q_{j,bt} n_{j,at-1}\left(\int_0^{\widetilde{a}_{j,t}} a dH(a)\right) - q_{j,bt} n_{j,it-1}\left(\int_0^{\widetilde{\zeta}_{j,t}} \zeta dR(\zeta)\right) - (n_{j,at-1} + n_{j,it-1})\left(\int_0^{\widetilde{b}_{j,t}} b dG(b)\right)$$

The firm faces its perceived laws of motion for active employment

$$n_{j,at} = q_{j,bt}(1 - q_{j,at}) n_{j,at-1} + q_{j,bt} q_{j,rt} n_{j,it-1} + v_{j,t} q_{j,t},$$

workers on temporary layoff

$$n_{j,it} = (1 - q_{j,rt})q_{j,bt}n_{j,it-1} + q_{j,at}q_{j,bt}n_{j,at-1},$$

and the evolution of vacancies

$$v_{j,t} = (1 - \rho_v)(1 - q_{j,t-1})v_{j,t-1} + (q_{j,bt}q_{j,at} + (1 - q_{j,bt}))n_{j,at-1} + v_{j,nt},$$

the capital accumulation with δ denoting the depreciation rate and i_j investment

$$k_{j,t+1} = (1 - \delta)k_{j,t} + i_{j,t},$$

and the collateral constraint

$$R_t l_{j,t} + \eta_w w_{j,t} n_{j,at} \leq \eta_t k_{j,t+1}.$$

The intermediate goods firm j choose $\{P_{j,t},\, n_{j,at},\, n_{j,it},\, v_{j,t},\, k_{j,t+1},\, l_{j,t},\, \widetilde{a}_{j,t},\, \widetilde{b}_{j,t},\, \widetilde{\zeta}_{j,t}\ \}$, The Lagrange function for the intermediate goods firm is

$$\begin{aligned}
\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_j^t \{&\mathbf{u}(c_{j,t}^i) + \mu_{j,ct}\Big[(\frac{P_{j,t}}{P_t})^{1-\epsilon} y_t - w_{j,t}n_{j,at} - \gamma v_{j,t} - \chi_i n_{j,it} - \chi_p n_{j,at-1}q_{j,bt} - \int_0^{\widetilde{e}_{j,t}} edF(e) \\
&+ q_{j,bt}n_{j,at-1}\left(\int_0^{\widetilde{a}_{j,t}} adH(a)\right) - q_{j,bt}n_{j,it-1}\left(\int_0^{\widetilde{\zeta}_{j,t}} \zeta dR(\zeta)\right) - (n_{j,at-1} + n_{j,it-1})\left(\int_0^{\widetilde{b}_{j,t}} bdG(b)\right) \\
&- k_{j,t+1} + (1-\delta)k_{j,t} + l_{j,t} - R_{t-1}l_{j,t-1} - \frac{\psi}{2}(\frac{P_{j,t}}{P_{j,t-1}} - 1)^2 - c_{j,t}\Big] \\
&+ mc_{j,t}[z_t f(k_{j,t}, n_{j,at}) - (\frac{P_{j,t}}{P_t})^{-\epsilon} y_t] \\
&+ \mu_{j,at}[q_{j,bt}(1 - q_{j,at})n_{j,at-1} + q_{j,bt}q_{j,rt}n_{j,it-1} + v_{j,t}q_{j,t} - n_{j,at}] \\
&+ \mu_{j,it}[(1 - q_{j,rt})q_{j,bt}n_{j,it-1} + q_{j,at}q_{j,bt}n_{j,at-1} - n_{j,it}] \\
&+ \mu_{j,vt}[(1-\rho_v)(1 - q_{j,t-1})v_{j,t-1} + (q_{j,bt}q_{j,at} + (1 - q_{j,bt}))n_{j,at-1} + v_{j,nt} - v_{j,t}] \\
&+ \lambda_{j,t}[\eta_t k_{j,t+1} - R_t l_{j,t} - \eta_w w_{j,t} n_{j,at}]\}
\end{aligned}$$

The first-order conditions to consumption $c^i_{j,t}$, total job vacancies $v_{j,t}$, active employment $n_{j,at}$, workers on temporary layoff $n_{j,it}$ are

$$\frac{\partial \mathcal{L}}{\partial c^i_{j,t}} = \mathbf{u}'(c^i_{j,t}) - \mu_{j,ct} = 0$$

$$\frac{\partial \mathcal{L}}{\partial v_{j,t}} = -\mu_{j,vt} - \mu_{j,ct}\gamma + \mu_{j,at}q_{j,t} + (1-\rho_v)(1-q_{j,t})\mathbb{E}_t\beta_j\{\mu_{j,vt+1}\} = 0$$

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial n_{j,at}} =& -\mu_{j,at} - \lambda_{j,t}\eta_w w_{j,t} - \mu_{j,ct}w_{j,t} + mc_{j,t}z_t f_{n_j}(k_{j,t}, n_{j,at}) \\ &+ \mathbb{E}_t\beta_j\{\mu_{j,ct+1}\left[q_{j,bt+1}\left(\int_0^{\tilde{a}_{j,t+1}} adH(a)\right) - \left(\int_0^{\tilde{b}_{j,t+1}} bdG(b)\right) - \chi_p q_{j,bt+1}\right] \\ &+ \left(q_{j,bt+1}q_{j,at+1} + (1-q_{j,bt+1})\right)\mu_{j,vt+1} + q_{j,bt+1}\left[(1-q_{j,at+1})\mu_{j,at+1} + q_{j,at+1}\mu_{j,it+1}\right]\} = 0\end{aligned}$$

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial n_{j,it}} =& -\mu_{j,it} - \mu_{j,ct}\chi_i + \mathbb{E}_t\beta_j\{\left[-q_{j,bt+1}\left(\int_0^{\tilde{\zeta}_{j,t+1}} \zeta dR(\zeta)\right) - \left(\int_0^{\tilde{b}_{j,t+1}} bdG(b)\right)\right]\mu_{j,ct+1} \\ &+ q_{j,bt+1}q_{j,rt+1}\mu_{j,at+1} + q_{j,bt+1}(1-q_{j,rt+1})\mu_{j,it+1}\} = 0\end{aligned}$$

The first-order conditions for capital $k_{j,t+1}$ and borrowed funds $l_{j,t}$ yield the Euler equation and the optimal choice over borrowed funds

$$\frac{\partial \mathcal{L}}{\partial k_{j,t+1}} = -\mu_{j,ct} + \lambda_{j,t}\eta_t + \mathbb{E}_t\beta_j\{\mu_{j,ct+1}(1-\delta) + mc_{j,t+1}z_{t+1}f_{k_j}(k_{j,t+1}, n_{j,at+1})\} = 0$$

$$\frac{\partial \mathcal{L}}{\partial l_{j,t}} = \mu_{j,ct} - \lambda_{j,t}R_t - \mathbb{E}_t\beta_j\mu_{j,ct+1}R_t = 0$$

The first-order condition to $P_{j,t}$ yields optimal pricing

$$\frac{\partial \mathcal{L}}{\partial P_{j,t}} = \mu_{j,ct}\{(1-\epsilon)\left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon}\frac{y_t}{P_t} + \epsilon mc_t\left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon-1}\frac{y_t}{P_t} - \psi\left(\frac{P_{j,t}}{P_{j,t-1}} - 1\right)\frac{1}{P_{j,t-1}}\}$$
$$+\mathbb{E}_t\beta_j\mu_{j,ct+1}\,\psi(\frac{P_{j,t+1}}{P_{j,t}} - 1)\frac{P_{j,t+1}}{{P_{j,t}}^2} = 0$$

Defining $mc_{j,t} \equiv mc_{j,t}/\mu_{j,ct}$, $\lambda_{j,t} \equiv \lambda_{j,t}/\mu_{j,ct}$, $\Xi^j_{t+1|t} \equiv \beta_j \mathbf{u'}(c^i_{j,t+1})/\mathbf{u'}(c^i_{j,t})$, $\mathbf{J}_{j,vt} \equiv (\mu_{j,vt}/\mu_{j,ct})$, $\mathbf{J}_{j,at} \equiv (\mu_{j,at}/\mu_{j,ct})$, and $\mathbf{J}_{j,it} \equiv (\mu_{j,it}/\mu_{j,ct})$. Then, the value expressions for the firm are given by

$$\mathbf{J}_{j,vt} = -\gamma + q_{j,t}\mathbf{J}_{j,at} + (1-\rho_v)(1-q_{j,t})\mathbb{E}_t\Xi^j_{t+1|t}\mathbf{J}_{j,vt+1}$$

$$\mathbf{J}_{j,at} = -\lambda_{j,t}\eta_w w_{j,t} + mc_{j,t}z_t f_{n_j}(k_{j,t}, n_{j,at}) - w_{j,t} + \mathbb{E}_t\Xi^j_{t+1|t}\{\left[q_{j,bt+1}\left(\int_0^{\widetilde{a}_{j,t+1}} adH(a)\right) - \int_0^{\widetilde{b}_{j,t+1}} bdG(b)\right]$$
$$+\left(q_{j,bt+1}q_{j,at+1} + (1-q_{j,bt+1})\right)\mathbf{J}_{j,vt+1} + q_{j,bt+1}\left[(1-q_{j,at+1})\mathbf{J}_{j,at+1} + q_{j,at+1}\mathbf{J}_{j,it+1}\right]\}$$

$$\mathbf{J}_{j,it} = -\chi_i + \mathbb{E}_t\Xi^j_{t+1|t}\{\left[-q_{j,bt+1}\left(\int_0^{\widetilde{\zeta}_{j,t+1}} \zeta dR(\zeta)\right) - \int_0^{\widetilde{b}_{j,t+1}} bdG(b)\right]$$
$$+q_{j,bt+1}q_{j,rt+1}\mathbf{J}_{j,at+1} + q_{j,bt+1}(1-q_{j,rt+1})\mathbf{J}_{j,it+1}\}$$

Turning to the condition that pins down $\widetilde{e}_{j,t}$, intermediate-goods firms will create new vacancies as long as $\mathbf{J}_{j,vt} \geq \widetilde{e}_{j,t}$. Thus, it must be that at the optimum,

$$\widetilde{e}_{j,t} = \mathbf{J}_{j,vt}.$$

Finally, turning to the first-order conditions with respect to $\widetilde{a}_{j,t}$, $\widetilde{b}_{j,t}$ and $\widetilde{\zeta}_{j,t}$, note that the choice over $\widetilde{a}_{j,t}$ implies a choice over $q_{j,at}$ since $q_{j,at} = H(\widetilde{a}_{j,t})$. Moreover, since $q_{j,at} = H(\widetilde{a}_{j,t})$, then $\partial q_{j,at}/\partial \widetilde{a}_{j,t} = \partial H(\widetilde{a}_{j,t})/\partial \widetilde{a}_{j,t} = h(\widetilde{a}_{j,t})$ (i.e., the pdf of H). Similarly, the choice over $\widetilde{b}_{j,t}$ and $\widetilde{\zeta}_{j,t}$ implies a choice over $q_{j,bt}$ and $q_{j,rt}$. Moreover, since $q_{j,bt} = G(\widetilde{b}_{j,t})$ and $q_{j,rt} = R(\widetilde{\zeta}_{j,t})$, then $\partial q_{j,bt}/\partial \widetilde{b}_{j,t} = \partial G(\widetilde{b}_{j,t})/\partial \widetilde{b}_{j,t} = g(\widetilde{b}_{j,t})$ (i.e., the pdf of G), $\partial q_{j,rt}/\partial \widetilde{\zeta}_{j,t} = \partial R(\widetilde{\zeta}_{j,t})/\partial \widetilde{\zeta}_{j,t} = r(\widetilde{\zeta}_{j,t})$ (i.e., the pdf of R). Then, the first-order condition with respect to $\widetilde{a}_{j,t}$ is

$$\frac{\partial \mathcal{L}}{\partial \widetilde{a}_{j,t}} = \mu_{j,ct} n_{j,at-1} \frac{\partial q_{j,at}}{\partial \widetilde{a}_{j,t}} \widetilde{a}_{j,t} - \mu_{j,at} n_{j,at-1} \frac{\partial q_{j,at}}{\partial \widetilde{a}_{j,t}} + \mu_{j,it} n_{j,at-1} \frac{\partial q_{j,at}}{\partial \widetilde{a}_{j,t}} + \mu_{j,vt} n_{j,at-1} \frac{\partial q_{j,at}}{\partial \widetilde{a}_{j,t}} = 0,$$

Similarly, the first-order condition with respect to $\widetilde{b}_{j,t}$ and $\widetilde{\zeta}_{j,t}$ is

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial \widetilde{b}_{j,t}} =& \mu_{j,ct}[n_{j,at-1} \int_0^{\widetilde{a}_{j,t+1}} a dH(a) - n_{j,it-1} \int_0^{\widetilde{\zeta}_{j,t+1}} \zeta dR(\zeta) - (n_{j,at-1} + n_{j,it-1})] \frac{\partial q_{j,bt}}{\partial \widetilde{b}_{j,t}} \\ &+ \mu_{j,at}[(1 - q_{j,at}) n_{j,at-1} + q_{j,rt} n_{j,it-1}] \frac{\partial q_{j,bt}}{\partial \widetilde{b}_{j,t}} + \mu_{j,it}[(1 - q_{j,rt}) n_{j,it-1} + q_{j,at} n_{j,at-1}] \frac{\partial q_{j,bt}}{\partial \widetilde{b}_{j,t}} \\ &- \mu_{j,vt}(1 - q_{j,at}) n_{j,at-1} \frac{\partial q_{j,bt}}{\partial \widetilde{b}_{j,t}} = 0,\end{aligned}$$

$$\frac{\partial \mathcal{L}}{\partial \widetilde{\zeta}_{j,t}} = -\mu_{j,ct} q_{j,bt} n_{j,it-1} \frac{\partial q_{j,rt}}{\partial \widetilde{\zeta}_{j,t}} \widetilde{\zeta}_{j,t} + \mu_{j,at} q_{j,bt} n_{j,it-1} \frac{\partial q_{j,rt}}{\partial \widetilde{\zeta}_{j,t}} - \mu_{j,it} q_{j,bt} n_{j,it-1} \frac{\partial q_{j,rt}}{\partial \widetilde{\zeta}_{j,t}} = 0,$$

which simplifies to

$$\widetilde{a}_{j,t} = \mu_{j,at} - \mu_{j,it} - \mu_{j,vt} = \mathbf{J}_{j,at} - \mathbf{J}_{j,it} - \mathbf{J}_{j,vt},$$

$$\begin{aligned}\widetilde{b}_{j,t} =& \left[(1 - q_{j,at})(\mathbf{J}_{j,at} - \mathbf{J}_{j,it} - \mathbf{J}_{j,vt}) + \int_0^{\widetilde{a}_{j,t}} a dH(a)\right] \left(\frac{n_{j,at-1}}{n_{j,at-1} + n_{j,it-1}}\right) \\ &+ \left[q_{j,rt}(\mathbf{J}_{j,at} - \mathbf{J}_{j,it}) - \left(\int_0^{\widetilde{\zeta}_{j,t}} \zeta dR(\zeta)\right)\right] \left(\frac{n_{j,it-1}}{n_{j,at-1} + n_{j,it-1}}\right) + \mathbf{J}_{j,it},\end{aligned}$$

$$\widetilde{\zeta}_{j,t} = \mu_{j,at} - \mu_{j,it} = \mathbf{J}_{j,at} - \mathbf{J}_{j,it}.$$

Normalizing firm j's multiplier on its collateral constraint by the marginal utility of consumption yields $\lambda_{j,t} = \lambda_{j,t}/\mu_{j,ct}$. Imposing symmetry across firms and defining $\pi_t = \frac{P_t}{P_{t-1}} - 1$, we can rewrite the above results as follows:

$$\mathbf{J}_{vt} = -\gamma + q_t \mathbf{J}_{at} + (1-\rho_v)(1-q_t)\mathbb{E}_t\{\Xi^j_{t+1|t}\mathbf{J}_{vt+1}\}$$

$$\mathbf{J}_{at} = -\lambda_t \eta_w w_t + mc_t z_t f_n(k_t, n_{at}) - w_t + \mathbb{E}_t \Xi^j_{t+1|t}\{\left[q_{bt+1}\left(\int_0^{\widetilde{a}_{t+1}} a dH(a)\right) - \int_0^{\widetilde{b}_{t+1}} b dG(b)\right]$$
$$+ \left(q_{bt+1}q_{at+1} + (1-q_{bt+1})\right)\mathbf{J}_{vt+1} + q_{bt+1}\left[(1-q_{at+1})\mathbf{J}_{at+1} + q_{at+1}\mathbf{J}_{it+1}\right]\}$$

$$\mathbf{J}_{it} = -\chi_i + \mathbb{E}_t \Xi^j_{t+1|t}\{-q_{bt+1}\left(\int_0^{\widetilde{\zeta}_{t+1}} \zeta dR(\zeta)\right) - \int_0^{\widetilde{b}_{t+1}} b dG(b) + q_{bt+1}q_{rt+1}\mathbf{J}_{at+1}$$
$$+ q_{bt+1}(1-q_{rt+1})\mathbf{J}_{it+1}\}$$

$$\widetilde{e}_t = \mathbf{J}_{vt}$$

$$\widetilde{a}_t = \mu_{at} - \mu_{it} - \mu_{vt} = \mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}$$

$$\widetilde{b}_t = \left[(1-q_{at})(\mathbf{J}_{at}-\mathbf{J}_{it}-\mathbf{J}_{vt}) + \int_0^{\widetilde{a}_t} adH(a)\right]\left(\frac{n_{at-1}}{n_{at-1}+n_{it-1}}\right)$$
$$+\left[q_{rt}(\mathbf{J}_{at}-\mathbf{J}_{it}) - \left(\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta)\right)\right]\left(\frac{n_{it-1}}{n_{at-1}+n_{it-1}}\right) + \mathbf{J}_{it}$$

$$\widetilde{\zeta}_t = \mu_{at} - \mu_{it} = \mathbf{J}_{at} - \mathbf{J}_{it}$$

$$1 - \lambda_t \eta_t = \mathbb{E}_t \Xi^j_{t+1|t}\{mc_{t+1} z_{t+1} f_k(k_{t+1}, n_{at+1}) + 1 - \delta\}$$

$$1 - \lambda_t R_t = \mathbb{E}_t \Xi^j_{t+1|t}\, R_t$$

$$(1-\epsilon+\epsilon mc_t)\, y_t - \psi\,(1+\pi_t)\,\pi_t + \mathbb{E}_t \Xi^j_{t+1|t}\,\psi\,(1+\pi_{t+1})\,\pi_{t+1} = 0$$

C.3 Household

The representative household chooses state-contingent decision rules for consumption c_t, and assets a_t to maximize expected lifetime discounted utility with habit formation $E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$, where $u(c_t) = ln(c_t - \phi_c c_{t-1})$, subject to the budget constraint

$$P_t\, c_t + a_t + T_t = w_t n_{at} + \chi_u(1-n_{at}) + \chi_i n_{it} + R_{t-1} a_{t-1} + \Pi_t,$$

The Lagrange function is

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ ln(c_t - \phi_c c_{t-1}) + \mu_t \Big[w_t n_{at} + \chi_u (1 - n_{at}) + \chi_i n_{it} + R_{t-1} a_{t-1} + \Pi_t - P_t\, c_t - a_t - T_t \Big] \right\}$$

The first-order conditions are:

$$\frac{\partial \mathcal{L}}{\partial c_t} = -\mu_t P_t + \frac{1}{c_t - \phi_c c_{t-1}} + \beta \phi_c E_t \frac{1}{c_{t+1} - \phi_c c_t} = 0,$$

$$\frac{\partial \mathcal{L}}{\partial a_t} = -\mu_t + \beta E_t \mu_{t+1} R_t = 0.$$

which can be simplified as

$$\mu_t = \frac{1}{c_t - \phi_c c_{t-1}} + \beta \phi_c E_t \frac{1}{c_{t+1} - \phi_c c_t},$$

$$1 = \beta R_t E_t \frac{\mu_{t+1}}{\mu_t} \frac{P_t}{P_{t+1}}.$$

To obtain the household value expressions, it proves useful to write the household's problem in recursive form.

Specifically, the value function of the household $V_t(n_{at-1}, n_{it-1}, a_{t-1})$ is

$$V_t(n_{at-1}, n_{it-1}, a_{t-1}) = \max \left[u(c_t) + \beta E_t V_{t+1}(n_{at}, n_{it}, a_t) \right],$$

subject to the budget constraint (multiplier μ_t)

$$P_t\, c_t + a_t + T_t = w_t n_{at} + \chi_u (1 - n_{at}) + \chi_i n_{it} + R_{t-1} a_{t-1} + \Pi_t$$

the perceived law of motion for active employment (multiplier μ_{at})

$$n_{at} = q_{bt}(1 - q_{at}) n_{at-1} + q_{bt} q_{rt} n_{it-1} + f_t s_t,$$

and the law of motion for inactive employment (multiplier μ_{it})

$$n_{it} = (1 - q_{rt})q_{bt}n_{it-1} + q_{at}q_{bt}n_{at-1},$$

and the job searcher can be defined as

$$s_t = n_{pt-1} + (1 - q_{bt})(n_{at-1} + n_{it-1}) = 1 - q_{bt}(n_{it-1} + n_{at-1}).$$

The first-order conditions with respect to n_{at} is

$$-\mu_{at} + \mu_t(w_t - \chi_u) + E_t\beta\frac{\partial V_{t+1}(n_{at}, n_{it}, a_t)}{\partial n_{at}} = 0,$$

the first-order condition with respect to n_{it} is

$$-\mu_{it} + \mu_t\chi_i + E_t\beta\frac{\partial V_{t+1}(n_{at}, n_{it}, a_t)}{\partial n_{it}} = 0.$$

Using the definition of s_t, we can write the law of motion for active employment as

$$\begin{aligned} n_{at} &= q_{bt}(1 - q_{at})n_{at-1} + q_{bt}q_{rt}n_{it-1} + [1 - q_{bt}(n_{at-1} + n_{it-1})]\, f_t \\ &= q_{bt}(1 - q_{at} - f_t)n_{at-1} + q_{bt}(q_{rt} - f_t)n_{it-1} + f_t. \end{aligned}$$

Then, the envelope condition with respect to n_{at-1} is

$$\frac{\partial V_t(n_{at-1}, n_{it-1}, a_{t-1})}{\partial n_{at-1}} = q_{bt}(1 - q_{at} - f_t)\mu_{at} + q_{bt}q_{at}\mu_{it} + (1 - q_{bt})\chi_p\mu_t,$$

so that

$$\frac{\partial V_t(n_{at}, n_{it}, a_t)}{\partial n_{at}} = q_{bt+1}(1 - q_{at+1} - f_{t+1})\mu_{at+1} + q_{bt+1}q_{at+1}\mu_{it+1} + (1 - q_{bt+1})\chi_p\mu_{t+1},$$

Similarly, the envelope condition with respect to n_{it-1} is

$$\frac{\partial V_t(n_{at-1}, n_{it-1}, a_{t-1})}{\partial n_{it-1}} = q_{bt}(q_{rt} - f_t)\mu_{at} + q_{bt}(1 - q_{rt})\mu_{it},$$

so that

$$\frac{\partial V_{t+1}(n_{at}, n_{it}, a_t)}{\partial n_{it}} = q_{bt+1}(q_{rt+1} - f_{t+1})\mu_{at+1} + q_{bt+1}(1 - q_{rt+1})\mu_{it+1},$$

and going back to first-order condition with respect to n_{at}, we can write

$$\mu_{at} = \mu_t(w_t - \chi_u) + E_t\beta \left\{q_{bt+1}(1 - q_{at+1} - f_{t+1})\mu_{at+1} + q_{bt+1}q_{at+1}\mu_{it+1}\right\}$$

or

$$\frac{\mu_{at}}{\mu_t} = w_t - \chi_u + E_t\beta\frac{\mu_{t+1}}{\mu_t}\left\{q_{bt+1}(1 - q_{at+1} - f_{t+1})\frac{\mu_{at+1}}{\mu_{t+1}} + q_{bt+1}q_{at+1}\frac{\mu_{it+1}}{\mu_{t+1}}\right\}.$$

The first-order condition with respect to n_{it} is

$$\mu_{it} = \mu_t\chi_i + E_t\beta[q_{bt+1}(q_{rt+1} - f_{t+1})\mu_{at+1} + q_{bt+1}(1 - q_{rt+1})\mu_{it+1}],$$

or

$$\frac{\mu_{it}}{\mu_t} = \chi_i + E_t\beta\frac{\mu_{t+1}}{\mu_t}\left[q_{bt+1}(q_{rt+1} - f_{t+1})\frac{\mu_{at+1}}{\mu_{t+1}} + q_{bt+1}(1 - q_{rt+1})\frac{\mu_{it+1}}{\mu_{t+1}}\right].$$

Defining $\Xi_{t+1|t} \equiv \beta(\mu_{t+1}/\mu_t)$, $\mathbf{W}_{at} = (\mu_{at}/\mu_t)$ and $\mathbf{W}_{it} = (\mu_{it}/\mu_t)$ as the net values to the household from having an active worker and an inactive worker. The net value to the household from having a household member in active employment is

$$\mathbf{W}_{at} = w_t - \chi_u + E_t\Xi_{t+1|t}\, q_{bt+1}\left\{(1 - q_{at+1} - f_{t+1})\mathbf{W}_{at+1} + q_{at+1}\mathbf{W}_{it+1}\right\}$$

The net value to the household of having a household member on temporary layoff is

$$\mathbf{W}_{it} = \chi_i + E_t\Xi_{t+1|t}\, q_{bt+1}\{(q_{rt+1} - f_{t+1})\mathbf{W}_{at+1} + (1 - q_{rt+1})\mathbf{W}_{it+1}\}.$$

C.4 Wage Determination

Denoting by $0 < \phi < 1$ the worker's bargaining power, the period-t Nash wage w_t is given by

$$\mathbf{W}_{at} = \frac{\phi}{1-\phi}(\mathbf{J}_{at} - \mathbf{J}_{vt})$$

so that

$$w_t - \chi_u + E_t \Xi_{t+1|t}\, q_{bt+1} \left\{ (1 - q_{at+1} - f_{t+1}) \left(\frac{\phi}{1-\phi} \right) (\mathbf{J}_{at+1} - \mathbf{J}_{vt+1}) + q_{at+1} \mathbf{W}_{it+1} \right\} = \left(\frac{\phi}{1-\phi} \right) (\mathbf{J}_{at} - \mathbf{J}_{vt})$$

C.5 Government

The government uses lump-sum taxes levied on households to finance unemployment benefits χ_u for household members on search unemployment and on temporary layoff. Then, the period-t flow government budget constraint is $\chi_u((1 - f_t)s_t + n_{it})$.

C.6 Function forms

Productivity Function $f(k_t, n_{at}) = k_t^{\alpha} n_{at}^{1-\alpha}$

Matching Function $m(s_t, v_t) = M s_t^{\xi} v_t^{1-\xi}$, where the matching elasticity with respect to searchers is $0 < \xi < 1$ and $M > 0$ is a matching efficiency parameter.

Equilibrium Recruiting Costs, Layoff Savings, and Recall Costs Recall that intermediate goods firms pay a fixed cost e as part of the worker recruiting process, drawn from an *i.i.d.* distribution $F(e)$, and a fixed cost ζ to recall workers on temporary layoff, drawn from an *i.i.d.* distribution $R(\zeta)$. In addition, when firms place a worker on temporary layoff, they save an amount of resources a drawn from an *i.i.d.* distribution $H(a)$. And when firms place a worker on permanent layoff, they save an amount of resources b drawn from an *i.i.d.* distribution $G(b)$. Following Leduc and Liu (2023) , we adopt power distributions for $F(e) = (e/\bar{e})^{\eta_e}$, $R(\zeta) = \left(\zeta/\bar{\zeta}\right)^{\eta_r}$ $H(a) = (a/\bar{a})^{\eta_a}$, and $G(b) = \left(b/\bar{b}\right)^{\eta_b}$, where $\eta_a > 0$, $\eta_b >$

$0,\ \eta_e > 0,\ \eta_r > 0$ and $\bar{a} > 0,\ \bar{b} > 0,\ \bar{e} > 0,\ \bar{\zeta} > 0$ are scaling parameters.

With this in mind, the total fixed costs of creating job vacancies in period t are given by $\int_0^{\widetilde{e}_t} e\,dF(e)$. The total amount of resources saved when placing active workers on temporary layoff in period t is given by $n_{at-1}\int_0^{\widetilde{a}_t} a\,dH(a)$. The total amount of resources saved when laying off active workers permanently in period t is given by $n_{at-1}\int_0^{\widetilde{b}_t} b\,dG(b)$. Finally, the total cost of recalling workers on temporary layoff back to the firm in period t is given by $(1-\rho_i)n_{it-1}\int_0^{\widetilde{\zeta}_t} \zeta\,dR(\zeta)$.

Note that

$$\int_0^{\widetilde{a}_t} adH(a) = \int_0^{\widetilde{a}_t} ah(a)da = \int_0^{\widetilde{a}_t} \eta_a \left(\frac{a}{\bar{a}}\right)^{\eta_a} da = \left(\frac{\eta_a}{1+\eta_a}\right)\left(\frac{\widetilde{a}_t}{\bar{a}}\right)^{\eta_a} \widetilde{a}_t = \left(\frac{\eta_a}{1+\eta_a}\right) q_{at}\widetilde{a}_t,$$

where we use the fact that in equilibrium $q_{at} = H(\widetilde{a}_t) = (\widetilde{a}_t/\bar{a})^{\eta_a}$. Following identical steps shows that

$$\int_0^{\widetilde{b}_t} bdG(b) = \left(\frac{\eta_b}{1+\eta_b}\right) q_{bt}\widetilde{b}_t$$

and

$$\int_0^{\widetilde{\zeta}_t} \zeta dR(\zeta) = \left(\frac{\eta_r}{1+\eta_r}\right) q_{rt}\widetilde{\zeta}_t,$$

where we use the fact that in equilibrium $q_{bt} = G(\widetilde{b}_t) = \left(\widetilde{b}_t/\bar{b}\right)^{\eta_b}$ and $q_{rt} = R(\widetilde{\zeta}_t) = \left(\widetilde{\zeta}_t/\bar{\zeta}\right)^{\eta_r}$.

Finally, we can show that

$$\int_0^{\widetilde{e}_t} edF(e) = \int_0^{\widetilde{e}_t} ef(e)de = \int_0^{\widetilde{e}_t} \eta_e \left(\frac{e}{\bar{e}}\right)^{\eta_e} de = \left(\frac{\eta_e}{1+\eta_e}\right)\left(\frac{\widetilde{e}_t}{\bar{e}}\right)^{\eta_e} \widetilde{e}_t = \left(\frac{\eta_e}{1+\eta_e}\right) \widetilde{e}_t v_{nt},$$

where we use the fact that in equilibrium $v_{nt} = (\widetilde{e}_t/\bar{e})^{\eta_e}$. Also, since in equilibrium $\widetilde{e}_t = \mathbf{J}_{vt}$, we can write $v_{nt} = (\widetilde{e}_t/\bar{e})^{\eta_e} = (\mathbf{J}_{vt}/\bar{e})^{\eta_e}$.

C.7 Equilibrium Conditions

Taking the shock process $\{z_t, \eta_t, \varepsilon_t^i\}$ as given, the endogenous processes $\{c_t, k_t, i_t, n_{at}, n_{it}, n_{pt}\}$ and $\{s_t, v_t, v_{nt}, \widetilde{e}_t, \widetilde{a}_t, \widetilde{\zeta}_t, \widetilde{b}_t, \mathbf{J}_{at}, \mathbf{J}_{it}, \mathbf{J}_{vt}, \mathbf{W}_{at}, \mathbf{W}_{it}, q_{at}, q_{bt}, q_{rt}, \theta_t, f_t, q_t, u_t, y_t, mc_t, \lambda_t, l_t, w_t, R_t, i_t, \pi_t\}$

satisfy the following equilibrium conditions

$$n_{at} = q_{bt}(1 - q_{at})n_{at-1} + q_{bt}q_{rt}n_{it-1} + m(s_t, v_t) \tag{44}$$

$$n_{it} = (1 - q_{rt})q_{bt}n_{it-1} + q_{at}q_{bt}n_{at-1} \tag{45}$$

$$n_{pt} = 1 - n_{at} - n_{it} \tag{46}$$

$$s_t = 1 - q_{bt}(n_{it-1} + n_{at-1}) \tag{47}$$

$$v_t = (1 - \rho_v)(1 - q_{t-1})v_{t-1} + (q_{bt}q_{at} + (1 - q_{bt}))n_{at-1} + v_{nt}, \tag{48}$$

$$\theta_t = \frac{v_t}{s_t} \tag{49}$$

$$f_t = \frac{m(s_t, v_t)}{s_t} \tag{50}$$

$$q_t = \frac{m(s_t, v_t)}{v_t} \tag{51}$$

$$u_t = 1 - n_{at} \tag{52}$$

$$\mathbf{W}_{at} = w_t - \chi_u + E_t\Xi_{t+1|t}\, q_{bt+1}\left\{(1 - q_{at+1} - f_{t+1})\mathbf{W}_{at+1} + q_{at+1}\mathbf{W}_{it+1}\right\} \tag{53}$$

$$\mathbf{W}_{it} = \chi_i + E_t\Xi_{t+1|t}\, q_{bt+1}\{(q_{rt+1} - f_{t+1})\mathbf{W}_{at+1} + (1 - q_{rt+1})\mathbf{W}_{it+1}\} \tag{54}$$

$$\mathbf{J}_{vt} = -\gamma + q_t \mathbf{J}_{at} + (1-\rho_v)(1-q_t)\mathbb{E}_t\{\Xi^j_{t+1|t}\mathbf{J}_{vt+1}\} \tag{55}$$

$$\begin{aligned}
\mathbf{J}_{at} = &-\lambda_t \eta_w w_t + mc_t z_t f_n(k_t, n_{at}) - w_t \\
&+ \mathbb{E}_t \Xi^j_{t+1|t}\{q_{bt+1}\left[\left(\frac{\eta_a}{1+\eta_a}\right) q_{at+1}\widetilde{a}_{t+1} - \left(\frac{\eta_b}{1+\eta_b}\right) q_b \widetilde{b}_t - \chi_p\right] \\
&+ \left(q_{bt+1}q_{at+1} + (1-q_{bt+1})\right)\mathbf{J}_{vt+1} + q_{bt+1}\left[(1-q_{at+1})\mathbf{J}_{at+1} + q_{at+1}\mathbf{J}_{it+1}\right]\}
\end{aligned} \tag{56}$$

$$\begin{aligned}
\mathbf{J}_{it} = &-\chi_i + \mathbb{E}_t \Xi^j_{t+1|t} q_{bt+1}\{-\left(\frac{\eta_r}{1+\eta_r}\right) q_{rt+1}\widetilde{\zeta}_{t+1} - \left(\frac{\eta_b}{1+\eta_b}\right)\widetilde{b}_{t+1} \\
&+ q_{rt+1}\mathbf{J}_{at+1} + (1-q_{rt+1})\mathbf{J}_{it+1}\}
\end{aligned} \tag{57}$$

$$\begin{aligned}
w_t - \chi_u + E_t \Xi_{t+1|t}\, q_{bt+1}\left\{(1-q_{at+1}-f_{t+1})\left(\frac{\phi}{1-\phi}\right)(\mathbf{J}_{at+1} - \mathbf{J}_{vt+1}) + q_{at+1}\mathbf{W}_{it+1}\right\} \\
= \left(\frac{\phi}{1-\phi}\right)(\mathbf{J}_{at} - \mathbf{J}_{vt})
\end{aligned} \tag{58}$$

$$\widetilde{e}_t = \mathbf{J}_{vt} \tag{59}$$

$$\widetilde{a}_t = \mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt} \tag{60}$$

$$\begin{aligned}
\widetilde{b}_t = &\left[(1-q_{at})(\mathbf{J}_{at} - \mathbf{J}_{it} - \mathbf{J}_{vt}) + \left(\frac{\eta_a}{1+\eta_a}\right) q_{at}\widetilde{a}_t\right]\left(\frac{n_{at-1}}{n_{at-1}+n_{it-1}}\right) \\
&+ \left[q_{rt}(\mathbf{J}_{at} - \mathbf{J}_{it}) - \left(\frac{\eta_r}{1+\eta_r}\right) q_{rt}\widetilde{\zeta}_t\right]\left(\frac{n_{it-1}}{n_{at-1}+n_{it-1}}\right) + \mathbf{J}_{it}
\end{aligned} \tag{61}$$

$$\widetilde{\zeta}_t = \mathbf{J}_{at} - \mathbf{J}_{it} \tag{62}$$

$$q_{at} = \left(\frac{\widetilde{a}_t}{\bar{a}}\right)^{\eta_a} \tag{63}$$

$$q_{bt} = \left(\frac{\widetilde{b}_t}{\bar{b}}\right)^{\eta_b} \tag{64}$$

$$q_{rt} = \left(\frac{\widetilde{\zeta}_t}{\bar{\zeta}}\right)^{\eta_r} \tag{65}$$

$$v_{nt} = \left(\frac{\widetilde{e}_t}{\bar{e}}\right)^{\eta_e} \tag{66}$$

$$1 - \lambda_t \eta_t = \mathbb{E}_t \Xi^j_{t+1|t} \{ mc_{t+1} z_{t+1} f_k(k_{t+1}, n_{at+1}) + 1 - \delta \} \tag{67}$$

$$\begin{aligned} y_t = {} & c_t + i_t + \gamma v_t + \left(\frac{\eta_e}{1+\eta_e}\right) \mathbf{J}_{vt} v_{nt} + (n_{at-1} + n_{it-1}) \left(\frac{\eta_b}{1+\eta_b}\right) q_{bt} \widetilde{b}_t \\ & - q_{bt} n_{at-1} \left(\frac{\eta_a}{1+\eta_a}\right) q_{at} \widetilde{a}_t + q_{bt} n_{it-1} \left(\frac{\eta_r}{1+\eta_r}\right) q_{rt} \widetilde{\zeta}_t + \frac{\psi}{2} \pi_t^2 \end{aligned} \tag{68}$$

$$\begin{aligned} c_t^i = {} & z_t f(k_t, n_{at}) - w_t n_{at} - \gamma v_t - \chi_i n_{it} - \chi_p n_{at-1}(1 - q_{bt}) - i_t + l_t - R_{t-1} l_{t-1} - \left(\frac{\eta_e}{1+\eta_e}\right) \mathbf{J}_{vt} v_{nt} \\ & + q_{bt} n_{at-1} \left(\frac{\eta_a}{1+\eta_a}\right) q_{at} \widetilde{a}_t - (n_{at-1} + n_{it-1}) \left(\frac{\eta_b}{1+\eta_b}\right) q_{bt} \widetilde{b}_t - q_{bt} n_{it-1} \left(\frac{\eta_r}{1+\eta_r}\right) q_{rt} \widetilde{\zeta}_t \end{aligned} \tag{69}$$

$$\mu_t = \frac{1}{c_t - \phi_c c_{t-1}} + \beta \phi_c E_t \frac{1}{c_{t+1} - \phi_c c_t} \tag{70}$$

$$1 = \beta R_t E_t \frac{\mu_{t+1}}{\mu_t} \frac{1}{1 + \pi_{t+1}} \tag{71}$$

$$1 - \lambda_t R_t = \mathbb{E}_t \Xi^j_{t+1|t} R_t \tag{72}$$

$$(1 - \epsilon + \epsilon mc_t) \, y_t - \psi \, (1 + \pi_t) \, \pi_t + \mathbb{E}_t \Xi^j_{t+1|t} \, \psi \, (1 + \pi_{t+1}) \, \pi_{t+1} = 0 \tag{73}$$

$$i_t = \mathbb{E}_t R_t \pi_{t+1} \tag{74}$$

$$\frac{i_t}{i} = \left(\frac{i_{t-1}}{i} \right)^{\rho_m} \left[\left(\frac{1 + \pi_t}{1 + \pi} \right)^{\delta_\pi} \left(\frac{y_t}{y} \right)^{\delta_y} \right]^{1-\rho_m} \varepsilon^i_t, \tag{75}$$

$$y_t = z_t f(k_t, n_{at}) \tag{76}$$

$$k_{t+1} = (1 - \delta) k_t + i_t, \tag{77}$$

$$R_t l_t + \eta_w w_t n_{at} = \eta_t k_{t+1} \tag{78}$$

C.8 Summary of Model Parameters and Endogenous Variables

Table 4: Benchmark Model Parameter

Parameter	Definition/Notes
α	Capital share
β	Subjective discount factor for household
β^j	Subjective discount factor for intermediate firms
δ	Capital depreciation rate
ϕ_c	Consumption habit parameter
ξ	Matching elasticity
ϕ	Worker bargaining power
ϵ	Substitution elasticity
ψ	Price adjustment cost parameter
e	Fixed cost associated with recruiting process
	Drawn from i.i.d. distribution $F(e)$
γ	Flow cost of vacancy posting
a	Saved resources from placing worker on temporary layoff
	Drawn from i.i.d. distribution $H(a)$
b	Saved resources from placing worker on permanent layoff
	Drawn from i.i.d. distribution $G(b)$
ξ	Fixed cost of recalling worker on temporary layoff back to firm
	Drawn from i.i.d. distribution $R(\xi)$
ρ_v	Exogenous rate of decay of unfilled vacancies
δ_y	The parameter of response to output gap
δ_π	The parameter of response to inflation
χ_i	Benefits provided by firm to workers on temporary layoff
χ_u	Unemployment insurance benefits
η_a	Uniform Distribution for H
η_b	Uniform Distribution for G
η_r	Uniform Distribution for R
η_e	Uniform Distribution for F
η_w	Fraction of wage bill that firms need to finance with borrowed funds
$\bar{a}$	Scaling parameter, H distribution
$\bar{b}$	Scaling parameter, G distribution
$\bar{\zeta}$	Scaling parameter, R distribution
$\bar{e}$	Scaling parameter, F distribution

Table 5: Endogenous Variables in Benchmark Model

Variable Name	**Definition/Notes**
c_t	Consumption
k_t	Capital accumulation
i_t	Investment
n_{at}	Active employment
n_{it}	Workers on temporary layoff
n_{pt}	Workers on permanent layoff (job searchers)
y_t	Total output
w_t	Nash-bargained real wage
$\mathbf{W}_{at}$	Net value to household of having a member in active employment
$\mathbf{W}_{it}$	Net value to household of having a member on temporary layoff
mc_t	Real price of intermediate goods/marginal cost of final-goods firms
v_t	Total job vacancies
v_{nt}	New job vacancies
$\mathbf{J}_{at}$	Value of having an active worker for intermediate-goods firm
$\mathbf{J}_{it}$	Value of having an inactive worker for intermediate-goods firm
$\mathbf{J}_{vt}$	Value of a vacancy for intermediate-goods firm
$\widetilde{e}_t$	Threshold level of e below which firm opens a new vacancy
$\widetilde{\zeta}_t$	Threshold level of ζ below which firm brings worker back from temporary layoff
$\widetilde{a}_t$	Threshold level of a below which firm places active worker on temporary layoff
$\widetilde{b}_t$	Threshold level of b below which firm lays off active worker permanently
q_{at}	Endogenous probability of temporary layoff
q_{bt}	Endogenous probability of permanent layoff
q_{rt}	Endogenous probability that firm brings worker back from temporary layoff
P_t	Price level
$P_{j,t}$	Optimal price of intermediate firm j
l_t	Borrowed funds
R_t	Real interest rate
λ_t	Multiplier on collateral constraint
π_t	Inflation rate
θ_t	Market tightness
f_t	Job finding rate
q_t	Job filling rate
u_t	Unemployment
z_t	Productivity level
η_t	Borrow capacity