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Euiyoung JUNG[*]

Abstract

This paper analyzes the optimal cyclical behavior of labor market policies in an economy with asset and labor market frictions. The policies of interest include unemployment insurance (UI) and employment protection (EP). In addition to their supply-side effects, labor market policies affect the aggregate demand via earning risk and redistribution channels. Under bilateral wage bargaining, I find that procyclical UI and countercyclical EP deliver superior welfare outcomes through stabilization via both supply and demand channels.

Keywords: New Keynesian, Uncertainty, Unemployment, Incomplete markets, Labor market policy
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1 Introduction

Policymakers use labor market policies as economic stabilizers. For instance, the experience-rating system in the United States, which links employers' social security contribution to their layoff history, essentially serves as countercyclical employment protection that dampens employment fluctuations. In addition, the US government has extended unemployment insurance benefits in response to almost all major recessions. In particular, unemployment benefits in the United States were extended to an unprecedented extent during the Great Recession of 2008. Recently, the Coronavirus Aid, Relief, and Economic Security (CARES) Act enabled the federal government to provide extended unemployment insurance to workers impacted by the COVID-19 pandemic, including workers who would not ordinarily qualify for unemployment benefits.

Although labor market policies are actively adjusted in response to business cycle fluctuations, few studies have focused on the macroeconomic implications of cyclical labor market policy accommodations. Recent findings in macroeconomics stress that stabilization policy has asymmetric impacts on heterogeneous agents, whose demand responses to policy adjustments can be an important source of endogenous (de)stabilization[1]. Because labor market policies crucially affect resource and risk allocation across heterogeneous agents over business cycles, the lesson implies that a policymaker adapting labor market programs should consider how policies affect aggregate demand in addition to conventional issues, such as the insurance-incentive tradeoff for unemployed workers and firm behavior in response to labor market policy adjustments. This paper aims to analyze the macroeconomic implications of cyclical labor market policies when these policies influence aggregate demand via redistribution and earning risk channels.

To this end, I build a model associated with the following frictions: an incomplete asset market in the absence of large family insurance, labor market search and matching frictions, endogenous job destruction, convex hiring costs, and nominal price rigidity. The labor market policies of interest consist of two central components of the modern labor market program: unemployment insurance (UI) and employment protection (EP).

[1] For example, one can refer to Werning (2015), McKay and Reis (2016), Ravn and Sterk (2016, 2017), Auclert (2019), and Bilbiie (2018, 2019).

Agents determine wages according to Nash bargaining. The general equilibrium interactions across market frictions endogenously (de)stabilize the economy. Concretely, asset market friction hinders households from insuring themselves against unemployment risk. As a result, households face different unemployment risks and income outlooks depending on their employment status, yielding heterogeneous marginal propensities to consume (MPCs) across agents. Moreover, households have an incentive to engage in precautionary saving against unemployment risk, which might endogenously amplify the impact of business cycle shocks as stressed in the literature[2]. Price rigidity induces demand-side responses to influence the supply-side over business cycles. On the other hand, supply-side reactions to business cycle shocks or policy adjustments also affect aggregate demand by influencing households' precautionary saving incentives and reallocating resources across heterogeneous agents. Consequently, endogenous feedback between supply and demand sides can dampen or amplify business cycle fluctuations, affecting the welfare of risk-averse households.

General equilibrium interactions between supply and demand sides in the face of cyclical policy reactions represent the key policy issue analyzed in this study. Based on a model economy calibrated to the U.S. labor market, I first compute the output multipliers of policy adjustments to clarify the impact of labor market policy adjustments on the supply and demand sides. After that, I numerically characterize the optimal cyclical behavior of labor market policies using the computation method in Schmitt-Grohe and Uribe (2007).

The key findings include the following. First, generous UI is generally harmful under bilateral wage bargaining. UI extension raises workers' reservation wages by raising their outside options (*outside option effect*). In addition, an increase in unemployment generates double externalities on government financing: total UI spending increases while the tax base diminishes. Each worker is liable for a higher tax, which induces them to insist on higher wages during wage bargaining to compensate for their income loss (*fiscal increasing return effect*). These effects reinforce each other and generate labor cost pressure that substantially reduces labor demand (*job destruction effect*). As UI extension reduces la-

[2] Werning (2015), Ravn and Sterk (2017), Den Haan et al. (2018).

bor demand, UI needs to be adjusted procyclically to stabilize employment [3], resulting in welfare gains from stabilization. However, excessively procyclical UI interrupts efficient labor allocation across business cycles by providing too much (too little) incentive to provide jobs during recessions (expansions). Thus, UI should be moderately procyclical to reconcile production efficiency with stabilization.

One may speculate that countercyclical UI stabilizes the economy because unemployment benefits financed by a tax on workers raise aggregate demand by reallocating resources from agents with a lower MPC (i.e., workers) to those with a higher MPC (i.e., unemployed households). In addition, countercyclical UI might efficiently dampen households' countercyclical precautionary saving demand against unemployment risk. If these positive demand effects dominate, UI should be structurally generous or adjusted countercyclically, as suggested by McKay and Reis (2016) and Kekre (2018). The job destruction effect overturns all these mechanisms. Procyclical UI can even yield more stabilizing or less destabilizing demand feedback over business cycles than countercyclical UI. Concretely, UI redistribution from workers to unemployed households can be contractionary, as it generates upward pressure on labor costs under wage bargaining, thereby reducing aggregate demand by increasing unemployment in equilibrium. In addition, the expected UI extension can even stimulate precautionary saving demand against unemployment risk because workers find unemployment more likely and prolonged as labor demand declines in response to the labor cost pressure caused by UI extension. Thus, when the government adjusts UI procyclically, there is no policy tradeoff between aggregate demand and supply stabilization as long as agents determine wages according to bilateral bargaining. Indeed, the adverse impact of UI on labor demand through its impact on labor cost has been stressed in several studies [4]. The current paper, however, suggests a policy implication that is stronger than that proposed in prior works: although policymakers are concerned about the potentially expansionary demand-side effects that may be brought about by UI expansion, procyclical UI is more efficient for stabilization through both supply and demand channels.

[3]Procyclical UI involves reducing (raising) UI benefits during recessions (expansions).

[4]Krusell et al. (2010), Hagedorn et al. (2013), Mitman and Rabinovich (2015, 2019), and Jung and Kuester (2015).

When workers have high wage bargaining power and are minimally liable for financing countercyclical government spending, countercyclical UI may enhance welfare despite bilateral wage bargaining. In this case, countercyclical UI results in stabilizing demand feedback over business cycles, as suggested in the previous literature. Nonetheless, the welfare gains generated by countercyclical UI are still primarily derived from the appropriate extent of the job destruction effect, which improves production efficiency by facilitating efficient labor reallocation over business cycles. More generally, I find that procyclical UI and countercyclical EP are more likely to be desirable when wages are affected by worker surplus and by procyclical fluctuations in workers' other income sources. Countercyclical UI and procyclical EP may be preferable only when wage determination barely relies on these factors.

The other policy of interest, i.e., EP, is measured in this study by the separation cost that firms must pay when firing incumbent workers. EP not only dampens layoffs but also discourages hiring because firms internalize future spending upon separation when making hiring decisions. Moreover, EP impedes worker reallocation from low- to high-productivity jobs. Thus, the optimal cyclical behavior of EP crucially depends on the relative size of the general equilibrium elasticity of job creation and destruction to separation cost. Under bilateral wage bargaining, I observe that EP has a larger impact on the incentive of firms to fire than to hire. Namely, a marginal relaxation of EP leads to more jobs being destroyed than created. Therefore, countercyclical EP [5] dampens employment and output fluctuations by moderating countercyclical fluctuations in layoffs, despite amplified procyclical fluctuations in vacancies and inefficient worker reallocation.

Under countercyclical EP, workers find that they are less likely to lose employment during recessions. As the labor market tightens due to larger decreases in inflows to unemployment than in vacancies, each job seeker is also more likely to secure employment than under procyclical EP. As a result, countercyclical EP leads to more stabilizing demand feedback by dampening countercyclical precautionary saving demand. Therefore, countercyclical EP stabilizes the economy through both supply and demand channels, yielding higher welfare. An increase in unemployment (and unemployment risk) produces an ex-

[5] Countercyclical EP involves raising (reducing) layoff costs during recessions (expansions).

ternality that generates destabilizing demand feedback while inducing further increases in unemployment due to the labor cost pressure from fiscal expansion and the disincentive to search for jobs. Countercyclical EP acts as a cyclical Pigouvian tax in this circumstance, inducing firms to internalize such social costs of unemployment (Blanchard and Tirole 2008).

An interesting implication of the current study is that the Keynesian stabilizing mechanism through redistribution can break down under bilateral wage bargaining. Redistribution that reduces workers' income induces workers to demand higher wages to compensate for their income loss. Unemployment can then rise as firms respond to labor cost pressure by reducing their labor demand, resulting in a decline in aggregate demand in equilibrium. This supply-side externality can cause redistribution from workers to agents in an economy with higher MPCs to be contractionary.

Related literature

This paper belongs to the vast body of macroeconomic literature exploring labor market policies. Based on a Bewley-Huggett-Aiyagari incomplete market model with labor market friction, Krusell et al. (2010) highlight that the job destruction effect is generally a significant factor in the welfare impact of UI. Differing from Krusell et al., I rule out time-varying household wealth heterogeneity and instead analyze UI policy in a New-Keynesian economy in which supply-demand feedback is relevant. Mitman and Rabinovich (2015) investigate optimal cyclical UI adjustment in a search model with risk-averse agents. They find that optimal UI should be procyclical overall due to the job destruction effect, although UI needs to increase at the beginning of recessions when the welfare gain from the UI insurance effect dominates the cost of distorting firm entry. Jung and Kuester (2015) study optimal labor market policies over business cycles in a similar environment. They stress that UI alone should be procyclical due to the job destruction effect. If the government can implement countercyclical layoff taxes and vacancy subsidies, however, UI should be countercyclical to provide insurance. Landais et al. (2010) stress that generous UI provision is detrimental if the job destruction effect is potent while the labor market is inefficiently slack. In contrast, if UI extension lessens inefficient competition for a limited number of jobs in the labor market, generous UI can improve welfare. Although these works all highlight the job destruction effect as a critical driver of the welfare outcomes of UI, they neglect the impact of UI on the demand-side and do not address the general equilibrium interactions between the supply and demand-side effects of UI. This paper shows that generous UI during recessions can be harmful due to the job creation effect even though we take into account the insurance and redistribution effects of UI.

The works of McKay and Reis (2016) and Kekre (2018) are useful counterparts to this paper. McKay and Reis (2016) analyze unemployment insurance and progressive income taxes as automatic stabilizers in an economy where supply-demand feedback is relevant. Because UI is a targeted transfer to households with higher MPCs and efficiently dampens destabilizing precautionary saving demand responses, they stress that ex-ante generous UI can be an efficient automatic stabilizer. Kekre (2018) notes a similar mechanism using a Heterogeneous Agents New Keynesian (HANK) model. Similar to previous authors, he proposes countercyclical UI adjustments to attain higher welfare via stabilizing demand feedback. He emphasizes that countercyclical UI can be particularly efficient if the monetary authority faces a zero lower bound on nominal interest rates. The positive demand effects of UI in these papers build upon the wage-setting assumption that restricts the adverse impact of UI on labor demand. Alternatively, this paper shows that UI expansion under bilateral wage bargaining may neither undermine precautionary saving demand nor generate expansionary demand effects through Keynesian redistribution.

Bentolila and Bertola (1990) find that employment protection has a larger impact on firms' incentives to fire than to hire. Thus, strict employment protection raises employment in the long run. In contrast, Hopenhayn and Rogerson (1993) find that the separation cost has a sizable negative impact on total employment due to its disincentive effect on hiring and reduces welfare as workers' average productivity decreases. Cahuc et al. (2019) study the detrimental impact of EP on employment in a dual labor market. Blanchard and Tirole (2008) study optimal labor market institutions in a static search and matching model with risk-averse agents. These authors find that when UI is incomplete, EP is a partial substitute for social insurance. Michau (2015) stresses that layoff taxes should balance the tradeoffs between production efficiency and their Pigouvian tax role in remedying externalities from loosened EP. Regarding the impact of costly separation on macroeconomic dynamics, Den Haan, Ramey, and Watson (2000) highlight an amplification process through an interaction between capital adjustment and endogenous job destruction. Thomas (2006) and Zanetti (2011) note that an increase in the separation cost reduces economic volatility because it decreases the number of marginal workers that are sensitive to firms' separation decisions. By extending the existing studies concerning endogenous job destruction, I examine the impact of employment protection in an economy where endogenous supply-demand feedback is relevant.

This paper aligns with the recent HANK literature concerning the destabilizing mechanism stemming from uninsured earnings risk and the ensuing countercyclical precautionary saving demand responses. Werning (2015) notes that precautionary saving demand against countercyclical earning risks can result in a destabilizing mechanism. Ravn and Sterk (2016, 2017) highlight the destabilizing mechanism in a New-Keynesian economy with frictional asset and labor markets. These authors show that when households cannot adequately insure themselves against unemployment risk due to asset market friction, countercyclical saving demand can result in a powerful destabilizing mechanism. Similarly, Den Haan et al. (2018) stress that interactions between incomplete markets and sticky nominal wages magnify business cycle fluctuations by destabilizing supply-demand feedback driven by precautionary behavior. Challe (2019) studies optimal monetary policy in this type of economy. Although previous findings emphasize the detrimental impact of countercyclical unemployment risk, no scholars have completely endogenized unemployment risk, particularly job separation dynamics. I incorporate costly separation and idiosyncratic productivity shocks, thus completely endogenizing unemployment risk. The findings of a companion study conducted by Jung (2020) indicate that allowing endogenous job destruction leads to a nontrivial difference in the magnitude of the destabilizing effect of countercyclical precautionary saving demand.

This paper is organized as follows. Section 2 describes the model. Section 3 discusses calibration. Section 4 investigates the output stimulus of labor market policies. Section 5 analyzes the optimal cyclical behavior of labor market policies. Section 6 examines the robustness of the policy implications. Section 7 concludes.

2 The Model

2.1 Final good producer

A representative firm produces a final good in a competitive market. The sector combines intermediate goods according to the production function given by

$$Y_t = \left[\int_0^1 Y_t(z)^{\frac{\eta-1}{\eta}} dz \right]^{\frac{\eta}{\eta-1}}$$

where $Y_t(z)$ is the input of the zth intermediate good, and η denotes the elasticity of substitution. The representative producer takes the final good price P_t as given and pays $P_t(z)$ for the z th input good. The optimal decision of the representative producer yields

$$Y_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\eta} Y_t \tag{1}$$

$$P_t = \left[\int_0^1 P_t(z)^{1-\eta} dz \right]^{\frac{1}{1-\eta}} \tag{2}$$

The first equation is a demand function of an input good $Y_t(z)$ produced by a firm z that sets the nominal price of the good at $P_t(z)$. The second equation describes the aggregate price index implied by the zero-profit condition.

2.2 Intermediate good producers

2.2.1 Environment

A unit continuum of risk-neutral entrepreneurs manages firms that produce intermediate goods in a monopolistic-competitive market. In addition to monopolistic competition, entrepreneurs face the following series of frictions: Rotemberg nominal price adjustment costs, labor market matching friction, costly job destruction, and convex hiring costs. Profits are taxable, and workers might qualify for profit dividends according to their untradeable and exogenously granted stakes in firms. Entrepreneurs consume net profits after paying out profit dividends, lump-sum corporate tax, and production costs. Risk-neutral entrepreneurs discount future surplus from ongoing matches by the constant discount rate instead of the stochastic discount factor endogenously determined by households' saving demand. Although saving demand does not directly affect inter-temporal labor allocation through the discount rate channel, it still affects labor demand through the price channel.

A firm possesses many matches, and each match is subject to a *match-specific* idiosyncratic productivity shock. The idiosyncratic productivity shock is *i.i.d.* in the sense that (a) productivity is newly drawn in each period from the time-invariant distribution with the cumulative distribution function $F(a)$ defined over $(0, \infty)$ and density function $F'(a)$, and (b) the idiosyncratic productivity of each match is not autocorrelated.

I assume that risk-neutral entrepreneurs provide insurance to risk-averse workers against the wage dispersion caused by idiosyncratic productivity shocks. Hence, wages are homogeneous regardless of the heterogeneous productivity across matches.

2.2.2 The labor market

A unit mass of households is either employed (n_t) or unemployed (u_t). The labor market has a Diamond-Mortensen-Pissarides (DMP) structure. The matching technology is specified as[6]

$$M_t = \frac{\widetilde{u}_t v_t}{(\widetilde{u}_t^{\gamma} + v_t^{\gamma})^{\frac{1}{\gamma}}} \tag{3}$$

Here, v_t and $\widetilde{u}_t$ represent the number of vacancies and the effective number of job seekers, respectively. The matching function exhibits constant returns to scale and strict concavity and is strictly increasing in both arguments. Labor market tightness is defined as

$$\theta_t \equiv \frac{v_t}{\widetilde{u}_t} \tag{4}$$

Job seekers endogenously determine the job search intensity. As explained in more detail later, job seekers are all symmetric in equilibrium. Hence, the effective number of job

[6]The matching function specification ensures that the job finding probability per unit of effort, $\frac{M_t}{\widetilde{u}_t}$, and the match finding rate, $\frac{M_t}{v_t}$, are always strictly less than 1. The commonly used alternative (i.e., the Cobb-Douglas matching function) does not necessarily guarantee these properties.

seekers can be written as

$$\widetilde{u}_t = s_t(u_{t-1} + F_t n_{t-1}) \tag{5}$$

where s_t denotes the job search intensity, and $u_{t-1} + F_t n_{t-1}$ indicates the number of job seekers at the beginning of period t. In particular, I assume that incumbent workers whose match-specific idiosyncratic productivity is low at the beginning of each period lose their jobs. However, discharged workers can participate in the labor market and be reemployed immediately. Allowing laid-off workers to find jobs during the same layoff period prevents the problematic time aggregation bias noted by Shimer (2012). Given the job finding probability per unit of effort f_t, a job seeker exerting search effort s_t could find a job with probability $f_t s_t$. Thus, the law of motion of unemployment can be written as

$$u_t = (1 - f_t s_t)(u_{t-1} + F_t n_{t-1}) \tag{6}$$

$F_t = F(\bar{a}_t)$ is the separation rate of incumbent workers in period t. All matches, including newly formed matches, are subject to idiosyncratic productivity shocks. Firms dissolve unproductive new matches before launching production. Thus, the job finding probability per unit of effort (f_t) and the vacancy filling rate (q_t) depend on the idiosyncratic productivity level of separation threshold for new matches and labor market tightness:

$$q_t = \frac{M_t}{v_t}(1 - \widehat{F}_t) \tag{7}$$

$$f_t = \frac{M_t}{\widetilde{u}_t}(1 - \widehat{F}_t) \tag{8}$$

$\widehat{F}_t = F(\widehat{a}_t)$ is the separation rate of new matches. The match finding rate $\tilde{q}_t = \frac{M_t}{v_t}$ is distinct from the vacancy filling rate q_t.

2.2.3 The entrepreneur's optimal decisions: The environment

Employment requires full-time work, implying that labor is adjusted over business cycles only through the extensive margin. As an entrepreneur manages many matches, idiosyncratic productivity across matches is well distributed in each firm. That is, if a firm employs n_t matches, it has $F'(a)n_t$ matches with an idiosyncratic productivity level of a.

In many countries, employment protection legislation tends to impose stricter regulations on the dismissal of workers with open-ended contracts, while new entrants to the labor market or temporary workers are likely to have looser protections. Thus, I assume that employment protections are asymmetric between new employees and incumbent workers: entrepreneurs can dissolve new matches without paying a separation cost, but the dismissal of incumbent workers incurs a strictly positive separation cost, i.e., $\Omega_{N,t} = 0$ and $\Omega_{I,t} = \Omega_t > 0$, respectively. The separation cost represents the intensity of employment protection in this economy. The separation cost is purely wasteful production costs, and neither severance payments to laid-off workers nor layoff taxes to the government exist. Nonetheless, the findings of the current study are robust under these redistributions.

Following Yashiv (2006, 2007), I assume that recruitment is subject to convex costs in the vacancy-employment rate. The convex hiring cost is motivated by a growing body of empirical findings such that (a) recruitment incurs considerable indirect costs due to training or inefficient labor utilization, and (b) the marginal hiring cost tends to diminish as the firm size grows [7]. The convex hiring cost assumption improves the empirical relevance of the model economy by producing a strongly negative sloped Beveridge locus. Similarly, the findings are robust to the inclusion of this additional friction.

2.2.4 The entrepreneur's problem

Each firm is small enough to take as given the match finding rate, $\tilde{q}_t$. The wage is determined according to Nash bargaining. The risk-neutral entrepreneur's problem can be described recursively. The value function of an entrepreneur i is written as

$$\begin{aligned} V(n_{t-1}(i), p_{t-1}(i)|\mathbf{S_t}) = \max_{\mathbf{x_t(i)}} & \left(\frac{p_t(i)}{P_t}\right) y_t(i) - \Omega_{I,t} F(\bar{a}_t(i)) n_{t-1}(i) - \Omega_{N,t} F(\widehat{a}_t(i)) \tilde{q}_t v_t(i) - w_t n_t(i) \\ & - \frac{\kappa}{1+\nu}\left(\frac{v_t(i)}{n_t(i)}\right)^{1+\nu} Y_t - \frac{\Psi}{2}\left(\frac{p_t(i)}{p_{t-1}(i)} - 1\right)^2 Y_t - (1-\alpha)T_t - D_t \\ & + \beta E_t[V(n_t(i), p_t(i)|\mathbf{S_{t+1}})] \end{aligned}$$

[7] See Yashiv (2006, 2007), Merz and Yashiv (2007), Blatter et al. (2016), and Faccini and Yashiv (2016).

subject to

$$[\mu_t(i)] : y_t(i) = A_t \left[n_{t-1}(i) \int_{\bar{a}_t(i)} a dF(a) + \tilde{q}_t v_t(i) \int_{\widehat{a}_t(i)} a dF(a) \right]$$

$$[\zeta_t(i)] : y_t(i) \geq \left(\frac{p_t(i)}{P_t} \right)^{-\eta} Y_t$$

$$[\lambda_t(i)] : n_t(i) = (1 - F(\bar{a}_t(i)))n_{t-1}(i) + (1 - F(\widehat{a}_t(i)))\tilde{q}_t v_t(i)$$

where β is the subjective discount rate, which is common across agents. $\mathbf{S_t}$ denotes the vector of exogenous state variables. $\mathbf{x_t(i)} = [p_t(i), \bar{a}_t(i), \widehat{a}_t(i), n_t(i), v_t(i), y_t(i)]$ is the set of choice variables of entrepreneur i. $(1-\alpha)T_t$ is the lump-sum tax, and D_t is the total profit dividends paid to households. A_t represents the aggregate technology shock. The variables in the square brackets denote the Lagrange multipliers attached to each constraint. Because firms are symmetric in equilibrium, we can obtain the following conditions:

$$\Psi(\Pi_t - 1)\Pi_t = 1 - \eta + \eta\mu_t + \beta E_t \left[\Psi(\Pi_{t+1} - 1)\Pi_{t+1} \frac{Y_{t+1}}{Y_t} \right] \tag{9}$$

$$\lambda_t = w_t - \kappa \left(\frac{v_t}{n_t} \right)^{1+\nu} \frac{Y_t}{n_t} - \beta E_t \left[(1 - F_{t+1})(\mu_{t+1} A_{t+1} \int_{\bar{a}_{t+1}} a \frac{dF(a)}{1 - F_{t+1}} - \lambda_{t+1}) - F_{t+1}\Omega_{t+1} \right] \tag{10}$$

$$\kappa \left(\frac{v_t}{n_t} \right)^{\nu} \frac{Y_t}{n_t} = \tilde{q}_t (1 - \widehat{F}_t)(\mu_t A_t \int_{\widehat{a}_t} a \frac{dF(a)}{1 - \widehat{F}_t} - \lambda_t) \tag{11}$$

$$\mu_t A_t \bar{a}_t - \lambda_t = -\Omega_t \tag{12}$$

$$\mu_t A_t \widehat{a}_t - \lambda_t = 0 \tag{13}$$

Equation (9) is the Phillips curve under Rotemberg quadratic price adjustment costs. The non-negative parameter Ψ denotes quadratic price adjustment costs, implying that prices are fully flexible if $\Psi = 0$ and rigid otherwise. μ_t indicates the real marginal cost of production, which equals the real marginal revenue from production in equilibrium.

Equation (10) decomposes the components of the *shadow cost of labor* λ_t. Employment incurs payroll costs w_t, but each match yields intangible benefits due to labor market frictions. On the one hand, employment reduces marginal hiring costs through the scale effect in the job creation margin, which is captured by the second term. On the other hand, each match has a continuation value due to labor market matching friction, which is captured by the expectation term. In period *t+1*, a firm declares separation and pays the separation cost if a match is revealed to be unproductive with probability F_{t+1}. With probability $1 - F_{t+1}$, a firm obtains a net match surplus, $\mu_{t+1} A_{t+1} \frac{\int_{\bar{a}_{t+1}} a dF(a)}{1-F_{t+1}} - \lambda_{t+1}$. Notably, μ_t is the real marginal revenue from production, $A_t \frac{\int_{\bar{a}_t} a dF(a)}{1-F_t}$ is the conditional average productivity of incumbent workers, and λ_t is the shadow cost of labor. Hence, the continuation value is simply the expected net surplus from an ongoing match.

Equation (11) is the *job creation condition* under the convex hiring cost. The left-hand side describes the marginal cost of vacancy posting, while the right-hand side denotes the expected surplus from job creation. Although job creation is not directly affected by separation costs, employment protection indirectly influences incentives to create jobs through the expectation channel. Given other things, an increase in the expected separation cost reduces the continuation value of a match, pushing up the shadow cost of labor. An increase in the shadow cost of labor discourages recruitment because the surplus from job creation declines.

Equation (12) is the *job destruction condition for incumbent matches* and determines the threshold productivity for the separation of incumbent workers. The right-hand side is the separation cost, and the left-hand side accounts for the net surplus from a marginal match. If a match is subject to match-specific productivity lower than $\bar{a}_t$, a firm dissolves the match because the net surplus that firms can obtain is smaller than the separation cost. Equation (13) determines the marginal productivity of new matches. Because of homogeneous wages, firms require higher productivity from new entrants than existing worker if the separation cost is strictly positive. Thus, on average, newly formed matches are more productive than incumbent matches due to asymmetric employment protections.

Equations (11) to (13) show that the cost important for labor demand is the shadow cost of labor and not merely wages. In addition, the optimal conditions imply that households' saving demand affects the supply side through the real marginal revenue from production μ_t. The real interest rate is driven by how saving demand affects nominal interest rates and (expected) inflation in equilibrium. The firm's markups fluctuate in response to price pressure, yielding a shift in labor demand in equilibrium.

The law of motion of labor and the aggregate production function can be written as

$$n_t = (1-F_t)n_{t-1} + f_t s_t(u_{t-1} + F_t n_{t-1}) \tag{14}$$

$$Y_t = A_t\Big(n_{t-1}(1-F_t)\int_{\bar{a}_t} a\frac{dF(a)}{1-F_t} + M_t(1-\widehat{F}_t)\int_{\widehat{a}_t} a\frac{dF(a)}{1-\widehat{F}_t}\Big) \tag{15}$$

The aggregate production function shows that a firm can improve the average labor productivity by raising separation thresholds, but in turn, fewer matches would remain. Thus, an entrepreneur faces a tradeoff between the quantity and quality of labor.

2.3 Households

2.3.1 Environment

The periodic felicity of a household is determined by the standard constant relative risk aversion $(CRRA)$ utility function

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}$$

where the degree of risk aversion σ is strictly greater than 1, and c_t denotes the amount of consumption.

Risk-averse households might want to trade bonds. To maintain model tractability, I make the following two strong assumptions: households cannot accrue debt, and the government cannot issue bonds and strictly balances its budget each period. Because labor is the sole production factor in this economy, the bonds held by each household should be zero in equilibrium regardless of employment status. The equilibrium bond price should be adjusted to clear the asset market [8]. Although households cannot save in equilibrium, the real interest rate dynamics driven by households' saving demand are the key channel of supply-demand feedback.

Both working and job search yield disutility. The total amount of time is normalized

[8] This asset market specification is called the *maximally tight bond market* and is comprehensively analyzed by Krusell et al. (2011) and used in subsequent studies, such as Werning (2015), Ravn and Sterk (2017), McKay and Reis (2016), and Challe (2019).

to 1. Workers have to work full-time, yielding disutility h. The job search produces a welfare cost determined by function $h(s)$, where s indicates the amount of time allotted to job search activities. As in Mitman and Rabinovich (2015), the disutility function of job search effort is specified as[9]

$$h(s_t) = \frac{\Phi}{1+\varepsilon}[(1-s_t)^{-(1+\varepsilon)} - 1] - \Phi s_t$$

Based on the employment status at the beginning and end of the period, five types of heterogeneous households exist (see Table 1). Due to a degenerated wealth distribution and *i.i.d.* idiosyncratic productivity shocks, type 2 and type 4 working households are symmetric. Similarly, type 3 and type 5 unemployed households are symmetric. Type 1 workers differ from other working households because they do not look for a job.

Household type	End of $t-1$	Beginning of t	End of t
Type 1	Employed	No separation	Employed
Type 2	Employed	Separation and Job search	Employed
Type 3	Employed	Separation and Job search	Unemployed
Type 4	Unemployed	Job search	Employed
Type 5	Unemployed	Job search	Unemployed

Table 1: Types of heterogeneous households

The timing of household decision making is as follows. At the beginning of each period, job seekers determine their job search intensity given the job finding probability per unit of effort and the (expected) welfare at each employment status. The household employment status in period t is then settled. Finally, households that are heterogeneous in terms of their employment status make saving decisions.

[9]The functional specification ensures that the search effort is always strictly between 0 and 1.

2.3.2 Optimal decision of the employed household

The employed household in period t has the following value function:

$$
\begin{aligned}
&V^w(d^w_{t-1}|\mathbf{X_t}, 1_t, s_t) \equiv \max_{c_{w,t}, d^w_t} u(c_{w,t}) - h - h(s_t)1_t \\
&+ \beta E_t \Big[(1 - F_{t+1}) h(s_{t+1}) + (1 - F_{t+1} + F_{t+1} f_{t+1} s_{t+1}) V^w(d^w_t|\mathbf{X_{t+1}}, \mathbf{1}_{t+1} = 1) \\
&\qquad + F_{t+1}(1 - f_{t+1} s_{t+1}) V^u(d^w_t|\mathbf{X_{t+1}}) \Big]
\end{aligned}
$$

The optimal decision is subject to the budget constraint and the zero lower bound borrowing constraint

$$
\begin{aligned}
&c_{w,t} + \frac{d^w_t}{R_t} = w_t + \frac{d^w_{t-1}}{\Pi_t} - \widehat{T}_t + \widehat{D}^w_t \\
&d^w_t \geq 0
\end{aligned}
$$

$\mathbf{X_t}$ is a vector of the state variables. The indicator function 1_t has a value of one when the worker is unemployed at the beginning of period t and zero otherwise. d^w_t is a bond purchased by a worker in period t. $\widehat{T}_t$ and $\widehat{D}^w_t$ denote the amount of the lump-sum tax and profit dividends per worker, respectively. w_t is the real wage, and $c_{w,t}$ denotes consumption. The nominal bond price equals $\frac{1}{R_t}$, where R_t is the gross nominal interest rate of the one-period bond held from t to $t+1$.

2.3.3 Optimal decision of the unemployed household

The unemployed household in period t has the following value function:

$$
\begin{aligned}
&V^u_t = V^u(d^u_{t-1}|\mathbf{X_t}, s_t) \equiv \max_{c_{u,t}, d^u_t} u(c_{u,t}) - h(s_t) \\
&+ \beta E_t \Big[f_{t+1} s_{t+1} V^w(d^u_t|\mathbf{X_{t+1}}, \mathbf{1}_{t+1} = 1) + (1 - f_{t+1} s_{t+1}) V^u(d^u_t|\mathbf{X_{t+1}}) \Big]
\end{aligned}
$$

The budget constraint and borrowing constraint are given by

$$
\begin{aligned}
&c_{u,t} + \frac{d_t^u}{R_t} = p + b_t + \frac{d_{t-1}^u}{\Pi_t} \\
&d_t^u \geq 0
\end{aligned}
$$

p denotes time-invariant home production, and b_t is the real UI benefits. Similarly, d_t^u denotes a bond purchased by an unemployed household in period t. I assume that unemployed workers always consume strictly less than employees as follows: $\frac{c_{u,t}}{c_{w,t}} = \tilde{r}_t < 1$ for all t in equilibrium.

2.3.4 Decisions

Households take job search disutility as given when making saving decisions. The income and expected transition probabilities are symmetric depending on the employment status at the end of the period. Because of borrowing constraints, neither borrowing nor lending across households is feasible in equilibrium. Consequently, the bond market boils down to autarky in the sense that households use all cash-in-hand during each period. Using budget constraints and the envelope condition, we derive the Euler equations of heterogeneous households

$$
\begin{aligned}
-c_{w,t}^{-\sigma} + \beta E_t\left[\frac{R_t}{\Pi_{t+1}}(P_{w,t+1}c_{w,t+1}^{-\sigma} + (1-P_{w,t+1})c_{u,t+1}^{-\sigma})\Big|\mathbf{X_{t+1}}\right] + R_t\mu_{w,t} = 0 \\
-c_{u,t}^{-\sigma} + \beta E_t\left[\frac{R_t}{\Pi_{t+1}}((1-P_{u,t+1})c_{w,t+1}^{-\sigma} + P_{u,t+1}c_{u,t+1}^{-\sigma})\Big|\mathbf{X_{t+1}}\right] + R_t\mu_{u,t} = 0
\end{aligned}
$$

where $\mu_{w,t}$ and $\mu_{u,t}$ are Lagrange multipliers on the borrowing constraints of employed and unemployed households, respectively. The transition probabilities are defined as $P_{u,t} \equiv 1 - f_t s_t$ and $P_{w,t} \equiv 1 - F_t + F_t f_t s_t$.

2.3.5 Asset pricing

As shown in Appendix A.3.1, the condition such that $0 \leq \mu_{w,t} < \mu_{u,t}$ always holds in equilibrium. Although any allocation satisfying $0 \leq \mu_{w,t} < \mu_{u,t}$ can constitute an equilibrium, allocation such that $0 = \mu_{w,t} < \mu_{u,t}$ for all t deserves special attention. This equilibrium allocation is the constrained Pareto optimum most preferred by households given the nominal bond price. In addition, Werning (2015) shows that this equilibrium is robust to the marginal relaxation of borrowing constraints. Therefore, I limit attention to the equilibrium such that $0 = \mu_{w,t} < \mu_{u,t}$ for all t, which enables us to pin down the equilibrium bond price that clears excess bond demand by workers.

Proposition 1. *The equilibrium nominal gross interest rate R_t^N is determined as*

$$\frac{1}{R_t^N} = \beta E_t \left[\frac{1}{\Pi_{t+1}} \underbrace{\left(\frac{c_{w,t+1}}{c_{w,t}}\right)^{-\sigma}}_{\textit{Consumption smoothing}} \underbrace{\left(P_{w,t+1} + (1-P_{w,t+1})\tilde{r}_{t+1}^{-\sigma}\right)}_{\textit{Endogenous wedge}} \Big| \mathbf{X_{t+1}} \right] \tag{16}$$

Proof) See Appendix A.3.1

The bond price is determined by workers' saving demand driven by the following two saving motives: *consumption smoothing* and *precautionary saving against unemployment risk*. When workers expect their income to decline, the real interest rate decreases because saving demand increases to smooth consumption. On the other hand, the *endogenous wedge*, $P_{w,t+1} + (1-P_{w,t+1})\tilde{r}_{t+1}^{-\sigma}$, captures the precautionary saving demand against unemployment risk, which results from asset market incompleteness. The precautionary saving demand is affected by relative consumption upon unemployment ($\tilde{r}_{t+1}$) and the probability of unemployment $(1-P_{w,t+1})$. Given the condition of $\tilde{r}_t < 1 < \sigma$, an expected increase in the unemployment likelihood in period *t+1* (i.e., a decrease in $P_{w,t+1}$) decreases the real interest rate in period t because workers want to increase savings due to precautionary concerns. Similarly, an expected decrease in consumption upon unemployment or an expected increase in consumption upon employment decreases the real interest rate by stimulating saving demand. Intuitively, precautionary saving demand against unemployment risk increases when workers expect that they will be relatively poorer in the case of unemployment. This implies that, all else being equal, an economy would be more volatile when inequality fluctuates countercyclically, which echoes Bilbiie (2019). I call $\tilde{r}_t$ *inequality*. Inequality rises (declines) when $\tilde{r}_t$ decreases (increases).

The income distribution across agents is important for aggregate demand dynamics because agents have heterogeneous MPCs. Concretely, precautionary saver (Ricardian consumer) workers have a lower MPC than other agents in the economy, i.e., unemployed workers, entrepreneurs, and the government, who behave as hand-to-mouth consumers (Non-Ricardian consumer). In addition, total employment is important for aggregate demand because the level of consumption differs according to the employment status. Using the market clearing condition, we can obtain the aggregate Euler equation elucidating this property.

Proposition 2. ***Aggregate Euler equation*** *– Aggregate consumption C_t satisfies*

$$u'(C_t) = \beta E_t \left[\left(P_{w,t+1} + (1 - P_{w,t+1}) \tilde{r}_{t+1}^{-\sigma} \right) \left(\frac{n_t(1+\chi_t)}{n_{t+1}(1+\chi_{t+1})} \right)^{-\sigma} \frac{R_t^N}{\Pi_{t+1}} u'(C_{t+1}) | \mathbf{X_{t+1}} \right]$$

where $C_t \equiv c_{w,t} n_t + c_{u,t} u_t + c_t^e + G$, *and* $\chi_t \equiv \frac{c_{u,t} u_t + c_t^e + G}{c_{w,t} n_t}$.

χ_t captures the aggregate MPC dynamics. The above aggregate Euler equation is distinct from the Euler equation suggested by the standard representative agent model. In addition to the precautionary saving demand against unemployment risk, the term $\left(\frac{n_t(1+\chi_t)}{n_{t+1}(1+\chi_{t+1})} \right)^{-\sigma}$ illustrates that aggregate demand is also affected by the inter-temporal income distribution and total employment. Given the equilibrium allocation from period *t+1*, the aggregate consumption demand rises (a) when hand-to-mouth agents account for a larger share of the aggregate demand or (and) (b) when employment is high. When households are risk-neutral or large family insurance is feasible, the Euler equation boils down to a standard equation in a representative agent economy.

2.3.6 Search decision

Given the job finding probability per unit of effort and the value functions conditional on the employment status, a job seeker chooses the job search intensity that maximizes the expected welfare

$$s_t = \text{argmax } s_t f_t V_t^w(s_t, d_{t-1} | \mathbf{X_t}, 1_t = 1) + (1 - s_t f_t) V_t^u(s_t, d_{t-1} | \mathbf{X_t})$$

The optimal condition is given by

$$h'(s_t) = f_t \Delta V_t \tag{17}$$

where the welfare surplus from employment, ΔV_t, is written as

$$\Delta V_t \equiv u(c_{w,t}) - u(c_{u,t}) - h + \beta E_t[(1 - F_{t+1})(1 - f_{t+1}s_{t+1})\Delta V_{t+1} + (1 - F_{t+1})h(s_{t+1})]$$

The condition indicates that job seekers exert more search effort when they are more likely to find a job or when employment produces a large welfare surplus.

2.4 Policies, market clearing conditions, and social welfare

2.4.1 Monetary policy

The monetary authority commits to a *Taylor rule* that responds to inflation fluctuations

$$R_t^N = R\left(\frac{\Pi_t}{\Pi}\right)^{\gamma_R} \tag{18}$$

where Π and R are the inflation and nominal interest rate targets, respectively. Because the zero lower bound rarely binds under the baseline calibration, I do not impose it explicitly.

2.4.2 Fiscal policy

The government must balance the budget in each period and cannot issue a bond. The government levies a lump-sum tax on both workers and entrepreneurs to finance unemployment insurance spending and government consumption. Workers are liable for α percent of the total tax, and entrepreneurs pay the remainder.

$$T_t = b_t u_t + G \tag{19}$$

$$T_t = \widehat{T}_t n_t + (1 - \alpha) T_t \tag{20}$$

Here, $\widehat{T}_t = \alpha \frac{T_t}{n_t}$ denotes the tax per worker. The amount of UI benefits directly controlled by the government can fluctuate over business cycles, while government consumption G is constant.

The parameter α determines the degree of redistribution from workers to hand-to-mouth consumers (i.e., unemployed workers and the government). The redistribution from workers to unemployed individuals may have a significant impact on the economic dynamics through several channels. First, fiscal transfers financed by workers are resource reallocations from agents with low MPCs to agents with higher MPCs. All else being equal, this redistribution should increase the aggregate demand. Second, the inter-temporal tax path directly affects workers' saving demand through the consumption smoothing motive and inequality channels. Finally, the tax on workers affects welfare upon employment, influencing the search intensity and the equilibrium wage under Nash wage bargaining. Thus, the lump-sum tax on workers is distortionary.

2.4.3 Market clearing conditions

Entrepreneurs consume the net profit after paying production costs and transfers

$$c_t^e = \left(1 - \frac{\kappa}{1+\nu}\left(\frac{v_t}{n_t}\right)^{1+\nu} - \frac{\Omega_t F_t n_{t-1}}{Y_t} - \frac{\Psi}{2}(\Pi_t - 1)^2\right)Y_t - w_t n_t - (1-\alpha)T_t - D_t \tag{21}$$

where the total profit dividends to workers D_t satisfy $D_t = \widehat{D}_t^w n_t$. For simplicity, I rule out profit redistribution to workers: that is, $\widehat{D}_t^w = 0$ for all t. Because profit dividends have distributional effects, how much and to whom profits are redistributed across heterogeneous agents can have a nontrivial impact on the aggregate demand dynamics. I discuss the role of profit transfers in the robustness analysis. The aggregate consumption equals the sum of the final output net of production costs and total home production.

$$C_t = c_{w,t} n_t + c_{u,t} u_t + c_t^e + G \tag{22}$$

$$C_t = \left(1 - \frac{\kappa}{1+\nu}\left(\frac{v_t}{n_t}\right)^{1+\nu} - \frac{\Omega_t F_t n_{t-1}}{Y_t} - \frac{\Psi}{2}(\Pi_t - 1)^2\right)Y_t + p u_t \tag{23}$$

2.4.4 Social welfare

I assume a *utilitarian* social welfare function that aggregates the inter-temporal utilities of households and entrepreneurs

$$SW_t \equiv (1-F_t)n_{t-1}V_t^w(1_t=0) + f_t s_t(u_{t-1}+F_t n_{t-1})V_t^w(1_t=1) + u_t V_t^u + \Lambda V_t^e \tag{24}$$

where $V_t^w(1_t=0)$ and V_t^u represent the value function of type 1 workers and unemployed workers, respectively. V_t^e denotes entrepreneurs' inter-temporal welfare, and $0 \leq \Lambda \leq 1$ is their relative welfare weight. The entrepreneur's welfare captures the welfare cost stemming from the supply-side frictions that the economy faces.

2.5 Shocks

2.5.1 Idiosyncratic match-specific productivity shock

The idiosyncratic productivity shock follows a log-normal distribution

$$F(x) = \Phi\Big(\frac{ln(x)-\mu_a}{\sigma_a}\Big)$$

$\Phi(\cdot)$ denotes the cumulative distribution function of the standard normal distribution. μ_a and σ_a are the mean and standard deviation, respectively, of the associated normal distribution.

2.5.2 Aggregate technology shock

The exogenous productivity shock A_t follows a log AR(1) process

$$A_t = A^{1-\rho_A} A_{t-1}^{\rho_A} e^{\sigma_A \varepsilon_t} \tag{25}$$

where A is normalized to 1. The white-noise process ε_t follows a standard normal distribution.

2.6 Wage determination: Nash wage bargaining

The baseline case supposes that agents determine wages according to Nash bargaining. Appendix A.3.2 presents the details of the bargaining process. In equilibrium, the Nash bargaining wage is determined as follows:

Proposition 3. *The equilibrium wage under Nash bargaining w_t is determined by*

$$w_t = \left(\frac{\zeta}{1-\zeta}\frac{S_t^f}{\Delta V_t}\right)^{\frac{1}{\sigma}} + \widehat{T}_t - \widehat{D}_t^w \tag{26}$$

where $S_t^f \equiv \mu_t \frac{Y_t}{n_t} - \lambda_t + \frac{n_{t-1}(1-F_t)\Omega_t}{n_t}$
Proof) See Appendix A.3.2

ζ denotes the worker's bargaining power, and S_t^f represents the firm's average match surplus. The equation suggests two different sources of upward pressure for wages that should be particularly crucial for UI policy. First, all else being equal, a decline in workers' surplus from employment increases wages because the relative value of workers' outside options increases (*outside option effect*). Additionally, an increase in the tax per worker leads workers to insist on higher wages to compensate for their income loss, which I call the *fiscal increasing return effect* consistent with Blanchard and Summers (1986). The outside option and the fiscal increasing return effects complement each other and generate labor cost pressure, reducing labor demand (*job destruction effect*). When workers' outside options increase for any reason, workers are reluctant to accept lower wage offers. Firms have to provide increased compensation, and thus, they curtail employment in reaction to this cost pressure. The consequent increase in unemployment causes double externalities on government financing: (a) total UI spending increases as discharged workers qualify for UI benefits, and (b) the government loses fiscal contributions from laid-off workers. Because government spending rises and the tax base shrinks, each worker is liable for a higher tax. In turn, workers seek an additional wage hike to compensate for their income loss due to fiscal redistribution, further reducing the labor demand.

3 Calibration

The model period is one quarter. I calibrate the model to match the labor market in the United States. Appendix A.2 discusses the data and estimation details. The external calibration refers to estimates in the literature. Some parameters are jointly computed to attain the designated steady-state targets. The remaining parameters are internally calibrated to reproduce the target second-order moments in the U.S. labor market. Table A.2 in the appendix summarizes the calibration targets and parameter values.

External calibration

The relative risk aversion σ is set to 2, which is consistent with the empirical estimates in the literature (Mankiw et al. 1985, Attanasio and Weber 1995, Havranek 2015). The elasticity of substitution between intermediates η is calibrated to 8, implying a steady-state markup of approximately 15 percent. The Rotemberg price adjustment cost Ψ equals 80, which is calibrated to an average price adjustment frequency of four quarters[10]. The Taylor rule parameter γ_R is set to 1.5, consistent with the standard choice in the New-Keynesian literature. Following the standard choice in the literature, I assume symmetric worker bargaining power, $\zeta = 0.5$, for the baseline case. The sensitivity of the results to the bargaining parameter value is investigated in the robustness analysis. Finally, the relative welfare weight on entrepreneurs Λ is set to $1-\beta$. Because entrepreneurs are risk neutral, steady-state social welfare is affected by the level of entrepreneur consumption in the steady-state equilibrium[11].

Steady-state targets and indirectly calibrated parameters

The model is calibrated at a zero-inflation steady-state, and I target the annual nominal interest rate at 4 percent, $R^N = 1.01$. I target the steady-state job finding rate and the separation rate of incumbent workers to their pre-crisis (Before the Great Recession) averages.

[10] I derive the log-linearized Phillips curve and adjust the slope attached to the marginal cost to be consistent with the Phillips curve under Calvo price rigidity with an expected duration of nominal prices of four quarters.

[11] Nonetheless, the results of this study are robust to the use of any values in $0 \leq \Lambda \leq 1$.

The targets correspond to $F = 0.032$ and $fs = 0.378$. Similarly, the steady-state vacancy-unemployment ratio is calibrated at the pre-crisis average, $v/u = 0.65$. I assume that the steady-state quarterly separation rate of newly formed matches equals 0.05 [12]. I assume that unemployed households consume 11 percent less than workers in the steady-state, $\tilde{r} = 0.89$. This target is consistent with the estimates in studies investigating the impact of unemployment on household spending[13]. The steady-state UI replacement rate is calibrated at 0.4, which is consistent with the average UI replacement rate in the United States during the sample periods[14]. The general government final consumption expenditure approximately accounts for 17.5 percent of the GDP in the United States[15]. Thus, government spending is calibrated to match $\frac{G}{Y} = 0.175$. Because the tax on personal income accounts for approximately 40 percent of the total tax revenue in the United States[16], I set $\alpha = 0.4$. Following the calibration strategy described in Mitman and Rabinovich (2015), I target the steady-state micro (partial-equilibrium) elasticity of the unemployment duration to UI benefits[17] at 0.9 (Meyer 1990). Finally, I assume that households spend 25 percent less time searching for a job than they spend on full-time work (i.e., $s = 0.75$). Given the steady-state targets, I jointly compute the following parameters by solving the steady-state equilibrium conditions: subjective discount rate (β), matching function parameter (γ), separation cost (Ω), home production (p), vacancy posting cost (κ), disutility of working (h), scale parameter of job search disutility (Φ), government spending (G), and curvature of the job search disutility (ε). The log-normal idiosyncratic distribution parameters μ_a and σ_a are estimated to have a minimum distance of the estimated cumulative distribution function

[12]The strictly positive separation cost implies that the steady-state separation rate of newly formed matches must be strictly higher than the rate of incumbent workers.

[13]See Chodorow-Reich and Karabarbounis (2016) or Hurd and Rohwedder (2010) for a discussion of the impact of unemployment on household consumption in the United States.

[14]See "Benefit Accuracy Measurement" from the Employment and Training Administration.

[15]The GDP in my model economy is defined as the total output net of production costs and home production.

[16]OECD (2020), tax on personal income (indicator).

[17]The definition of the micro elasticity is the percentage change in unemployment duration ($\frac{1}{fs}$) in response to the percentage change in the level of UI benefits conditional on the job finding probability per unit of effort (f). Researchers usually compute the micro elasticity conditional on labor market tightness, which fixes the job finding probability. In the current study, however, the job finding probability per unit of effort also depends on the separation rate of new matches. Therefore, I compute elasticity directly based on the job finding probability per unit of effort while allowing for steady-state variations in the separation rate and labor market tightness.

from the empirical counterpart over the entire distribution support. The resulting values are $\mu_a = -0.186$ and $\sigma_a = 0.103$.

Internal calibration

The convexity of the hiring cost, ν, is calibrated to match the empirical vacancy-unemployment correlation. The persistence and size of shocks are adjusted to match the volatility of output, unemployment, and transition rates (i.e., job finding and destruction rates) as closely as possible. In addition to these targets, I roughly match the cyclicality of the transition rates. Internal calibration suggests that $\rho_A = 0.9$ and $\sigma_A = 0.0025$ produce reasonably good fits along the dimensions of interest. Table 2 presents the model-fitting results.

		u	F	fs	Y
Standard deviation	Data	0.107	0.046	0.090	0.010
	Model	0.134	0.044	0.084	0.012
		u	F	fs	Y
Correlation with output	Data	-0.910	-0.106	0.859	1
	Model	-0.992	-0.390	0.996	1
Vacancy-unemployment correlation	Data		-0.91		
	Model		-0.85		

Note: Due to data availability, the vacancy and vacancy-unemployment ratio statistics are computed over periods from Q1 2000 to Q3 2019. The other statistics build upon data ranging from Q1 1995 to Q3 2019. The model estimates are stochastic second-order moments of variables in logs obtained by simulation based on second-order approximation. The simulated business cycle statistics are based on 1,000 simulations over a 1,000 quarter horizon from which the initial 100 periods are discarded.

Table 2: Empirical second-order moments and internal calibration results

Although it does not qualify as an indirect calibration target, we may need to look at the cyclical behavior of real wages under the baseline calibration. It is well known that wages tend to be neither volatile nor strongly procyclical. For instance, Hagedorn and Manovskii (2008) estimate that a one percentage point increase in labor productivity is associated with around a 0.45 percentage point increase in real wages [18]. The baseline calibration overshoots the real wage productivity elasticity. Conditional on the baseline

[18] They measure labor productivity using seasonally adjusted quarterly real average output per person in the nonfarm business sector constructed by the Bureau of Labor Statistics. The data covers from Q1 1951 to Q4 2004. Both time series of real wages and labor productivity are reported in logs and are detrended using an HP filter with a smoothing parameter of 1,600.

calibration, I observe that a one percentage point increase in labor productivity leads to a 0.71 percentage point increase in real wages, which is 1.58 times higher than Hagedorn and Manovskii's estimate [19]. The main findings discussed in the following sections are generally robust to the indirect calibration of wage elasticity, nonetheless [20].

4 Output stimulus of labor market policies

To understand how labor market policy adjustment affects the aggregate economy, I begin the quantitative analysis by computing the output multiplier in response to a single-quarter exogenous policy change in period 1 or 2. As demand-side responses cannot affect the supply side under flexible prices, the differences in output multipliers between rigid and flexible prices capture the (de)stabilizing impact of demand feedback. The short-run (SR) and long-run (LR) output multipliers of the policy shock are measured by

$$\text{SR output multiplier} \equiv \frac{\Delta Y_1}{\Delta x_1 + \beta \Delta x_2}$$
$$\text{LR output multiplier} \equiv \frac{\Sigma_{t=1}^{40} \beta^{t-1} \Delta Y_t}{\Delta x_1 + \beta \Delta x_2}$$
$$\text{where } x \in \{b, \Omega\}$$

ΔY_t denotes the *level* deviation from the deterministic steady-state in period t, and the policy shock size Δx_t is defined similarly. The SR output multiplier measures an output stimulus in response to the policy shock. I assume that the agents are perfectly informed of future policy shocks. Hence, the SR output multiplier in period 1 for the expected policy change in the next period measures an output stimulus through the forward-looking behavior of the agents, i.e., households and entrepreneurs, in the economy.

[19] The wage elasticity is computed based on the simulated time series over a 10,000 quarter horizon. The initial 1,000 periods are discarded. Both time series of real wages and the average output per worker are reported in logs and are detrended using an HP filter with a smoothing parameter of 1,600.

[20] For instance, I examine an economy associated with alternative calibration under which worker bargaining power is adjusted to match the real wage productivity elasticity. Still, numerical results are consistent with those obtained under the baseline calibration.

4.1 Impact of UI extension

I assess the output multiplier of a single-quarter 1 percent increase in UI benefits in period 1 or 2. Table 3 summarizes the output multipliers of the UI extension policy shock under rigid and flexible prices.

Price rigidity	Timing	SR multiplier	LR multiplier
Flexible price	t=1	-0.013	-1.813
	t=2	-0.006	-2.654
Rigid price	t=1	-0.021	-1.972
	t=2	-0.002	-2.205

Table 3: Output multiplier of a single-quarter UI extension policy shock

4.1.1 Contemporaneous UI extension

If prices are flexible and wages are constant, UI extension has a contractionary effect due to households' moral hazard response. Nash bargaining reinforces the contractionary effect of UI extension because of the job destruction effect. UI extension reduces worker surplus and raises the tax per worker, thereby increasing wages. In turn, labor demand declines, and firms dismiss workers while curtailing hiring. Furthermore, an increase in unemployment discourages job search. Not only does finding a job become more demanding as firms cut back hiring and the number of job seekers increases due to increased layoffs, but the welfare surplus of employment also declines because unemployed households benefit from higher UI while workers are liable for a heavier tax burden. Both the job destruction effect and the disincentive to engage in job searching lead to a decline in employment.

One may speculate that UI redistribution should lead to expansionary demand feedback contemporaneously because it reallocates resources from agents with a low MPC (i.e., workers) to those with a higher MPC (i.e., unemployed workers). The general equilibrium mechanism of this Keynesian redistribution works in the following way. Because unemployed households live hand-to-mouth, they immediately consume any resources provided to them. Meanwhile, UI redistribution that reduces workers' after-tax income causes their saving demand to decline according to the consumption smoothing motive, thereby pushing up the real interest rate. In equilibrium, the current nominal interest rate (and thus prices) rises while the expected inflation rate declines. According to the Philips curve, the inflationary pressure raises the firm's marginal revenue from matches, increasing the labor demand. Thus, unemployment declines, and aggregate demand rises. According to this mechanism, UI extension should lead to expansions or, at least, dampen the contractionary job destruction effect. Interestingly, the short-run multiplier under rigid prices indicates that demand feedback is not expansionary but rather amplifies the recessionary effect of UI extension.

Despite its Keynesian redistribution feature, UI extension results in a decline in aggregate demand because unemployment rises due to the job destruction effect. In addition, demand feedback is contractionary because workers' saving demand increases, rather than decreases, after the contemporaneous UI extension. Concretely, workers' after-tax income declines in response to UI extension because the tax per worker increases. However, UI extension is the pressure that pushes wages upward, which partially dampens the income decline. Because the shock lasts only a single quarter while unemployment adjusts sluggishly due to labor market friction, workers expect their after-tax income in the next period to be lower than their current income. Hence, workers save more based on the consumption smoothing motive. An increase in the saving demand deepens downturns through contractionary supply-demand feedback[21]. Concretely, a decline in the real interest rate to clear the asset market leads to a decline in match surplus, resulting in two countervailing effects. On the one hand, the decline reduces the labor demand. On the other hand, it decreases the current wage as the firm's match surplus declines. Because the first effect dominates, output decreases more under rigid prices than under flexible prices, while the latter effect dampens the labor cost response to the policy shock. From period *t+1*, the after-tax income steadily increases as the economy returns to the steady-state. Workers who expect an increasing income stream reduce the saving demand, generating

[21] The precautionary saving motive plays a minor role in explaining the saving demand response in this case. The probability of unemployment in period *t+1* slightly declines in equilibrium. In addition, the consumption ratio $\tilde{r}_{t+1}$ increases as workers' after-tax income declines. Consequently, currently, precautionary saving demand decreases in response to the contemporaneous UI extension. However, the real interest rate falls in equilibrium because the consumption smoothing motive is a predominant force driving the saving demand.

expansionary demand feedback in equilibrium. The first row in Figure 1 illustrates that the declines in output and unemployment under rigid prices are larger at the outset of the shock due to contractionary demand feedback. After a few quarters, however, the economy recovers relatively quickly because of expansionary demand feedback.

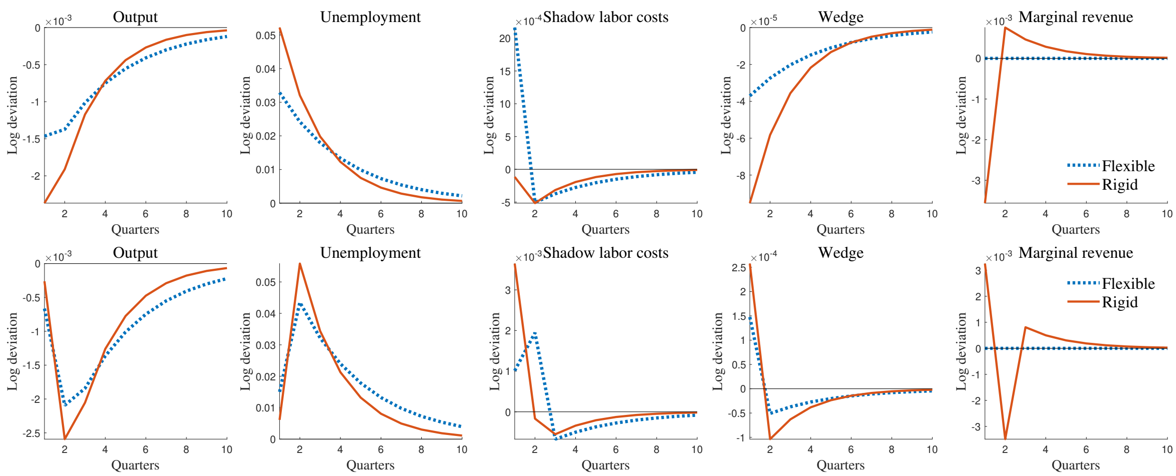


Figure 1: Impulse-Responses to a contemporaneous (first row) or expected (second row) single-quarter UI extension

4.1.2 Expected UI extension

As UI extension generates contractionary effects, the current continuation value of a match declines in response to an expected UI extension. Thus, labor demand declines in response to the expected UI extension via the expectation channel as the shadow cost of labor rises. Consequently, output declines follow. Table 3 reports the negative SR multiplier in period 1 in response to the expected policy shock in period 2.

One may think that an expected UI extension increases the aggregate demand by dampening precautionary saving demand against unemployment risk. Indeed, the output multiplier states that the contractionary effect abates once demand feedback is allowed. This result, however, does not come from the dampened precautionary saving demand. According to the endogenous wedge dynamics shown in Figure 1, we can observe that the precautionary saving demand even rises in response to an expected UI extension. The adverse impact of UI extension on labor demand raises the separation rate while lowering the job finding probability. Despite the generous UI benefits provided upon unemployment, the precautionary saving demand rises as workers find unemployment more likely.

Despite the increase in the precautionary saving demand, the net saving demand declines due to the consumption smoothing motive. Because the expected policy shock decreases current employment, the current after-tax income declines as the tax per worker increases. Because the UI extension pushes wages up, workers expect their after-tax income in the following period when the policy shock will occur to be higher than their current income, although the tax per worker is expected to be raised because unemployment goes up due to the wage cost pressure generated by UI extension. In equilibrium, the current saving demand declines in response to the expected UI extension according to the consumption smoothing motive, which dominates precautionary concerns. The decline in the saving demand generates expansionary demand feedback, explaining why the negative SR output multiplier is smaller under rigid prices than under flexible prices. The dynamics after the shock are symmetric to the case above.

4.1.3 Discussion

According to McKay and Reis (2016) and Kekre (2018), UI redistribution is expansionary resource reallocation from agents with a lower MPC to those with a higher MPC. UI redistribution can also dampen households' precautionary saving demand against unemployment risk, which raises the aggregate demand. Consequently, UI extension increases output in equilibrium through expansionary demand feedback.

In the literature, the expansionary impact of UI expansion crucially hinges on the wage-setting assumption restricting the job destruction effect. The analysis above shows that the expansionary mechanism driven by UI extension does not work under Nash wage bargaining. When wages are determined by Nash bargaining or, more broadly, by bilateral wage bargaining, UI extension generates labor cost pressure that reduces the labor demand. If the job destruction effect is sufficiently strong, the current or expected UI extension neither undermines the precautionary saving demand nor raises the aggregate demand through resource reallocation. Instead, UI redistribution from workers to unemployed households can be contractionary because it raises unemployment by reducing labor demand and stimulates workers' saving demand according to the consumption smoothing motive. In addition, the expected UI extension can intensify households' precautionary saving behavior because workers find unemployment more likely.

4.2 Impact of EP intensification

I evaluate the output multiplier of a single-quarter 10 percent increase in the separation cost in period 1 or 2. Table 4 presents the results.

Price rigidity	Timing	SR multiplier	LR multiplier
Flexible price	t=1	0.011	1.516
	t=2	-0.008	0.476
Rigid price	t=1	0.002	0.256
	t=2	-0.002	0.073

Table 4: Output multiplier of a single-quarter EP intensification policy shock

4.2.1 Contemporaneous EP intensification

Under Nash bargaining, employment rises in response to a contemporaneous increase in the separation cost. The policy shock raises the shadow cost of labor because it reduces the continuation value of a match. Although labor costs increase, firms reduce layoffs because the general equilibrium elasticity of the shadow cost of labor to the separation cost is smaller than 1. Although labor becomes costly in response to EP intensification, firing becomes an even more costly choice for firms. On the other hand, firms post fewer vacancies because the surplus from job creation diminishes as the shadow cost of labor increases. In equilibrium, employment rises because layoffs decrease more than the reduction in recruitment. Although matches are less productive on average as idiosyncratic productivity across incumbent matches declines, output increases as employment increases. Output expansion is supported in equilibrium by an increase in the aggregate demand due to an increase in employment.

Saving demand in response to the concurrent policy shock deserves attention. Because a higher separation cost decreases unemployment, workers obtain a higher after-tax income as the tax per worker declines. As the policy change is a one-time event, workers know that their current income is higher than usual. Workers seek to smooth consumption, and thus, saving demand increases. The consequent contractionary demand feedback dampens the expansionary impact of the policy shock and induces the economy to return to the steady-state more swiftly than in the case without demand feedback. The first row in Figure 2 illustrates these dynamics. Both the SR and LR output multipliers are smaller under rigid prices than flexible prices due to demand feedback.

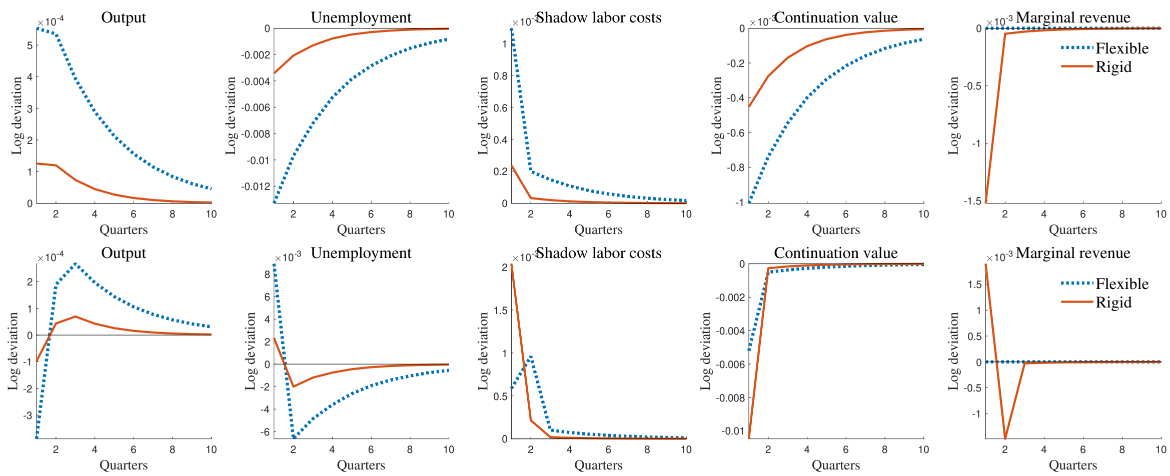


Figure 2: Impulse-Responses to contemporaneous (first row) or expected (second row) single-quarter EP intensification

4.2.2 Expected EP intensification

Under Nash bargaining, an expected increase in the separation cost reduces employment regardless of price rigidity. In response to an expected EP intensification, the current labor demand declines because each match is expected to incur a higher separation cost upon dismissal. Consequently, firms lay off workers and curtail recruitment. Output falls as employment declines in response to the expected EP intensification.

Households expect their income to be higher in the next period because unemployment will drop in response to EP intensification. The consumption smoothing motive depresses the current saving demand. In addition, workers have less precautionary saving demand. Despite the expected decline in vacancies, workers expect that they are less likely to be discharged and more likely to be reemployed upon separation as the number of job seekers reduces due to the decreased inflows to unemployment. The decrease in the saving demand produces expansionary demand feedback, thereby moderating contraction in the short run. Similarly, demand feedback becomes contractionary from the period when the policy shock occurs. As it dampens expansions, demand feedback expedites a return to the steady-state.

Two issues deserve comments. First, Table 4 indicates that the effects of contemporaneous and expected EP intensification almost cancel each other in the short run. This explains why the real impact of cyclical EP adjustments on the aggregate economy could be feeble, as observed in the next section. Second, the dynamics imply that the expected policy reform intensifying EP depresses current economic activities because it reduces labor demand through firms' forward-looking behavior.

5 Optimal cyclical behavior of labor market policies

5.1 Optimal simple and implementable labor market policies

This section analyzes the optimal cyclical labor market policy adjustments. Model complexity does not allow a closed-form solution of the first-best policies. Alternatively, I evaluate the welfare impact of cyclical policy adjustments by focusing on the class of policy regimes restricted by a particular policy rule specified as follows [22].

$$b_t = b\left(\frac{Y_t}{Y}\right)^{\gamma_b} \quad \text{and} \quad \Omega_t = \Omega\left(\frac{Y_t}{Y}\right)^{\gamma_\Omega}$$

b, Ω, and Y represent the long-run policy targets and the deterministic steady-state output[23]. Following Schmitt-Grohe and Uribe (2007), I numerically evaluate conditional

[22] Optimal policies should be a function of the state variables and Lagrange multipliers attached to equilibrium conditions. Although the policy rules might not precisely approximate the optimal policies, the numerical results help us characterize advisable policy reactions in response to business cycle fluctuations and might provide more practical policy guidelines.

[23] The policy rules imply that labor market policies seek to stabilize output fluctuations from their deterministic steady-state level. Nonetheless, stabilizing output to its non-stochastic level is not necessarily desirable, particularly in response to supply shocks. The standard New-Keynesian model states that output should vary consistently with variations in the natural level of output. When nominal rigidity coexists with real imperfections, however, the flexible price equilibrium allocation is not inefficient in general. Thus,

volatility and stochastic social welfare corresponding to the different value of the policy rule coefficients using the second-order approximation and a grid search method. The policy coefficients γ_b and γ_Ω capture the direction and extent of the committed cyclical policy adjustments in response to output fluctuations. The current exercise limits attention to the UI policy coefficient in the interval [-3, 3], where the grid step size is set to 0.1. The previous section indicates that separation cost adjustment yields a fairly small output stimulus. Therefore, I allow a broader interval and a coarser grid step size to the EP policy coefficient, i.e., [-10, 10], where the grid step size is set to 1. Although the coefficient intervals are arbitrarily chosen, they cover plausible ranges of policy adjustments at a business cycle frequency in the United States [24]. As the steady-state equilibrium is invariable to policy rule coefficients, the differences in economic dynamics across regimes result from the different intensity and cyclicality of policy reactions to output fluctuations.

5.2 Unemployment insurance

Under Nash bargaining and conditional on an acyclical separation cost, the UI policy coefficient should be higher than -0.6 to obtain a locally unique and stable solution. The numerical search indicates that UI should be adjusted procyclically to reduce volatility in the real economy and raise the conditional welfare of all households. Social welfare is maximized under $\gamma_b = 1.2$.

Procyclical UI facilitates flexible wage arrangements across business cycles. Stated differently, procyclical UI produces countercyclical incentives for firms to provide jobs. Consequently, employment fluctuations are moderated, and the economy attains higher welfare

there is no reason to suppose that a policymaker seeks to replicate the natural level of output. Indeed, a policymaker might want to replicate efficient equilibrium allocation in which all real imperfections and nominal rigidities are corrected. Due to the model complexity, identifying efficient allocation is challenging. Therefore, I suppose that policy rules respond to output deviations from the deterministic steady-state, which directly addresses the key policy question in this paper (i.e., cyclical policy adjustments in response to economic circumstances). Nevertheless, the results and intuitions of this study are robust under policy rules indexed to output deviations from their time-varying natural counterparts (i.e., output under flexible prices). In addition, the results are robust under alternative policy rules that respond to fluctuations in other variables, such as unemployment, labor market tightness, and endogenous and exogenous state variables n_{t-1} and A_t.

[24] For example, the 99 percent confidence interval of the simulated UI replacement rate is no higher than 0.48 and no lower than 0.35 across all grids, approximating the range of the UI replacement rate before the Great Recession.

γ_b	Baseline	-0.6	-0.1	1.2	3
σ_Y	0.01	128.8%	9.7%	-49.9%	-70.5%
σ_u	0.13	235.2%	17.8%	-91.9%	-70.0%
σ_Π	0.00	49.9%	4.0%	-20.8%	-28.7%
SW	-37.74	-0.82	-0.02	0.03	0.03

Note: The Baseline column describes the standard deviation of output, unemployment, inflation, and level of the conditional social welfare under acyclical UI. The other columns describe the percentage difference in volatility and level difference in welfare relative to the baseline case under different levels of γ_b.

Table 5: Volatility and social welfare *w.r.t.* different UI policy rules under Nash bargaining

from stabilization. One may speculate that procyclical UI can be harmful when the asset market is incomplete because it reinforces countercyclical precautionary saving demand against unemployment risk or amplifies aggregate demand fluctuations due to procyclical redistribution from agents with a lower MPC to those with a higher MPC. Again, these intuitions are reversed under Nash bargaining. In response to contractionary shocks, procyclical UI induces workers to expect the unemployment risk will rise less or even decline. Although workers might expect a large consumption decline upon unemployment during recessions, they are less willing to engage in precautionary saving due to the lower chance of unemployment. On the other hand, procyclical UI redistribution stabilizes the aggregate demand by dampening employment fluctuation. In a nutshell, when the government implements procyclical UI, there is no policy tradeoff regarding stabilization through both supply and demand channels.

Although risk-averse households prefer a stabilized consumption stream, allowing some extent of business cycle fluctuations can enhance welfare if it helps the economy take advantage of economic fluctuations (Lester et al., 2014). When the economy is driven by supply shocks, stimulating economic activity during upturns and dampening economic activity during downturns can increase the overall average output, thereby increasing welfare at the cost of greater volatility[25]. This finding implies that procyclical UI should address a policy tradeoff between stabilization and production efficiency[26]. This is why the welfare-

[25]In other words, the social cost of unemployment is relatively higher when a technology shock is positive while it is lower when adverse technology shocks occur.

[26]Regarding demand shocks, this tradeoff between stabilization and production efficiency might be ir-

maximizing regime is distinct from the volatility-minimizing one. Under the output (and aggregate demand) volatility-minimizing regime, UI is so procyclical that unemployment fluctuates procyclically. The excessively procyclical UI lowers the stochastic average output and welfare due to inefficient inter-temporal labor allocation. Therefore, UI should be procyclical but not too procyclical in order to reconcile production efficiency with stabilization. One should note that, although it may align with efficient labor allocation over business cycles, countercyclical UI is not desirable because it is extremely destabilizing for the economy. Countercyclical UI reduces stochastic output and employment and causes substantial welfare losses due to destabilization.

Figure A.1 illustrates the dynamics under different UI policy rules. In response to negative technology shocks, procyclical UI causes a larger and more persistent decrease in the shadow cost of labor. The consequent increase in labor demand neutralizes the adverse impact of technology shocks on output. Unemployment even declines after adverse technology shocks under the strongly procyclical UI. The strongly procyclical UI induces precautionary saving demand to fluctuate procyclically as unemployment risk fluctuates procyclically under this UI scheme. The responses of μ_t indicate that procyclical UI results in more stabilizing demand feedback than other regimes at the outset of recessions. In contrast, we can observe that the optimal regime allows unemployment to rise in response to adverse technology shocks, indicating that the policy pursues efficient labor allocation across business cycles. The more extensive fluctuations in the real economy under the optimal scheme than under the strongly procyclical UI scheme suggest that higher welfare can be achieved when UI balances both stabilization and production efficiency.

In contrast, countercyclical UI causes unemployment risk to rise sharply after the shock. Workers respond to a surge in unemployment risk by significantly raising the precautionary saving demand, generating contractionary demand feedback that deepens recessions in the beginning. We can observe that the precautionary saving demand declines after a few quarters of downturns. The unemployment risk declines, and workers have less incentive to engage in precautionary savings as inequality declines. Concretely, the tax per

relevant. The optimal policy should induce the economy to replicate efficient allocation, which might be attainable without compromising stabilization.

worker largely increases due to countercyclical UI spending and an increase in unemployment. Together with the procyclical consumption smoothing motive, the saving demand declines unambiguously in equilibrium. As a result, demand feedback helps economic recovery after a few quarters. One can observe hump-shaped increases in the real interest rate and inflation under the countercyclical UI regime. The Phillips curve suggests that marginal revenue can fall when firms anticipate higher inflation in subsequent periods.

5.3 Employment protection

The numerical search indicates that countercyclical EP is welfare-enhancing under Nash bargaining. The most countercyclical regime, $\gamma_\Omega = -10$, yields the smallest volatility and the highest welfare. Under Nash bargaining, the job destruction margin is more sensitive to separation cost adjustment than the job creation margin. Thus, countercyclical EP dampens employment fluctuations and delivers higher welfare through stabilization. The output stimulus of EP adjustment is small because its effects on employment through the contemporaneous and expectation channels almost cancel each other. Hence, the differences in stochastic welfare and volatility are not large across the regimes I consider.

Production efficiency requires relaxing EP during recessions when worker reallocation from low- to high-productivity jobs are comparatively efficient. The social cost of impeding efficient worker reallocation is relatively low when technology shocks are positive as incumbent matches are relatively productive. This finding implies that countercyclical EP results in higher welfare through stabilization at the cost of production inefficiency.

γ_Ω	Baseline	-10	-5	5	10
σ_Y	0.01	-4.2%	-2.1%	2.2%	4.6%
σ_u	0.13	-8.0%	-4.1%	4.3%	8.8%
σ_Π	0.00	-0.6%	-0.3%	0.3%	0.5%
SW	-37.74	0.005	0.003	-0.003	-0.005

Note: The Baseline column describes the standard deviation of output, unemployment, inflation, and level of conditional social welfare under acyclical EP. The other columns describe the percentage difference in volatility and level of difference in welfare relative to the baseline case under different levels of γ_Ω.

Table 6: Volatility and social welfare *w.r.t.* different EP policy rules under Nash bargaining

Figure A.2 displays the dynamics. Countercyclical EP renders layoffs more costly during recessions. Hence, the shadow cost of labor declines less under this regime than under the other regimes due to a relatively large decline in the continuation value. Therefore, vacancies decrease more extensively under countercyclical EP. Nonetheless, countercyclical EP also dampens job destruction. In equilibrium, unemployment fluctuations are dampened due to moderated layoffs across business cycles. Procyclical EP causes a larger decline in the job finding probability and more extensive countercyclical fluctuations in the separation rate. Despite the relatively small reduction in vacancies, massive job destruction causes intense competition in the labor market under procyclical EP. That is, each worker expects a lower chance of reemployment and a higher probability of layoff under procyclical EP. Not only does it discourage job search activities, but it also stimulates countercyclical precautionary saving demand against unemployment risk. As a result, demand feedback is more destabilizing or less stabilizing under procyclical EP. The responses of the endogenous wedge and marginal revenue illustrate this mechanism. In sum, countercyclical EP is a more efficient economic stabilizer through both the supply and demand channels.

An increase in unemployment (and unemployment risk) generates labor cost pressure by increasing the tax per worker, depresses search efforts due to the congestion externality in the labor market, and stimulates precautionary saving demand against unemployment risk. Countercyclical EP serves as a cyclical Pigouvian tax that induces firms to internalize such social costs of unemployment.

5.4 Labor market policy mix

Figure 3 illustrates the volatility and stochastic social welfare that occur when both UI and EP are simultaneously adjusted according to the different policy rule coefficients. Under Nash bargaining, the most procyclical UI and the most countercyclical EP result in the lowest output and price volatility. The smallest unemployment volatility is associated with relatively moderate procyclical UI ($\gamma_b = 1.4$) combined with the most countercyclical EP ($\gamma_\Omega = -10$). Stochastic social welfare is maximized under $\gamma_b = 1.2$ and $\gamma_\Omega = -10$. No-

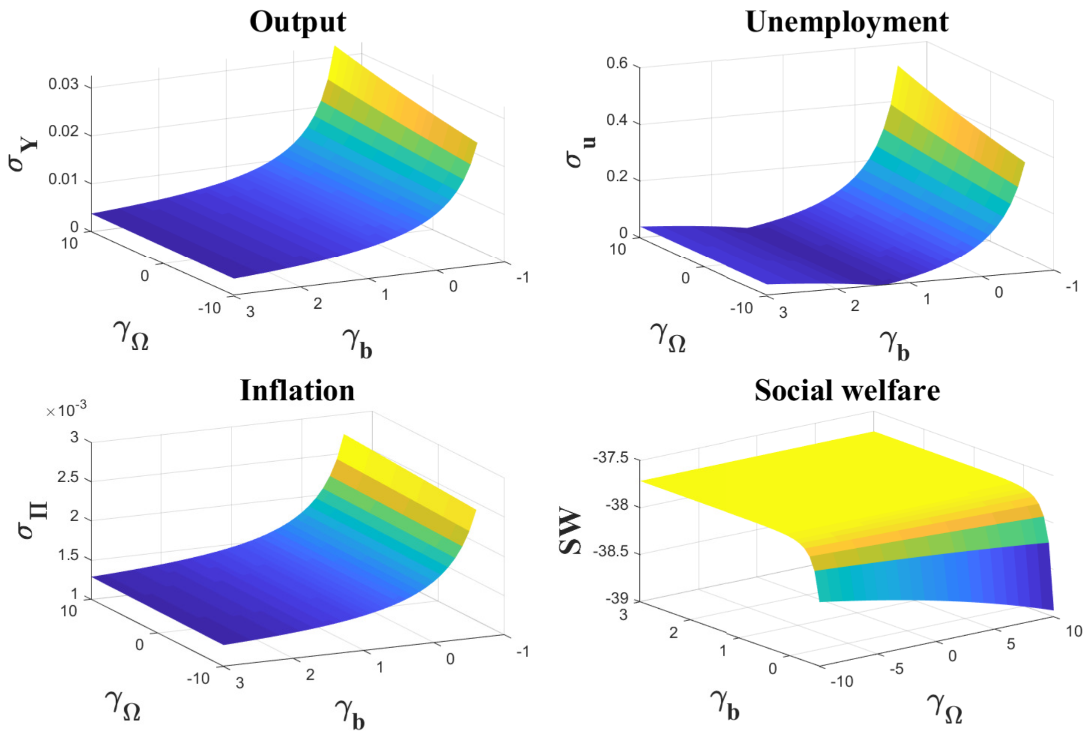


Figure 3: Volatility and social welfare corresponding to different policy rules

tably, cyclical UI adjustment is a more critical factor for welfare outcomes. Given γ_b, the changes in γ_Ω yield only very small welfare differences. In contrast, given γ_Ω, conditional welfare decreases when γ_b falls below a certain positive threshold. The welfare gain from stabilization almost compensates for the welfare cost of inefficient business cycle exploitation. Thus, the welfare difference between the welfare-maximizing regime and the output volatility-minimizing regime is quite small. This result is robust under different ex-ante policies. Given any ex-ante levels of UI benefit and separation cost, Nash wage bargaining renders procyclical UI and countercyclical EP welfare-enhancing through stabilization.

Based on the real business cycle framework, Jung and Kuester (2015) suggest that countercyclical UI under Nash bargaining can be beneficial from an insurance perspective if the government can implement countercyclical hiring subsidies and layoff taxes. In this case, countercyclical layoff taxes and hiring subsidies constrain the adverse impact of UI on the labor demand. In contrast, this paper suggests that UI needs to be procyclical despite countercyclical EP. Countercyclical EP adjustment is not efficient enough to restrain the job destruction effect caused by countercyclical UI. In addition, countercyclical UI does not provide appropriate insurance against unemployment because it amplifies countercyclical fluctuations in unemployment risks.

6 Robustness analysis

6.1 Alternative calibration - risk aversion and the size of consumption cut upon unemployment

One may speculate if the robustness of the numerical results heavily relies on the choices of parameters and steady-state targets. In particular, the baseline economy suggests that the supply-side responses to labor market policies are the primary driver of welfare outcomes of the labor market policies, while the demand-side feedback plays a secondary role. However, when households are more averse to intertemporal substitution or unemployment causes a more significant decline in consumption, households' precautionary behavior might be more influential, thereby altering the desirable cyclical policy behavior.

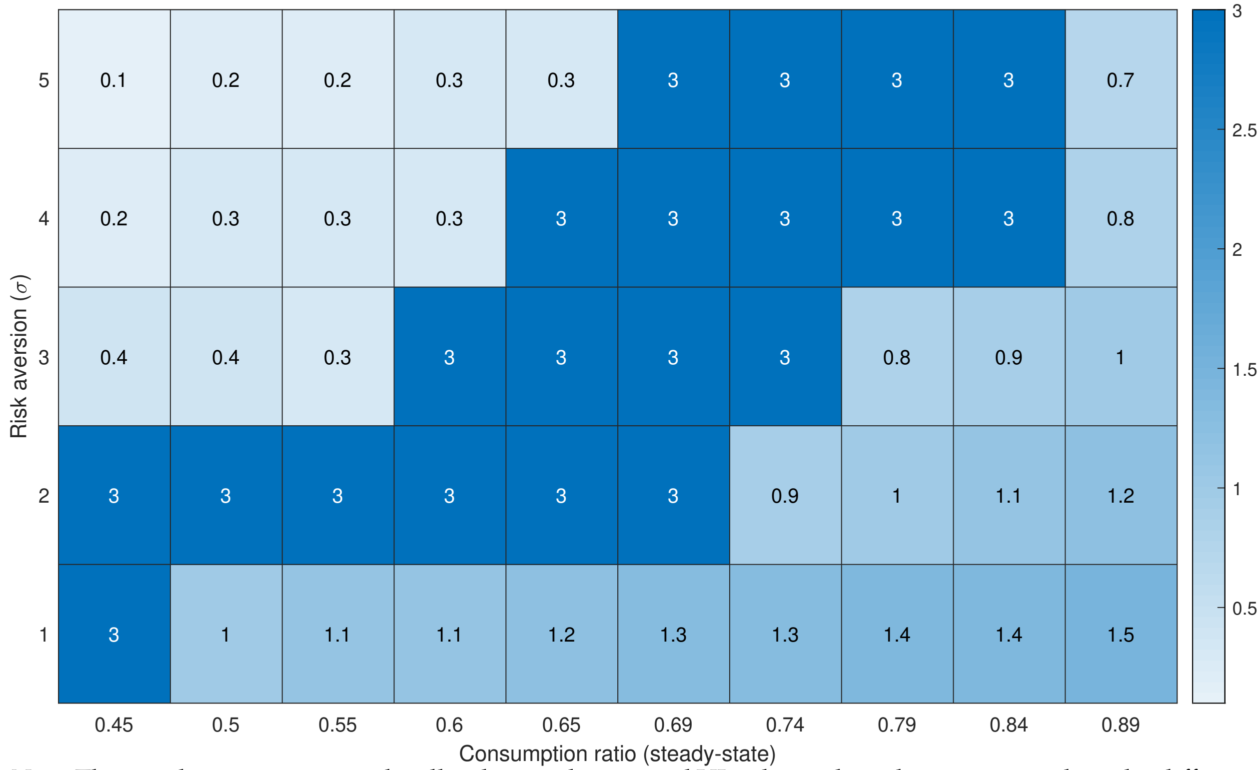
To investigate this issue, I conduct a sensitivity analysis by looking at the optimal labor market policies associated with alternative values of the intertemporal elasticity of substitution and the size of consumption decline upon unemployment. Concretely, I examine the different degrees of risk aversion whose integer values range from 1 to 5[27]. Concerning the size of consumption cut upon unemployment, I adjust the amount of home production so that the extent of the steady-state consumption reduction upon unemployment relative to workers' consumption ranges from an 11 percent decline to a 55 percent collapse. That is, I consider alternative targets of $\tilde{r} = c_u/c_w$, which varies from $\tilde{r} = 0.45$ to $\tilde{r} = 0.89$ [28]. For each alternative calibration tuple, $(\sigma_{new}, \tilde{r}_{new})$, a similar numerical search for optimal labor market policies is carried out [29]. The grid intervals for the policy coefficients and the step

[27]When $\sigma = 1$, the utility function conforms to the logarithmic utility function.

[28]I construct 10 equidistant grids for $\tilde{r}$ in the interval between 0.45 and 0.89.

[29]Because σ and $\tilde{r}$ are newly assigned, some parameters need to be adjusted in order to preserve other steady-state targets. Concretely, subjective discount rate (β), home production (p), vacancy posting cost (κ), the disutility of working (h), and scale parameter of job search disutility (Φ) are recomputed to be consistent with the baseline steady-state targets discussed in Section 3: *Steady-state targets and indirectly calibrated*

sizes are the same as those described in the baseline analysis in Section 5.1.



Note: The number written on each cell indicates the optimal UI policy rule γ_b that corresponds to the different levels of σ (Y-axis) and $\tilde{r}$ (X-axis). The optimal policy coefficient is derived through a numerical search over the interval [-3, 3] with the step size of 0.1, conditional on the constant EP ($\gamma_\Omega = 0$).

Figure 4: The optimal UI policy rule with respect to the different extents of risk aversion and of the (steady-state) consumption cut upon unemployment

Numerical results support the robustness of the baseline findings. First of all, regardless of the levels of σ and $\tilde{r}$, the EP policy coefficient yielding the highest social welfare indicates $\gamma_\Omega = -10$. Namely, the optimal EP should be strongly countercyclical. On the other hand, UI should also be adjusted procyclically to attain superior welfare outcomes. Figure 4 displays the optimal UI policy coefficient corresponding to the alternative calibrations. The desirable extent of the committed cyclical UI policy reactions to output fluctuations can vary depending on the levels of σ and $\tilde{r}$, but UI should be procyclical to deliver higher welfare in any case. In addition, I observe across all alternative calibrations that countercyclical UI would either violate the Blanchard-Khan condition or cause excessive destabilization.

parameters.

6.2 When might countercyclical UI be desirable under Nash bargaining?

We have observed that, as long as agents determine wages according to Nash bargaining, procyclical UI and countercyclical EP are preferable. Furthermore, these policy implications are robust to the wide variety of the degree of relative risk aversion and the impact of unemployment on household consumption. I do not comment on its details, but similar results are also obtained for the monetary policy rule parameter. The question arises under which conditions policy implications can differ from the baseline case, despite Nash wage bargaining.

I now explore the conditions that induce the optimal cyclical policy behavior, particularly UI, to deviate from its baseline counterpart. Recall that UI needs to be procyclical under Nash wage bargaining because UI extension substantially hurts firms' labor demand. As previously discussed, the job destruction effect can be stratified into the following two cost pressure channels: the outside option effect and the fiscal increasing return effect. The key parameters determining the magnitude of the job destruction effect are worker bargaining power (ζ) and the degree of fiscal redistribution (α). I examine the optimal labor market policies under alternative calibrations of ζ and α[30].

To begin with, conditional on the baseline symmetric worker bargaining power $\zeta = 0.5$, I find that UI should still be procyclical to obtain both stabilization and superior welfare outcome, even in the absence of the fiscal increasing return effect ($\alpha = 0$). This result suggests an important implication. The model does not allow government debt financing, which can be problematic due to the following two consequent restrictions: (a) wealth distribution across households due to public debt holdings disappears, and (b) the government must adjust the tax per worker countercyclically to finance its countercyclical UI spending. $\alpha = 0$ indicates a case in which the government relies only on the corporate tax to finance its spending. Redistribution from firms to unemployed workers and the government is neutral resource reallocation in my model economy as they all behave as hand-to-mouth consumers. Thus, the robustness of the results under $\alpha = 0$ suggests that

[30] For simplicity, I suppose that $G = 0$ in this section. Given the new values of α and ζ, some parameters are recalibrated to obtain the steady-state targets discussed in Section 3.

relaxing the balanced-budget restriction on government financing, particularly in terms of the second restriction, does not hurt the main findings [31].

Second, given the baseline extent of fiscal redistribution $\alpha = 0.4$, I observe that UI should be procyclical regardless of the level of worker bargaining power. In particular, I find that the job destruction effect becomes more potent as workers have less bargaining power. The intuition is clear. As worker bargaining power decreases, the equilibrium wage under Nash bargaining is weighted more by the worker's reservation wage. The equilibrium wage is more responsive to fluctuations in workers' outside labor market conditions, resulting in a stronger job destruction effect. Therefore, workers should have considerable bargaining power to curb the magnitude of the job destruction effect.

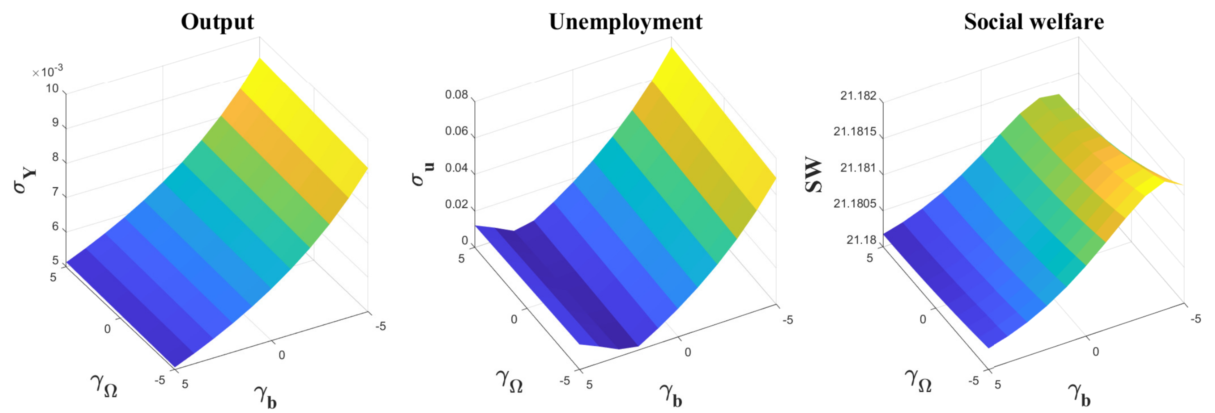


Figure 5: Volatility and welfare corresponding to different policy rules under Nash bargaining (conditional on $\alpha = 0$ and $\zeta = 0.9$)

I find that both α and $1 - \zeta$ should simultaneously be close to 0 to make countercyclical UI implementable and welfare-enhancing. For example, I set $\alpha = 0$ and $\zeta = 0.9$ and conduct a similar numerical search as described in the previous section. The policy coefficients range in the interval [-5, 5], and the step size is set to 1. The numerical search indicates that the economy attains the highest conditional welfare under strongly countercyclical UI ($\gamma_b = -4$) at the cost of higher volatility. Figure 5 illustrates that the volatility of output and unemployment increases as γ_b declines while social welfare increases in γ_b.

[31] Regarding the first restriction, we may refer to McKay and Reis (2016). They point out that allowing deficits and public debt dynamics tends to have little impact on economic dynamics and policy implications in this line of models. This is because, according to the wealth concentration data, almost all public debts are held by households who are already close to fully self-insured.

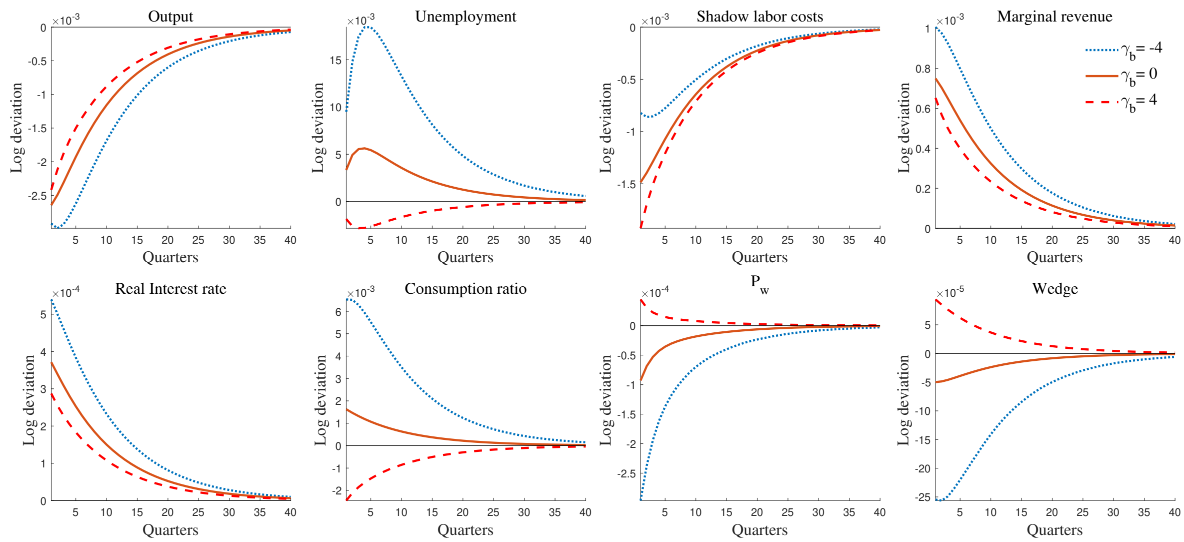


Figure 6: Impulse-Responses to adverse technology shocks, different UI rules and constant EP

Even under the alternative calibration restricting the magnitude of the job destruction effect, countercyclical UI is preferable mostly due to the job destruction effect. Figure 6 illustrates this idea. We can observe that unemployment fluctuations are still more extensive due to the job destruction effect under the optimal countercyclical UI regime. Thus, the superior welfare outcome of countercyclical UI is not derived from welfare gains from stabilization. Instead, countercyclical UI is advantageous because of the enhanced production efficiency. Under the alternative calibration that weakens the job destruction effect, UI extension distorts labor demand to a lesser extent. Countercyclical UI does not cause excessive destabilization. Rather, the appropriate extent of the job destruction effect facilitates efficient labor allocation across business cycles. Despite the amplified unemployment fluctuations, countercyclical UI results in higher stochastic consumption, output, and welfare through efficient labor allocation across business cycles. Furthermore, precautionary saving demand responses to UI adjustments are primarily driven by the consumption ratio rather than countercyclical unemployment risk fluctuations under the alternative calibration because the job destruction effect is limited. Hence, countercyclical UI produces more stabilizing demand feedback by dampening the countercyclical precautionary saving demand aginst unemployment risk through its insurance impact on the consumption level upon unemployment. The stabilizing demand feedback partially neutralizes the destabilizing job destruction effect. Finally, I observe that strongly countercyclical EP ($\gamma_\Omega = -5$) still yields the highest welfare even under alternative calibrations and countercyclical UI.

6.3 Alternative offer bargaining

This section investigates cyclical labor market policies under a different wage bargaining scheme, namely, alternative offer bargaining (AOB) as described in Hall and Milgrom (2008) and Christiano et al. (2016). The details of the bargaining process are presented in Appendix A.3.3. It is well known that AOB restricts the impact of workers' outside labor market conditions on wage determination. Therefore, this alternative wage bargaining scheme may lead to policy implications that differ from those under Nash bargaining. The equilibrium wage under AOB should satisfy the following equation:

$$\frac{\zeta}{1-\zeta}\Delta V_t = \frac{\left(\zeta S_t^f + (1-\zeta)\delta + c_{w,t}\right)^{1-\sigma} - c_{w,t}^{1-\sigma}}{1-\sigma} \quad \text{where } 0 \leq \delta \text{ and } 0 < \zeta < 1$$

where ζ denotes a probability that wage negotiation terminates exogenously, and δ indicates the firm's wage negotiation cost. The parameter ζ, which plays a similar role as the worker's bargaining power in Nash bargaining, is the key parameter determining the magnitude of the job destruction effect. If ζ is high, wage bargaining is more likely to be annulled exogenously, and a match is dissolved. Because I suppose that a firm makes an initial wage offer, the equilibrium wage would be close to the upper bound of the wage bargaining set as ζ is low. Thus, firms have a smaller match surplus as ζ declines, and the wage is likely to be less affected by the worker's outside options.

The numerical results confirm the previous findings[32]. UI should be moderately procyclical given acyclical EP: $\gamma_b = 1.3$ attains the highest welfare. Similarly, conditional on acyclical UI, EP should be strongly countercyclical: $\gamma_\Omega = -10$ yields the highest welfare. The policy mix of $\gamma_b = 1.3$ and $\gamma_\Omega = -10$ yields the highest stochastic welfare among the ex-

[32]The calibration under AOB is as follows. First, for simplicity, I suppose that $\delta = 0$. Nonetheless, this simplification does not affect the main results. Most parameters remain the same, but η, Φ, and h require recomputing to be consistent with the steady-state targets. ζ and σ_A are calibrated to attain target second-order moments similar to those discussed in Section 3. $\zeta = 0.1$ and $\sigma_A = 0.002$ yield almost identical business cycle moments in the baseline Nash bargaining case. The grid intervals for the policy coefficients and the grid step sizes are the same as those described in the baseline analysis in Section 5.1.

plored regimes. The reasons are the same as those in the Nash bargaining case. Although AOB curbs the impact of workers' outside labor market option on wages, the job destruction effect is still strong enough to make procyclical UI desirable. Similarly, EP has a more significant impact on the job destruction margin than the job creation margin under AOB, inducing countercyclical EP to be more preferable.

When agents determine wages using a wage posting scheme, it is well known that wages are fairly responsive to fluctuations in the worker's outside option, implying that the results in the current study might also apply to models with a wage posting scheme. More generally, for a wide variety of micro-founded wage determination used in the search and matching literature that makes wages responsive to workers' outside options, the policy implications of this paper are likely to be relevant.

6.4 An ad hoc wage rule

This section examines cyclical labor market policies when agents determine wages according to an ad hoc wage rule

$$w_t = w\left(\frac{S_t^f}{S^f}\right)^{\gamma_w} \tag{27}$$

where w is the long-run wage target determined by steady-state Nash bargaining, S_t^f is the firm's average match surplus, and S^f is its steady-state level. The parameter γ_w controls real wage elasticity to the firm's match surplus[33]. Conditional on the reasonable range of γ_w, this wage rule specification ensures that real wages remain within the wage bargaining set across business cycles. The ad hoc wage rule prevents wages from being affected by fluctuations in worker surplus and fiscal redistribution. Therefore, the wage rule excludes the job destruction effect of UI adjustments that is the key driver of the UI policy effect when wages are determined by bilateral bargaining.

Table 7 presents the output multiplier in response to a single-quarter 1 percent increase

[33]Wage rigidity associated with the ad hoc wage rule is calibrated to reconstruct the second-order moments of the selected variables presented in Table 2. I observe that $\gamma_w = 0.59$ yields business cycle moments approximately similar to those in the Nash bargaining baseline case.

Type of policy shock	Price rigidity	Timing	SR multiplier	LR multiplier
1% increase in UI benefits	Flexible price	t=1	-0.000	-0.012
		t=2	-0.000	-0.019
	Rigid price	t=1	0.001	0.031
		t=2	0.001	0.104
10% increase in separation cost	Flexible price	t=1	0.005	3.741
		t=2	-0.006	-0.495
	Rigid price	t=1	0.003	2.402
		t=2	-0.005	-1.459

Table 7: Output multiplier of a single-quarter adjustment in labor market policies

in UI benefits or a 10 percent increase in the separation cost. First, in contrast to the case under Nash bargaining, we can observe that the UI extension under rigid prices generates an expansionary impact under the ad hoc wage rule, regardless of the timing of the policy shock. The intuition is straightforward. Because the ad hoc wage setting assumption rules out the job destruction effect, UI extension does not adversely influence labor demand, while the expansionary demand externality generated by UI extension should still be relevant. Hence, UI redistribution raises aggregate demand because of its Keynesian redistribution feature. In addition, UI extension dampens the precautionary saving demand against unemployment risk through the expectation channel. Workers not only expect the reduction in consumption upon unemployment to be moderated but also expect that unemployment risk declines because the expansionary impact of UI extension through Keynesian redistribution increases labor demand. The consequent expansionary demand feedback further stimulates employment and output, as highlighted in McKay and Reis (2016) and Kekre (2018). Figure 7 illustrates the dynamics in response to a single-quarter contemporaneous (first row) or expected (second row) UI extension under the ad hoc wage rule.

In response to EP adjustments, the output stimulus effects are similar to the baseline case of Nash bargaining. EP intensification increases output contemporaneously as it increases employment by reducing layoffs. The expected EP intensification reduces output because it lowers labor demand by reducing the continuation value of a match. Differing from the baseline case, however, the SR output multiplier indicates that an expected

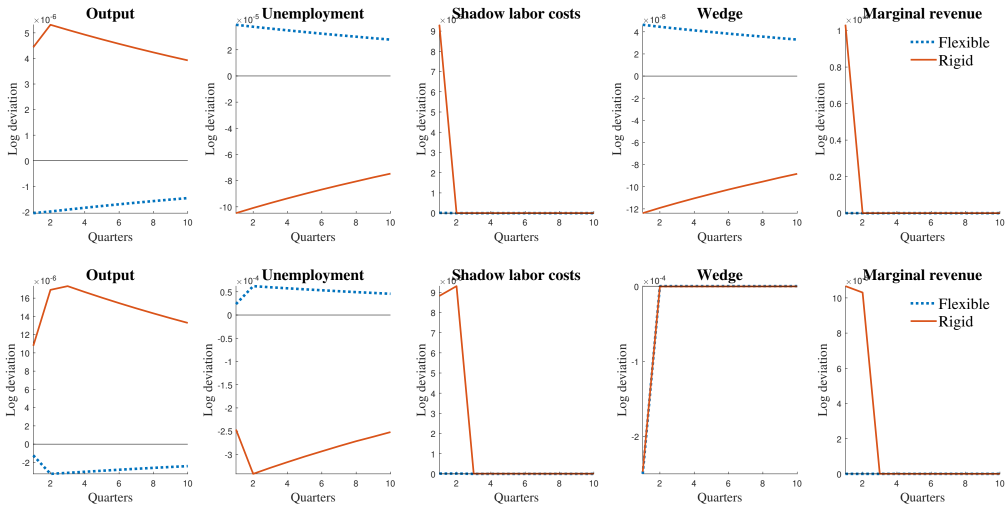


Figure 7: Impulse-Responses to contemporaneous (first row) or expected (second row) single-quarter UI extension, Ad-hoc wage rule

EP intensification yields a more contractionary impact than the expansionary impact in response to contemporary EP extension. This result implies that the economy will experience downturns in the short run when the separation cost is raised for a while. This is because firms reduce hiring more than they decrease layoffs in reaction to the current and expected increases in the separation cost. Figure 8 illustrates the dynamics in response to a single-quarter contemporaneous (first row) or expected (second row) EP extension under the ad hoc wage rule.

Considering the output stimulus, the optimal cyclical behavior of the labor market policies under the ad hoc wage rule is clear. UI should be countercyclical, and EP should be procyclical[34]. Countercyclical UI stabilizes the economy by generating stabilizing demand feedback over business cycles. Procyclical EP is welfare-enhancing because EP adjustment affects firms' incentive to hire more than to fire. Procyclical EP dampens unemployment fluctuations by providing incentives to create jobs during recessions in exchange for amplified job destruction, which also propagates more stabilizing demand feedback over business cycles. Moreover, procyclical EP helps firms dissolve unproductive matches while

[34] I conduct a similar numerical search in which the grid intervals and the step sizes are kept the same as those applied to the baseline analysis in Section 5.1. Among the policy coefficient grid points allowed, the most countercyclical UI ($\gamma_b = -3$) and the most procyclical EP (γ_Ω=10) are optimal and deliver the highest welfare through stabilization.

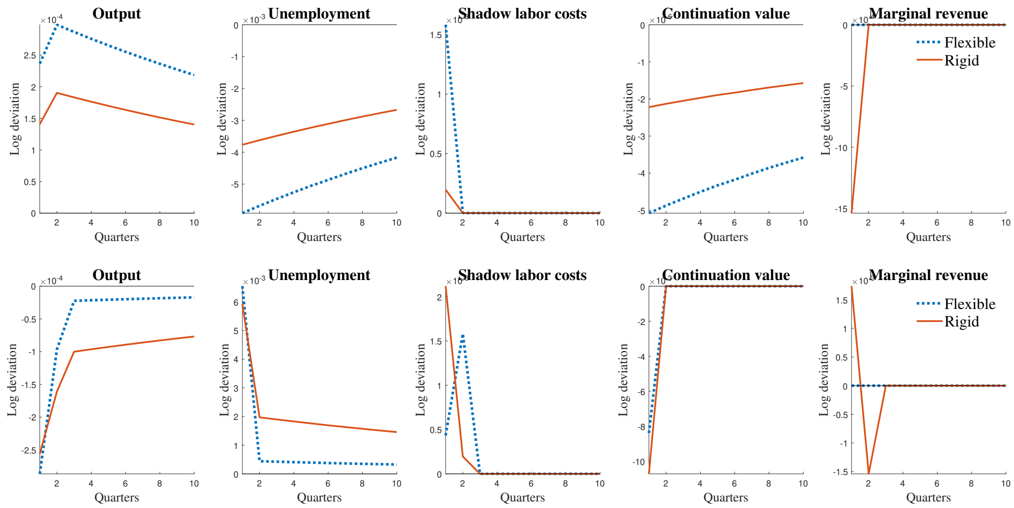


Figure 8: Impulse-Responses to contemporaneous (first row) or expected (second row) single-quarter EP intensification, Ad-hoc wage rule

encouraging firms to create relatively more productive jobs during recessions.

γ_b	Baseline	-3	-1.5	1.5	3
σ_Y	0.01	-13.5%	-6.9%	7.2%	14.5%
σ_u	0.14	-26.1%	-13.3%	13.6%	27.4%
σ_Π	0.00	108.7%	57.8%	-40.8%	5.3%
SW	-37.78	0.05	0.03	-0.04	-0.11
γ_Ω	Baseline	-10	-5	5	10
σ_Y	0.01	30.5%	12.3%	-8.9%	-15.7%
σ_u	0.14	55.8%	22.7%	-16.8%	-29.8%
σ_Π	0.00	-13.2%	-6.3%	5.4%	9.9%
SW	-37.78	-0.232	-0.061	0.025	0.035

Note: The Baseline column in the above table describes the standard deviation of the output, unemployment, inflation, and the conditional social welfare level under acyclical UI. The other columns describe the percentage difference in volatility and the level difference in stochastic welfare relative to the baseline case under different levels of γ_b. The interpretation of the lower table is similar.

Table 8: Volatility and social welfare *w.r.t.* different UI and EP policy rules under the ad hoc wage rule

Figure 9 displays the volatility and stochastic social welfare corresponding to the different policy rule coefficients under the ad hoc wage rule. The ad hoc wage rule suggests that the regime such that $\gamma_b = -3$ and $\gamma_\Omega = 10$ leads to stabilization in the real economy as well as the highest welfare. In this case, countercyclical UI stabilizes an economy through stabilizing demand feedback. Similarly, given countercyclical UI, procyclical EP attains higher welfare through stabilization and efficient cyclical worker reallocation.

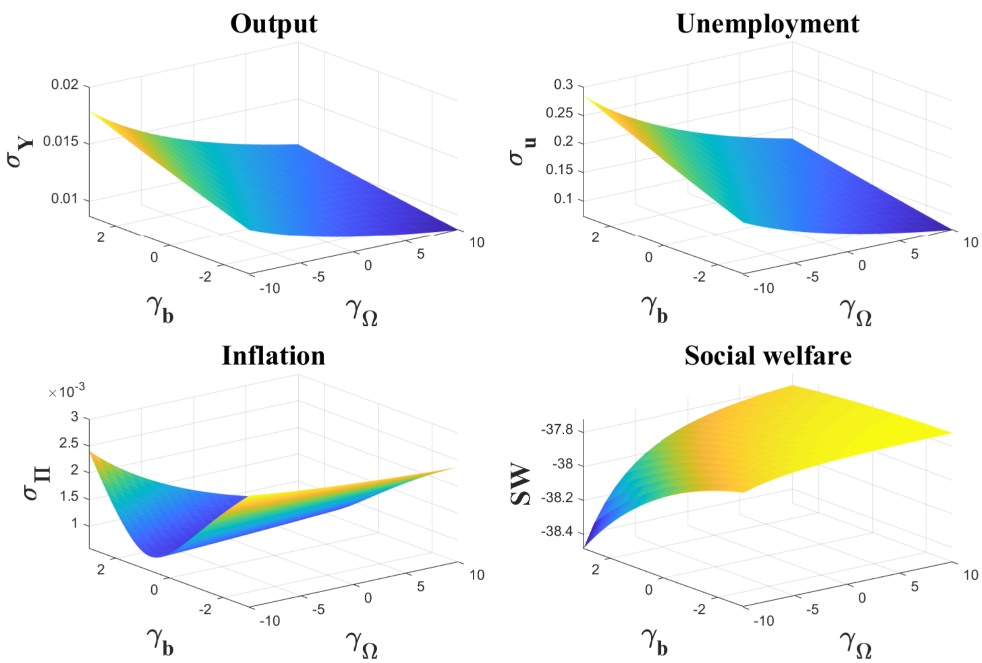


Figure 9: The volatility and welfare corresponding to the different policy rules, ad hoc wage rule

The lessons from the ad hoc wage rule do not repudiate the main results of the paper. Instead, they confirm our intuition and bolster the policy implications. Procyclical UI and countercyclical EP would be desirable when wages are affected by worker surplus and by procyclical fluctuations in workers' other income sources. Countercyclical UI and procyclical EP may be preferable only when wage determination barely relies on these factors.

6.5 The malfunctioning Keynesian automatic stabilizer in a frictional labor market

The Keynesian stabilizing mechanism suggests that redistribution from workers to other agents should raise the aggregate demand in my model economy because workers have a lower MPC than others. However, redistribution that diminishes workers' after-tax income reduces the labor demand through the fiscal increasing return effect, causing a decrease in the aggregate demand as unemployment rises. If the latter effect dominates, redistribution from workers to others with a higher MPC can be contractionary. Figure 10 illustrates this idea.

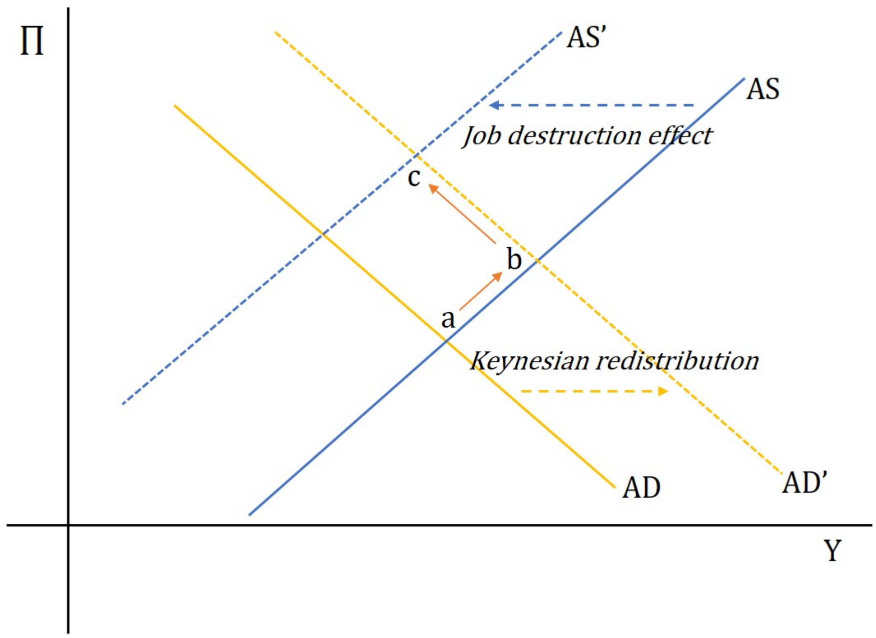


Figure 10: The conflict between the expansionary Keynesian redistribution effect and the contractionary job destruction effect

I examine this intuition through a simple exercise such that the degree of fiscal redistribution from employed workers to unemployed workers varies according to the following policy rule: $\alpha_t = \alpha \left(\frac{Y_t}{Y} \right)^{\gamma_\alpha}$. When the Keynesian stabilization effect dominates, the economy should be less volatile under countercyclical fiscal transfers from workers to unemployed households and the government. In contrast, procyclical fiscal redistribution stabilizes the economy if the job destruction effect dominates. The impact of profit transfers to workers should work in the opposite direction[35]. The policy coefficients range from -5 to 5, and the step size is set to 0.1.

Figure 11 illustrates that procyclical fiscal transfers from workers to unemployed households or countercyclical profit transfers from entrepreneurs to workers lead to higher

[35]Since entrepreneurs are hand-to-mouth consumers, profit transfers should produce stabilizing effects when profits are rebated to workers countercyclically (procyclically) according to the job destruction effect (the Keynesian redistribution effect). I denote the worker's ex-ante profit share as δ. The baseline calibration supposes that workers do not receive profit dividends, i.e., $\delta = 0$. To examine the impact of cyclical profit redistribution, I suppose that workers can claim 50 percent of the total net profits in a steady-state equilibrium, $\delta = 0.5$.

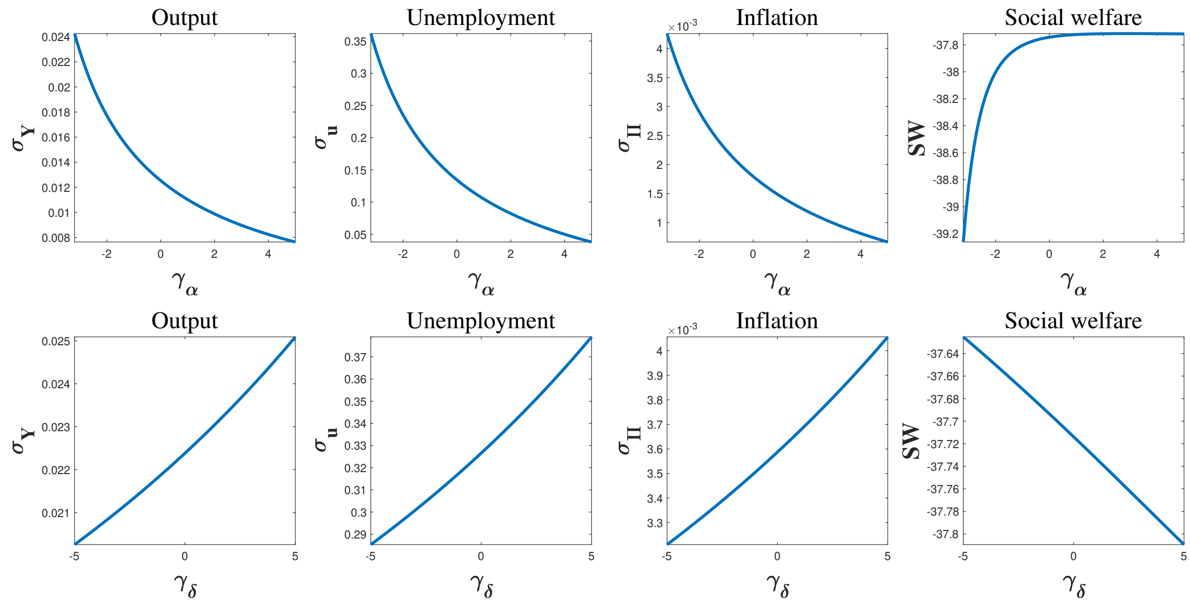


Figure 11: Business cycle properties *w.r.t.* extent of cyclical adjustment of fiscal (first row) and profit (second row) transfers

stochastic welfare through stabilization. The result confirms the intuition of the job destruction effect: any redistribution amplifying procyclical fluctuations in the worker's net income could be destabilizing because the destabilizing job destruction effect negates the stabilizing Keynesian redistribution effect. More generally, the result indicates that the negative supply-side externality may neutralize the expansionary effect of Keynesian redistribution when wages are responsive to workers' surplus. The negative supply-side externality of Keynesian redistribution is irrelevant if the labor market is complete and if wages are unaffected by workers' surplus from employment. A standard example is when wages equal the marginal productivity of labor.

Workers' ex-ante profit share deserves attention. Profits fluctuate procyclically in response to technology shocks. As profit dividends account for a large part of workers' after-tax income, workers face more extensive procyclical income fluctuations. Hence, the job destruction effect causes the economy to be more volatile when workers have a higher ex-ante profit share. The result is the opposite under alternative shocks (e.g., demand shocks) that result in countercyclical profit fluctuations. In this case, the economy is likely to be more stable when workers have a higher ex-ante profit share.

7 Conclusion

I examine the macroeconomic implications of cyclical labor market policy accommodations. UI extension considerably hurts firms' incentive to provide jobs under bilateral wage bargaining. Hence, procyclical UI is preferable. On the other hand, EP should be countercyclical because the separation cost affects firms' incentive to fire more than to hire. Countercyclical EP leads to higher welfare through stabilization both via supply and demand channels. The wage-setting assumption is crucial for policy implications. When wages are independent of workers' outside options and procyclical fluctuations in other income sources, countercyclical UI and procyclical EP can efficiently stabilize the economy and yield superior welfare outcomes.

The theory leaves out some essential features of the real world. Specifically, the model rules out household wealth accumulation and income heterogeneity. In addition, government debt dynamics are absent. Allowing rich heterogeneity might lead to non-trivial differences in policy implications. Second, EP usually results in a dual labor market, which implies an asymmetric impact of EP on households depending on their contract type and employment status. Indeed, labor market duality seems to be an essential factor in determining the efficiency of EP legislation. Third, I do not discuss cyclical labor market policy adjustment when monetary policy is restricted by a zero lower bound on the nominal interest rates or a single currency regime. It could be interesting to examine whether cyclical labor market policy accommodations might be an effective alternative to restricted monetary policy. Finally, the results predict that the economy is more prone to the UI job destruction effect when workers have less wage-bargaining power. One of the standard measures of worker bargaining power is labor union density, which has been declining since the 1970s. One way to examine the proposed theory is to investigate whether the decline in labor union density induces UI extension to have a more detrimental impact on employment. Furthermore, this analysis could reassess the adequacy of the bilateral wage bargaining assumption in the search and matching literature. I plan to pursue these issues in future works.

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A Appendix

A.1 Figures

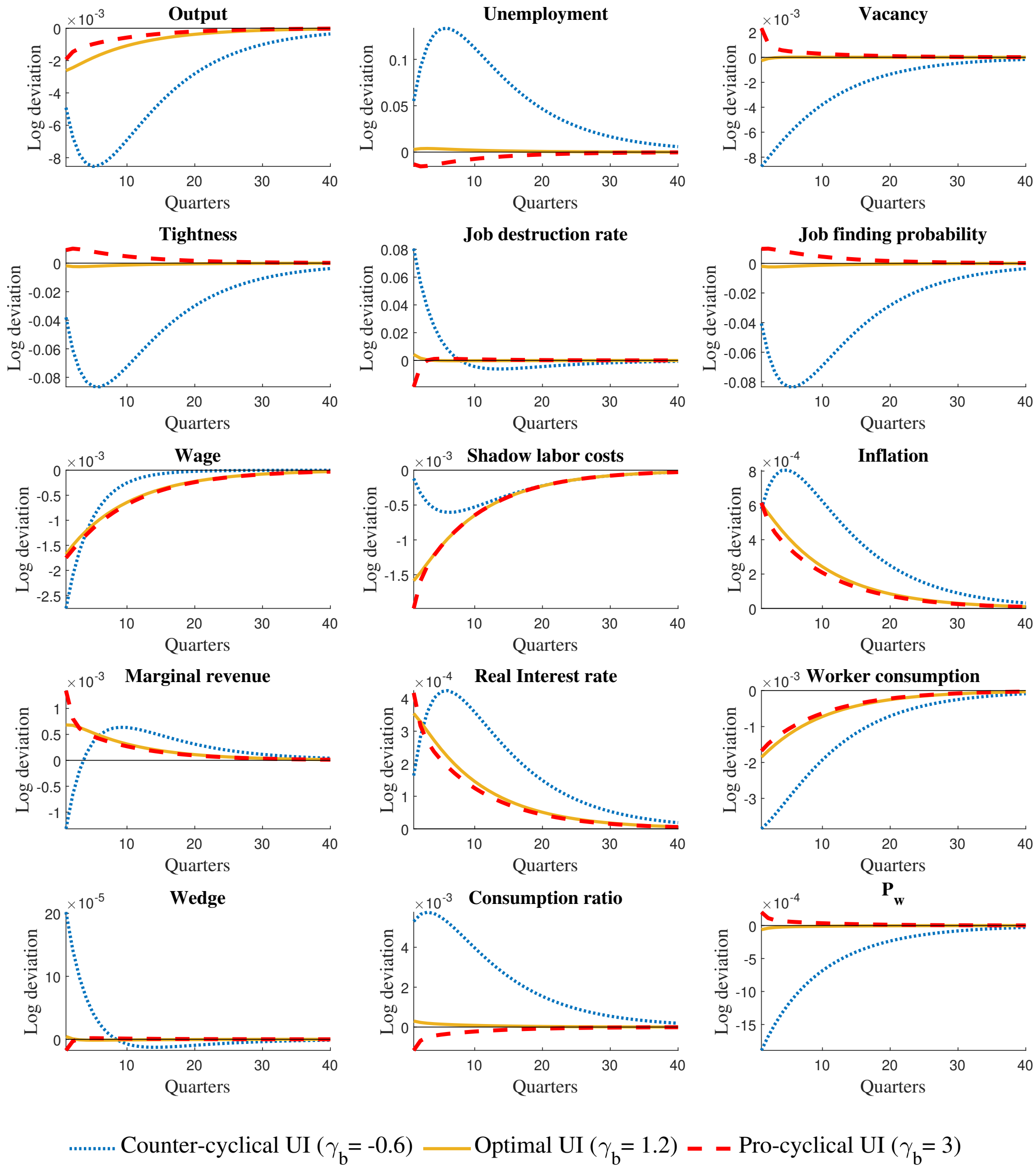


Figure A.1: Impulse-Responses to one standard deviation adverse technology shocks, UI rule

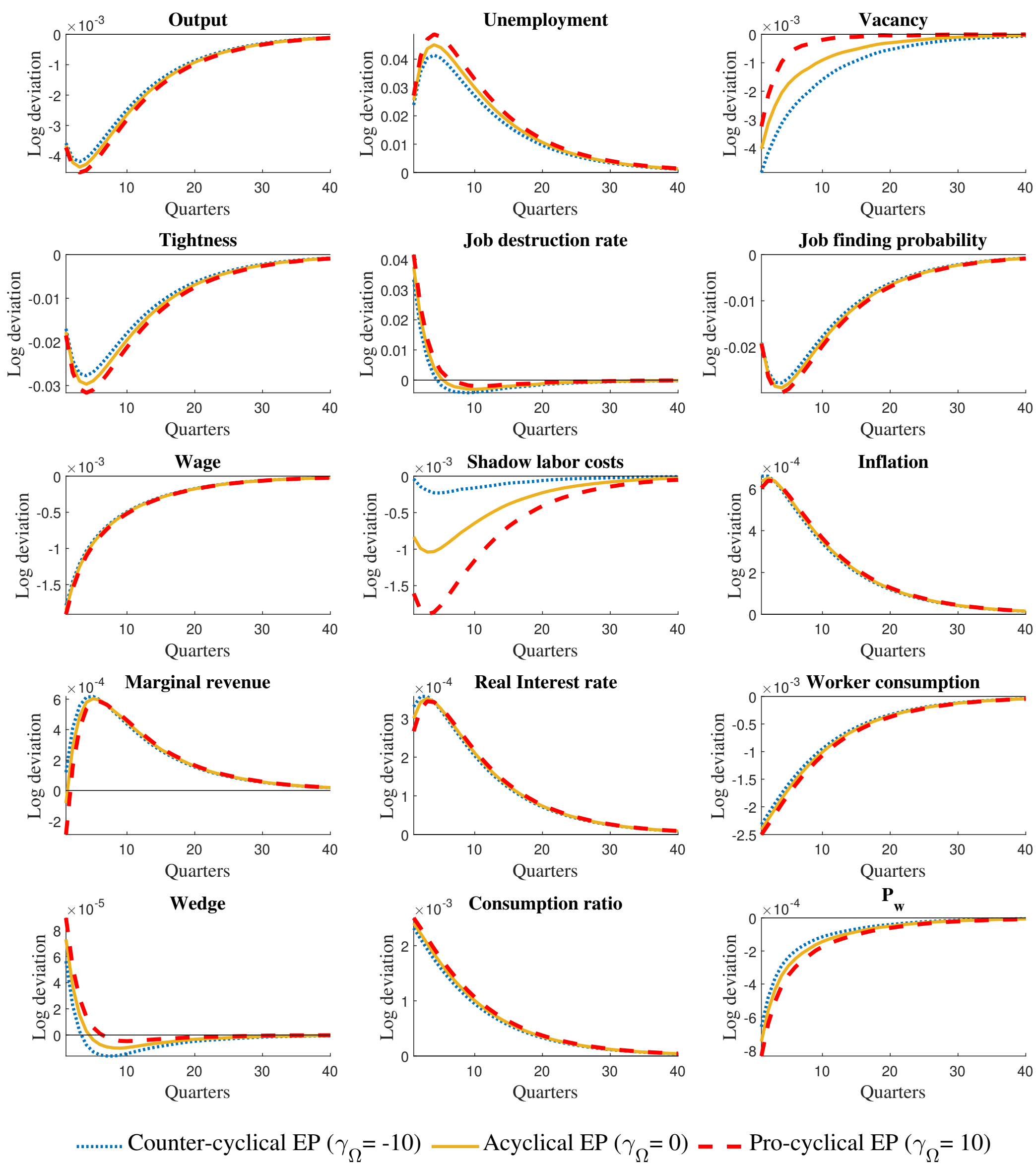


Figure A.2: Impulse-Responses to one standard deviation adverse technology shocks, EP rule

A.2 Estimation details

A.2.1 Data and measurement

I reconstruct the time series of the job finding probability and separation rate using Current Population Survey (CPS) gross flows and unemployment duration data. The data are collected monthly and seasonally adjusted. According to Abraham and Shimer (2001), the redesign of the CPS instrument in 1994 produces a discontinuity in the short-term unemployment series. Thus, I restrict the sample period from the first quarter of 1995 to the third quarter of 2019.

The empirical moments of the vacancy-unemployment ratio are computed using Job Openings and Labor Turnover Survey (JOLTS) data. The data provide the number of job openings in the entire non-farm business sector and are collected monthly and seasonally adjusted. Due to data availability, the vacancy-unemployment ratio is computed over the first quarter of 2001 to the third quarter of 2019.

Using the stream of the quarterly real GDP per capita provided by the Bureau of Economic Analysis, I compute the cyclicality of the variables of interest and the volatility of the output. The sample covers the first quarter of 1995 to the third quarter of 2019.

The log-normal distribution of idiosyncratic productivity approximates the empirical distribution of net compensation to employees by employers in 2012 using Social Security Administration data. The sample year is chosen arbitrarily, but the estimation result is generally robust to the reference year. The data report the net compensation subject to federal income taxes reported by employers. Since I seek to approximate the idiosyncratic productivity distribution, it seems more appropriate to use the distribution of the net compensation than household income distribution from the CPS census, which includes all sources of household income.

The monthly data are averaged quarterly, and the quarterly data are detrended using an HP filter with a smoothing parameter of 1600. Table A.1 summarizes the business cycle statistics in the U.S labor market.

		u	v	v/u	fs	F	Y
Standard deviation		0.107	0.120	0.229	0.090	0.046	0.010
Quarterly autocorrelation		0.961	0.912	0.942	0.905	0.539	0.926
Correlation matrix	u	1	-0.906	-0.960	-0.945	-0.032	-0.910
	v	-	1	0.983	0.837	-0.042	0.877
	v/u	-	-	1	0.902	0.012	0.892
	fs	-	-	-	1	0.274	0.859
	F	-	-	-	-	1	-0.106
	Y	-	-	-	-	-	1

Note: All variables are reported in logs as a deviation from the HP trend with a smoothing parameter of 1600. Due to data availability, the vacancy and v-u ratio statistics are computed over periods from Q1 2000 to Q3 2019. The other statistics build upon data ranging from Q1 1995 to Q3 2019.

Table A.1: Business cycle statistics, Quarterly, U.S labor market, Q1 1995 - Q3 2019

A.2.2 The estimation strategy

A.2.3 Transition rates

Given the level data of the employed (N_t), unemployed (U_t), and short-term unemployed (U_t^s), the gross flow of unemployment can be described according to our model as follows:

$$U_t = (1 - f_t s_t)U_{t-1} + U_t^s$$
$$U_t^s = (1 - f_t s_t)F_t N_{t-1}$$

The short-term unemployed are workers who were dismissed less than one month ago at a certain date of the survey and are still classified as unemployed, indicating that they are conducting job-seeking activities. Hence, the short-term unemployed correspond to $(1 - f_t s_t)F_t N_{t-1}$ rather than $F_t N_{t-1}$. Workers could find a job and be dismissed several times in the same survey month. I treat this case as if firing occurs only once among these workers.

Given the data, I cannot separately identify f_t and s_t and can only reconstruct the job finding rate, $f_t s_t$. Since the model does not allow entry or exit from the labor force, I need to correct the measurement equations appropriately as follows:

$$u_t = g_L(1 - f_t s_t)u_{t-1} + u_t^s$$
$$u_t^s = g_L(1 - f_t s_t)F_t n_{t-1}$$

where $u_t = \frac{U_t}{L_t}$, $n_t = \frac{N_t}{L_t}$, $u_t^s = \frac{U_t^s}{L_t}$, $g_L = \frac{L_{t-1}}{L_t}$ and $L_t = U_t + N_t$. Using the stream of data of n_t, u_t and u_t^s, I can recover $f_t s_t$ from the first equation and F_t from the second equation.

A.2.4 The idiosyncratic productivity distribution

The data provide the number of wage earners by the level of net compensation classified by 59 class intervals. The data entail a truncation issue from below by construction. I first take a log on average wages in each bin. Subsequently, the empirical distribution of the log wage is standardized to obtain a unit mean. Then, the log-normal distribution parameters, μ_a and σ_a, are estimated to yield the minimum difference between the estimated cumulative distribution function and the empirical counterpart over the entire support of the distribution.

A.3 Mathematical appendix

A.3.1 Proposition 1 - Asset pricing

Given the nominal interest rate R_t and using the condition $c_{u,t} = \tilde{r}c_{w,t}$, the Euler equations of employed and unemployed households can be written as follows:

$$R_t \mu_{w,t} = c_{w,t}^{-\sigma}\left[1 - \beta E_t\left(\frac{1}{\Pi_{t+1}}(P_{w,t+1} + (1 - P_{w,t+1})\tilde{r}_t^{-\sigma})(\frac{c_{w,t+1}}{c_{w,t}})^{-\sigma}\right)\right]$$

$$R_t \mu_{u,t} = c_{u,t}^{-\sigma}\left[1 - \beta E_t\left(\frac{1}{\Pi_{t+1}}\frac{((1 - P_{u,t+1}) + P_{u,t+1}\tilde{r}_t^{-\sigma})}{\tilde{r}_t^{-\sigma}}(\frac{c_{w,t+1}}{c_{w,t}})^{-\sigma}\right)\right]$$

$$\therefore \quad \frac{\mu_{w,t}}{\mu_{u,t}} = \tilde{r}_t^{\sigma}\frac{\left(1 - \beta E_t\left[\frac{1}{\Pi_{t+1}}(P_{w,t+1} + (1 - P_{w,t+1})\tilde{r}_t^{-\sigma})(\frac{c_{w,t+1}}{c_{w,t}})^{-\sigma}\right]\right)}{\left(1 - \beta E_t\left[\frac{1}{\Pi_{t+1}}(\tilde{r}_t^{\sigma}(1 - P_{u,t+1}) + P_{u,t+1})(\frac{c_{w,t+1}}{c_{w,t}})^{-\sigma}\right]\right)}$$

Since $\tilde{r}_t < 1 < \sigma$, we obtain the following:

$$\tilde{r}_t^{\sigma}(1 - P_{u,t+1}) + P_{u,t+1} \leq P_{w,t+1} + (1 - P_{w,t+1})\tilde{r}_t^{-\sigma}$$

Thus, the following is trivial:

$$\frac{(1-\beta E_t[\frac{1}{\Pi_{t+1}}(P_{w,t+1}+(1-P_{w,t+1})\tilde{r}_t^{-\sigma})(\frac{c_{w,t+1}}{c_{w,t}})^{-\sigma}])}{(1-\beta E_t[\frac{1}{\Pi_{t+1}}(\tilde{r}_t^{\sigma}(1-P_{u,t+1})+P_{u,t+1})(\frac{c_{w,t+1}}{c_{w,t}})^{-\sigma}])}\leq 1$$

Since $\tilde{r}_t^{\sigma} << 1$, $\mu_{w,t} < \mu_{u,t}$ follows. □

The equilibrium with any $\mu_{w,t}$ satisfying $0 \leq \mu_{w,t} < \mu_{u,t}$ can constitute an equilibrium such that $d_t = 0$ among all households. Among the infinite number of feasible equilibria, the equilibrium in which $\mu_{w,t} = 0$ for all t is the constrained Pareto optimum given the nominal interest rate that households take as a given. Suppose that $\mu_{w,t} = \bar{\mu} > 0$ and denote $c_{w,t,1}$ as the consumption of workers corresponding to the Lagrange multiplier $\bar{\mu} > 0$. The corresponding Euler equation can be written as follows:

$$c_{w,t,1}^{-\sigma} = \beta E_t\left[\frac{R_t}{\Pi_{t+1}}(P_{w,t+1}c_{w,t+1}^{-\sigma}+(1-P_{w,t+1})b_{t+1}^{-\sigma})\middle|\mathbf{S_{t+1}}\right]+R_t\bar{\mu}$$

Conditional on R_t and the allocation from period *t+1*, suppose an alternative allocation in period t such that the worker's consumption equals $c_{w,t,2}$ and the corresponding Lagrange multiplier $\widehat{\mu}$ satisfies $0 < \widehat{\mu} < \bar{\mu}$. Formally,

$$c_{w,t,2}^{-\sigma} = \beta E_t\left[\frac{R_t}{\Pi_{t+1}}(P_{w,t+1}c_{w,t+1}^{-\sigma}+(1-P_{w,t+1})b_{t+1}^{-\sigma})\middle|\mathbf{S_{t+1}}\right]+R_t\widehat{\mu}$$

It is obvious that the new allocation with $\widehat{\mu}$ and $c_{w,t,2}$ also satisfies the equilibrium condition. The allocation in other periods is unaffected by this marginal adjustment. Since $\widehat{\mu} < \bar{\mu}$, conditional on the same allocation of the other variables, $c_{w,t,2} > c_{w,t,1}$. If $\mu_{w,t}$ is strictly positive, a worker can increase welfare by reducing $\mu_{w,t}$ and raising $c_{w,t}$ without violating the equilibrium condition. Thus, the equilibrium allocation maximizing workers' lifetime utility should be $\mu_{w,t} = 0$, and $c_{w,t}$ is determined to be consistent with this Lagrange multiplier. The Euler equation can be written as follows:

$$c_{w,t}^{-\sigma} = \beta E_t\left[\frac{R_t}{\Pi_{t+1}}(P_{w,t+1}c_{w,t+1}^{-\sigma}+(1-P_{w,t+1})b_{t+1}^{-\sigma})\middle|\mathbf{S_{t+1}}\right]$$

The equilibrium price of a bond, R_t^N, clearing the bond market should be as follows:

$$\frac{1}{R_t^N} = \beta E_t \left[\frac{1}{\Pi_{t+1}} (\frac{c_{w,t+1}}{c_{w,t}})^{-\sigma} (P_{w,t+1} + (1 - P_{w,t+1}) \tilde{r}^{-\sigma}) \Big| \mathbf{S_{t+1}} \right]$$

The saver in this economy is indifferent at zero bond holding under the price of the bond R_t^N. Thus, $\frac{1}{R_t^N}$ is a global upper bound on the equilibrium bond price. □

A.3.2 Proposition 3 - Nash wage bargaining

The firm's surplus

To define the firm's average surplus from a match, I begin by the following job destruction condition for an incumbent worker:

$$\mu_t A_t \bar{a}_t - w_t + \kappa \Big(\frac{v_t}{n_t}\Big)^{1+\nu} \frac{Y_t}{n_t} + \beta E_t \Big[- \Omega_{t+1} F_{t+1} + \mu_{t+1} A_{t+1} \int_{\bar{a}_{t+1}} a dF(a) - (1 - F_{t+1}) \lambda_{t+1} \Big] = -\Omega_t$$

$\bar{a}_t$ is the marginal productivity producing zero net surplus from an incumbent match. The left-hand side indicates the gross surplus that a firm obtains from a match with a marginal productivity $\bar{a}_t$. If the surplus is smaller than $-\Omega_t$, a firm declares separation. The job destruction condition for an incumbent worker suggests that the net surplus from an incumbent match with idiosyncratic productivity a should be written as follows:

$$J^I(a) = \mu_t A_t a - w_t + \kappa \Big(\frac{v_t}{n_t}\Big)^{1+\nu} \frac{Y_t}{n_t} + \Omega_t + \beta E_t \Big[- \Omega_{t+1} F_{t+1} + \mu_{t+1} A_{t+1} \int_{\bar{a}_{t+1}} a dF(a) - (1 - F_{t+1}) \lambda_{t+1} \Big]$$

The net surplus from newly formed matches is similar as follows:

$$J^N(a) = \mu_t A_t a - w_t + \kappa \Big(\frac{v_t}{n_t}\Big)^{1+\nu} \frac{Y_t}{n_t} + \beta E_t \Big[- \Omega_{t+1} F_{t+1} + \mu_{t+1} A_{t+1} \int_{\bar{a}_{t+1}} a dF(a) - (1 - F_{t+1}) \lambda_{t+1} \Big]$$

The conditional average net surplus from a match, J_t^f, can be computed as follows:

$$
\begin{aligned}
J_t^f &= \frac{n_{t-1}\int_{\bar{a}_t} J^I(a)dF(a) + M_t \int_{\widehat{a}_t} J^N(a)dF(a)}{n_t} \\
&= \mu_t \frac{Y_t}{n_t} - w_t + \kappa\left(\frac{v_t}{n_t}\right)^{1+\nu}\frac{Y_t}{n_t} + \beta E_t\Big[-\Omega_{t+1}F_{t+1} + \mu_{t+1}A_{t+1}\int_{\bar{a}_{t+1}} adF(a) - (1-F_{t+1})\lambda_{t+1}\Big] \\
&+ \frac{n_{t-1}(1-F_t)\Omega_t}{n_t}
\end{aligned}
$$

The net surplus from a vacancy posting (VC_t) can be obtained from the job creation condition as follows:

$$
VC_t \equiv \tilde{q}_t\Big(\mu_t A_t \int_{\widehat{a}_t} adF(a) - (1-\widehat{F}_t)\lambda_t\Big) - \kappa\left(\frac{v_t}{n_t}\right)^{\nu}\frac{Y_t}{n_t}
$$

If $v_t > 0$, the net surplus should be zero in equilibrium. The firm's average net surplus from a match, S_t^f, is defined as follows:

$$
\begin{aligned}
S_t^f &= J_t^f - \max\{0, VC_t\} \\
&= \mu_t \frac{Y_t}{n_t} - w_t + \kappa\left(\frac{v_t}{n_t}\right)^{1+\nu}\frac{Y_t}{n_t} + \beta E_t\Big[-\Omega_{t+1}F_{t+1} + \mu_{t+1}A_{t+1}\int_{\bar{a}_{t+1}} adF(a) - (1-F_{t+1})\lambda_{t+1}\Big] \\
&+ \frac{n_{t-1}(1-F_t)\Omega_t}{n_t}
\end{aligned}
$$

The worker's surplus

The job search and recruitment processes are over when the wage is bargained. Workers could be either employed by accepting the wage offer or unemployed by rejecting the offer and terminating the contract. Thus, the heterogeneity across workers in terms of the employment status at the beginning of each period is irrelevant. The worker's surplus (S_t^w) can be written as follows:

$$
S_t^w = \frac{c_{w,t}^{1-\sigma} - c_{u,t}^{1-\sigma}}{1-\sigma} - h + \beta E_t[(1-F_{t+1})(1-f_{t+1}s_{t+1})\Delta V_{t+1} + (1-F_{t+1})h(s_{t+1})]
$$

where $c_{w,t} = w_t - \widehat{T}_t + \widehat{D}_t^w$ in equilibrium. S_t^w equals ΔV_t.

Nash bargaining solution

The optimal Nash bargaining wage maximizes the following weighted surplus of a match:

$$w_t = \underset{w_t}{\text{argmax}} (S_t^w)^{\zeta} (S_t^f)^{1-\zeta}$$

where ζ denotes the worker's bargaining power. Using equation (10) and the worker's equilibrium budget constraint, we can obtain the wage equation (26). □

A.3.3 Alternative offer bargaining

This section describes the details of alternative wage offer bargaining (AOB). The basic setup is similar to that described by Christiano et al. (2016), but a few changes were made to consider the worker's risk aversion during bargaining. The bargaining process proceeds as follows. At the start of period t, n_t workers exist. Similarly, risk-neutral entrepreneurs provide insurance against wage dispersion resulting from idiosyncratic productivity shocks. Hence, wages are homogeneous. Workers and entrepreneurs negotiate the wage, w_t. Each worker takes the lump-sum transfers and future welfare as given during wage bargaining. Similarly, each firm takes the gain or loss from matches as given, except for the wage. Finally, each worker-firm bargaining pair takes the bargaining outcome of all other periods as given.

The wage is negotiated across infinite subperiods within each quarter. For simplicity, I assume that both parties do not time-discount subperiods. A firm makes an initial wage offer and is eligible for wage offers at the start of a subsequent odd subperiod if all previous wage negotiations were rejected. Similarly, a worker can offer a wage at the beginning of an even subperiod if wage negotiation cannot reach an agreement until that subperiod. The wage negotiation is terminated exogenously with probability ζ. In this case, the match is over, and the worker ends up being unemployed, while the firm has a zero match surplus. Finally, firms must pay the negotiation cost $-\delta$ when making a counteroffer. The equilibrium wage, w_t, would be determined by the initial wage proposal by firms. I write the firm's wage offer w_t, which would be the equilibrium wage. The worker's wage offer is denoted as w_t^I.

If the equilibrium wage is $\tilde{w}_t$, the firm's surplus, $S_t^f \equiv S(\tilde{w}_t)$, can be written as follows:

$$S(\tilde{w}_t) = \mu_t \frac{Y_t}{n_t} - \tilde{w}_t + \kappa\left(\frac{v_t}{n_t}\right)^{1+\nu}\frac{Y_t}{n_t} \tag{A.1}$$

$$+\beta E_t\left[-\Omega_{t+1}F_{t+1} + \mu_{t+1}A_{t+1}\int_{\bar{a}_{t+1}} adF(a) - (1-F_{t+1})\lambda_{t+1}\right] + \frac{n_{t-1}(1-F_t)\Omega_t}{n_t}$$

$$= X_t - \tilde{w}_t \tag{A.2}$$

where X_t aggregates the firm's gross match surplus, which the firm takes as a given. Similarly, given the equilibrium wage $\tilde{w}_t$, the worker would obtain the surplus $V_t(\tilde{w}_t)$ if employed and U_t if any party in the bargaining chooses to terminate the match. V_t and U_t can be described as follows:

$$V_t(\tilde{w}_t) = \frac{(\tilde{w}_t + TR_t)^{1-\sigma} - 1}{1-\sigma} + Z_{w,t} \tag{A.3}$$

$$U_t = \frac{c_{u,t}^{1-\sigma} - 1}{1-\sigma} + Z_{u,t} \tag{A.4}$$

where TR_t denotes the transfers that workers obtain in period t, and $Z_{w,t}$ includes the worker's future surplus and disutility from working. Similarly, $Z_{u,t}$ represents the future surplus of the unemployed. Again, the worker takes these terms as a given when she bargains the wage. In the odd subperiod, a firm offers the wage, which satisfies the worker's indifference condition as follows:

$$V(w_t) = \zeta U_t + (1-\zeta)V(w_t^I) \tag{A.5}$$

Similarly, a worker offers the wage at every even subperiod, satisfying the firm's indifference condition as follows:

$$S(w_t^I) = (1-\zeta)(-\delta + S(w_t)) \tag{A.6}$$

Using equations (A.2) and (A.6), we can obtain the following:

$$
\begin{aligned}
& X_t - w_t^I = (1-\zeta)(-\gamma + X_t - w_t) \\
& \therefore w_t^I = (1-\zeta)\delta + \zeta X_t + (1-\zeta) w_t
\end{aligned}
\tag{A.7}
$$

Equations (A.2), (A.5), and (A.7) yield the following:

$$
\begin{aligned}
V(w_t) &= \zeta U_t + (1-\zeta) V\big((1-\zeta)\delta + \zeta X_t + (1-\zeta) w_t\big) \\
&= \zeta U_t + (1-\zeta) V\big(\zeta S_t^f + w_t + (1-\zeta)\delta\big)
\end{aligned}
\tag{A.8}
$$

Equation (A.8) implicitly determines the equilibrium wage, w_t. If $\zeta = 1$, the wage would equal the worker's reservation wage. In contrast, the equilibrium wage approaches the firm's reservation wage as ζ declines. We can simplify equation (A.8) using equation (A.3). Then, we can find the following:

$$
V\big(\zeta S_t^f + w_t + (1-\zeta)\delta\big) = V(w_t) - \frac{c_{w,t}^{1-\sigma}}{1-\sigma} + \frac{(\zeta S_t^f + (1-\zeta)\delta + c_{w,t})^{1-\sigma}}{1-\sigma} \tag{A.9}
$$

where $c_{w,t} = w_t + TR_t$ denotes the worker's net income. After inserting equation (A.9) into equation (A.8), we can obtain the following equilibrium wage equation:

$$
\frac{\zeta}{1-\zeta} \Delta V_t = \frac{(\zeta S_t^f + (1-\zeta)\delta + c_{w,t})^{1-\sigma} - c_{w,t}^{1-\sigma}}{1-\sigma} \qquad \square
$$

External calibration		
Parameter	Value	Remark
σ	2	Coefficient of relative risk aversion
η	8	Elasticity of substitution between intermediates
Ψ	80	Rotemberg price adjustment costs
γ_R	1.5	Taylor rule coefficient on inflation
ζ	0.5	Worker's bargaining power
Λ	0.015	Social welfare weight to entrepreneurs
Steady-state targets and indirectly calibrated parameters		
Steady-state targets		
Target	Value	Remark
F	0.032	Quarterly job destruction rate for incumbent workers
$\widehat{F}$	0.05	Quarterly job destruction rate for newly formed matches
fs	0.378	Quarterly job finding rate
$\frac{v}{u}$	0.65	Vacancy-to-Unemployment ratio
c_u/c_w	0.89	Relative consumption upon unemployment
b/w	0.4	Steady-state UI replacement rate
G/Y	0.175	Government final consumption spending per GDP
$\widehat{T}n/T$	0.4	Tax on personal income / Total tax revenue
s	0.75	Average job search hours relative to working hours
R^N	1.01	Quarterly nominal interest rates
Π	1	Zero gross inflation
$\left.\frac{\partial \frac{1}{fs}}{\partial b}\right\|_f$	0.9	Partial equilibrium unemployment duration elasticity to UI benefits
Indirectly calibrated parameters		
Parameter	Value	Remark
β	0.985	Time discount rate
h	0.0650	Disutility of working
p	0.3015	Home production
ε	11.5	Curvature of job search disutility
Φ	$1.1332e^{-09}$	Scale parameter of job search disutility
μ_a	-0.186	Idiosyncratic productivity shock parameter (average)
σ_a	0.0130	Idiosyncratic productivity shock parameter (standard deviation)
G	0.1397	Quarterly government consumption
α	0.4	Degree of redistribution
γ	4.2847	Matching function elasticity
Ω	0.0130	Separation cost
κ	$3.4561e^{03}$	Vacancy posting cost
Internal calibration		
Parameter	Value	Remark
ν	4	Convexity of hiring costs
ρ_A	0.9	Autocorrelation of technology shocks
σ_A	0.0025	Standard deviation of technology shocks
γ_w	0.59	Real wage rigidity for the ad hoc wage rule

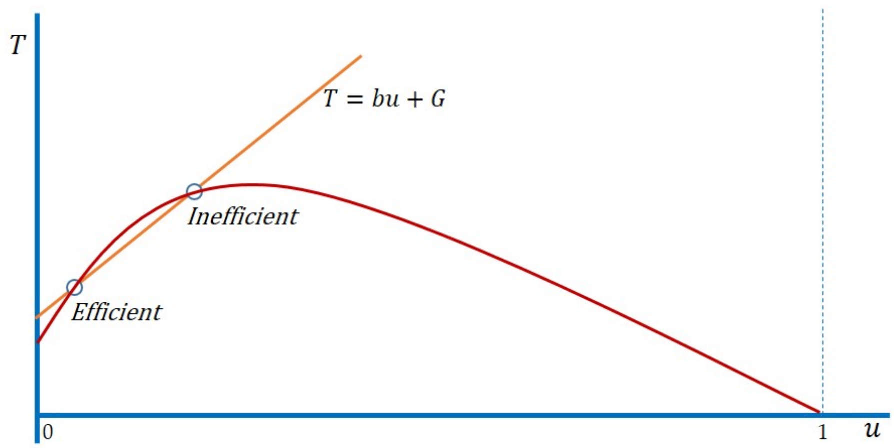
Table A.2: Calibration targets and parameter values

A.4 The optimal *ex-ante* level of labor market policies

A.4.1 Unconditional welfare analysis

This section addresses the steady-state analysis. Although the aggregate economy remains at a deterministic equilibrium in which aggregate shocks are shut off, households' employment status is time-varying as idiosyncratic productivity shocks still occur.

The steady-state multiplicity



Note: The yellow linear line depicts the total government spending as a function of unemployment. The red inverted U-shaped curve illustrates the total tax revenue similarly as a function of unemployment.

Figure A.3: The multiple steady-states

In addition to the corner solution cases, the system has two interior steady-states. The steady-state multiplicity stems from the Laffer-curve relationship originating from the fiscal increasing return effect. Given UI benefits and government consumption, fiscal regimes are characterized by low tax per worker - low unemployment (*Efficient*) or high tax per worker - high unemployment (*Inefficient*). Efficient allocation is the steady-state that I target through calibration, while inefficient allocation is an auxiliary equilibrium. Blanchard and Summers (1986) and Den Haan (2007) also note the steady-state multiplicity due to fiscal redistribution. If the tax burden on workers is a function of unemployment and government spending is sufficiently large, the model may yield multiple steady-state equilibria under reliable calibration. Furthermore, both equilibria can be locally stable if the labor market is associated with the matching friction. The steady-state multiplicity disappears if $\alpha = 0$. Table A.3 compares the steady-states.

Compared to efficient allocation, the inefficient equilibrium features a lower after-tax income of workers, higher unemployment, fewer vacancies, lower job search intensity, and lower welfare of all types of households. Although the transition between these multiple equilibria due to shocks or policy reforms would be an interesting research topic, it is outside of this paper's scope. Hence, I limit attention to the dynamics of efficient equilibrium.

	Y	u	v	θ	F	f	s	c_w	λ	V^w	V^u
Efficient	0.799	0.050	0.033	0.539	0.032	0.504	0.750	0.668	0.613	-37.712	-38.014
Inefficient	0.694	0.175	0.028	0.192	0.033	0.182	0.732	0.641	0.614	-42.178	-42.505

Table A.3: The multiple steady-state equilibria under baseline calibration

Unemployment Insurance

After the seminal works by Baily (1978) and Chetty (2006a), it is well understood that optimal unemployment insurance should solve the insurance-incentive tradeoff. UI is a social safety net protecting households from a sharp income decline upon unemployment. However, UI also discourages an incentive to search for a job, leading to inefficiently high and prolonged unemployment. The Baily-Chetty formula resolves this incentive-insurance tradeoff.

The Baily-Chetty framework is an incomplete argument because it does not consider firm behavior. If workers have some bargaining power, generous UI raises wages as workers' outside options increase. Since firms obtain a smaller match surplus, the labor demand declines (*job destruction effect*). If the job destruction effect is potent, UI extension not only stimulates moral hazard behavior but also generates supply-side externality decreasing the labor demand. Thus, the optimal UI should be lower than the Baily-Chetty optimum. This effect implies that a reduction in UI may provide better insurance against unemployment risk because workers are less likely to be laid off, while job seekers are more likely to find a job. The welfare benefits from the increased chances of employment may more than offset the welfare costs from a large consumption reduction upon unemployment.

Landais et al. (2010) document that generous UI provision may be desirable if the labor market is slack (i.e., labor market tightness is inefficiently low), and that UI extension reduces tightness. Generous UI relieves inefficient competition in the labor market (*rat race effects*). UI extension efficiently discourages job searching, which raises the job finding probability per unit of effort and employment. In this case, the optimal UI should be higher than the Baily-Chetty optimum.

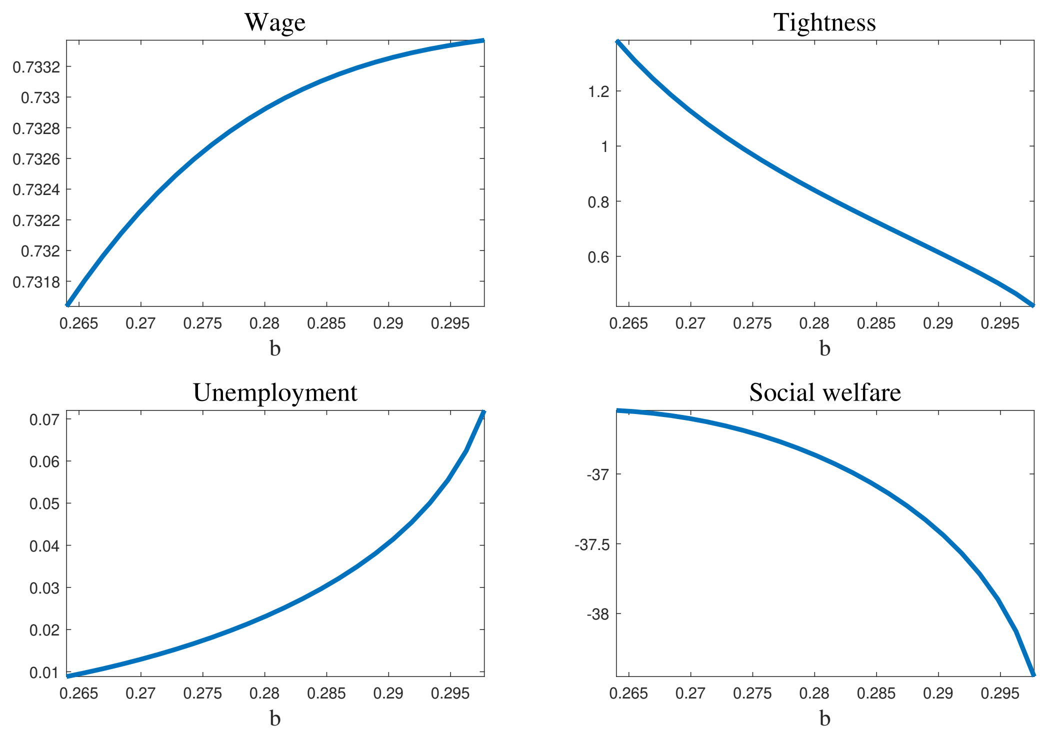


Figure A.4: The deterministic steady-state variations *w.r.t* UI benefits

Figure A.4 displays the steady-states of the selected variables corresponding to the different levels of UI benefits. The figure illustrates the potent job destruction effect. UI extension raises the wage, raising the shadow cost of labor. The labor demand declines as the shadow cost of labor increases. As a result, the job destruction rate rises, while vacancies diminish. I observe that steady-state unemployment increases by 24.8 percent in response to a 1 percent increase in unemployment benefits. As the number of job seekers increases and vacancies decrease, each worker faces a lower chance of finding a job, which dissuades job searching. Notably, the disincentive effect does not result from an increase in the unemployed's outside condition. Instead, job seekers search less because they are less likely to find a job. The job finding probability(fs) unambiguously declines, and unemployment lasts longer. Aggregate output diminishes as employment decreases.

Workers are worse off as UI rises because the unemployment risk increases while the after-tax income decreases as the tax per worker increases. Despite the decrease in searching effort and increased consumption due to generous UI provision, unemployed households are also worse off because of the lower chance of employment and smaller welfare upon employment. The result is robust to the level of employment protection: Regardless of the level of employment protection, UI should be less generous to raise employment, output, and welfare. The optimal UI should be lower than the Baily-Chetty optimum and far from perfect insurance even without moral hazard concerns.

The result overturns at the auxiliary equilibrium where the welfare of all households increases with the replacement rate. The underlying mechanism is similar, and the job creation effect is again a primary driver. The critical difference in this case is that the equilibrium wage declines in the replacement rate. The UI extension raises the firm's surplus while reducing the worker's surplus in equilibrium. Although both factors increase the wage, the decrease in tax per worker due to a decline in unemployment lowers the equilibrium wage. The equilibrium is a coordinated allocation: the wage declines because unemployment declines and vice versa. The rat race intuition is twisted. That is, the labor market is slack, and generous UI efficiently raises the labor market's tightness. However, the increase in tightness does not originate from a discouraged job search intensity but rather is related to the increase in labor demand.

Employment Protection

Since employment protection simultaneously discourages job creation and destruction, the impact of employment protection on total employment or welfare is generally ambiguous. Bentolila and Bertola (1990) suggest that strict employment protection raises employment because the separation cost affects firms' propensity to fire than to hire. In contrast, Hopenhayn and Rogerson (1993) find that the separation cost has a sizable negative impact on employment. Furthermore, strict employment protection results in welfare loss because it reduces the average productivity of workforces. Therefore, Michau (2015) stresses that employment protection should balance employment security and efficient worker reallocation from low- to high-productivity jobs.

Thus, the optimal separation cost could depend on the elasticity of job creation and destruction in relation to the separation cost. For example, if the separation cost affects firms' propensity to fire more than that to hire, relaxing employment protection would raise unemployment. In this paper, the decline in the separation cost and the consequent increase in unemployment could be a source of various externalities. First, an increase in unemployment raises the tax per worker, further reducing the labor demand under Nash bargaining through the fiscal increasing return effect. Additionally, an increase in inflows to unemployment lowers labor market tightness, which distorts the incentive to search for a job. Although the decline in the separation cost improves production efficiency by stimulating job creation, an increase in layoffs may lead to welfare deterioration.

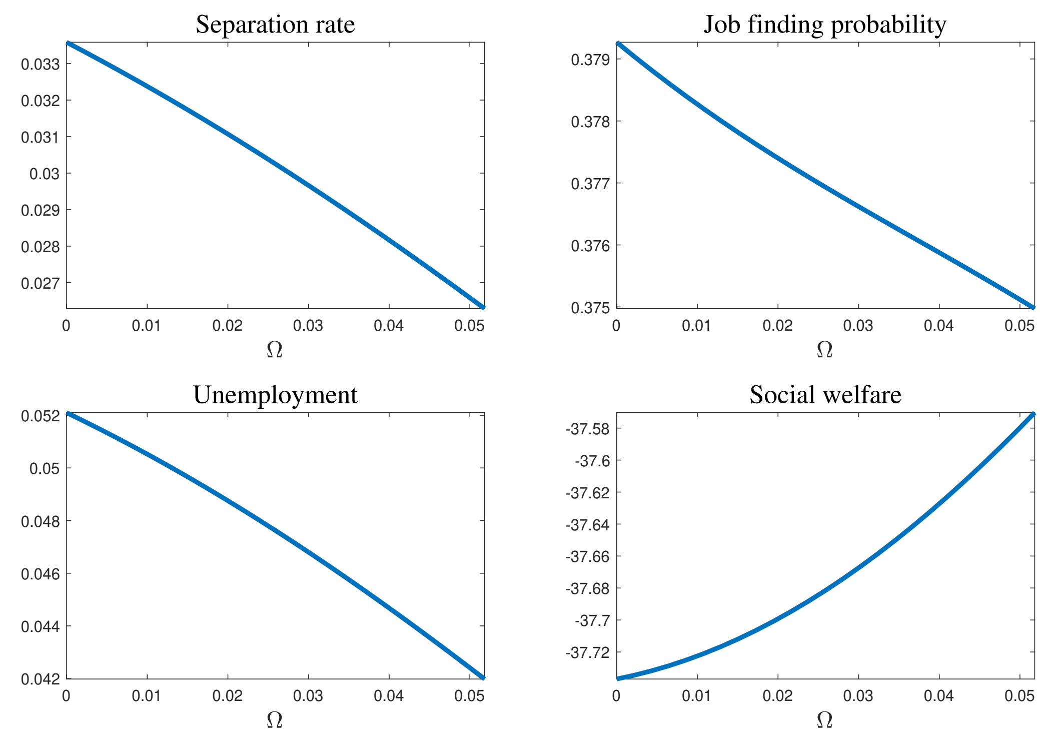


Figure A.5: The deterministic steady-state variations *w.r.t* the separation cost

Figure A.5 displays the steady-states corresponding to the different levels of the separation cost. First, intensifying employment protection lowers the wage because the average match productivity decreases, while the worker's surplus from employment increases. However, EP intensification raises the shadow cost of labor because each match has a lower continuation value due to an increase in the expected cost in the case of separation. In equilibrium, the separation rate of incumbent workers decreases in Ω because the elasticity of the shadow cost of labor to the separation cost is smaller than one. Although incumbent matches yield a smaller surplus, a layoff is a more costly option for firms. In contrast, firms curtail hiring as the surplus from job creation decreases. As a result, both the job separation rate and job finding probability (fs) decline. The elasticity of the job finding probability to the separation cost is smaller than the elasticity of the separation rate at efficient allocation. Thus, the equilibrium employment determined by $\frac{fs}{fs+(1-fs)F}$ increases with the separation cost. Although employment protection lowers the average match productivity, output rises as employment increases.

The job search effort increases with the separation cost because the welfare surplus from employment rises as employment lasts longer. Despite the decline in vacancies and the increase in searching intensity, labor market tightness increases with the separation cost as inflows to unemployment diminish. Although tightness rises, the job finding probability per unit of effort declines because firms require higher productivity from new employees. Although the wage decreases, the worker's after-tax income increases with the separation cost since the tax per worker decreases. Consequently, employment protection increases the welfare of workers because they are better protected from layoffs and can enjoy more consumption. Interestingly, unemployed households are also better off. Despite the longer unemployment duration, these households benefit from higher expected welfare upon employment.

The welfare impact of employment protection relies on the level of unemployment insurance. Concretely, EP intensification lowers the wage but also decreases the tax per worker by reducing unemployment in equilibrium. Given b, the tax per worker is an increasing convex function of unemployment, implying that the elasticity of the after-tax income would differ depending on the level of UI. On the other hand, EP intensification protects incumbent workers by lowering the separation rate at the cost of a longer unemployment duration of the unemployed. Thus, an insider-outsider insurance tradeoff is relevant. Figure A.6 illustrates the welfare impact of EP conditional on different UI. Panels (A) and (B) display the social welfare and worker's consumption with respect to different separation costs conditional on a 10 and 2.5 percent lower UI, respectively, than the baseline unemployment benefits. Panel (C) illustrates the baseline case. As discussed, an increase in the separation cost renders all households better off under the baseline calibration. In contrast, panel (A) suggests that household welfare decreases with the separation cost if UI is sufficiently low. Conditional on low UI, loosening employment protection causes a relatively smaller increase in the tax per worker. The worker's after-tax income decreases with the separation cost. Although relaxing employment protection raises the unemployment risk, workers benefit from an increase in current consumption. The unemployed are also better off as the separation cost declines because they are more likely to find a job and benefit from increased welfare upon employment. Panel (B) displays the welfare tradeoff. The reduced separation cost may lower the worker's welfare either because it diminishes the after-tax income or raises unemployment risk. On the other hand, if relaxing employment protection results in a sufficient wage increase, a decline in the separation cost could make workers better off because of its positive impact on workers' current welfare and the expected welfare for the unemployed. The U-shaped social welfare curve shown in panel (B) illustrates this non-monotone welfare impact of employment protection.

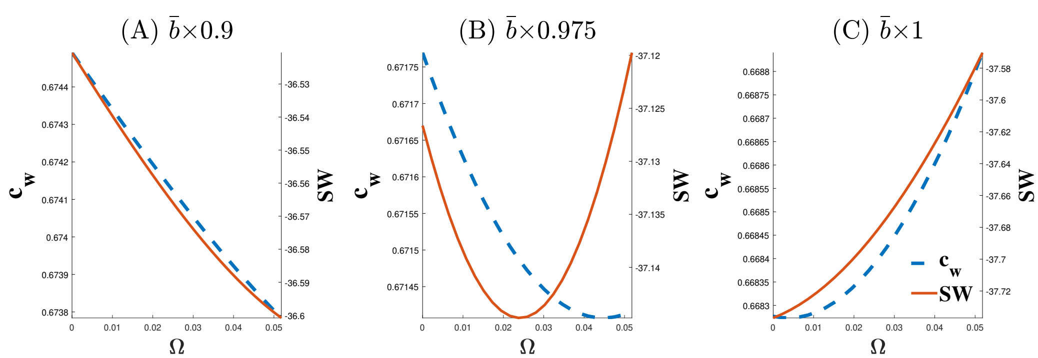


Figure A.6: The non-monotone welfare impact of EP conditional on the different levels of UI

The result overturns around the auxiliary steady state. The consumption of workers decreases with the separation cost because of the increase in the tax per worker. The duration of unemployment is longer because firms reduce hiring while households search less. As a result, intensified employment protection reduces the output and welfare of all types of households regardless of the level of UI benefits.

A.4.2 Conditional welfare analysis

This section examines the business cycle implications of the *ex-ante* different labor market policies. Considering the existence and plausibility [36] of equilibrium, the policy ranges are specified as follows:

$$b \in [\bar{b} \times 0.9, \bar{b} \times 1.02]$$

$$\Omega \in [0, \bar{\Omega} \times 4]$$

$\bar{b}$ and $\bar{\Omega}$ denote the baseline level of UI benefits and the separation cost, respectively. Each interval has 25 equidistant grids. Figure A.7 illustrates the volatility of the key macroeconomic aggregates and stochastic social welfare. Wages are determined by Nash bargaining over the business cycles. However, the result is robust even if wages are determined by the ad hoc wage rule over the cycles.

Regardless of the wage-setting assumption over the business cycles, the stochastic welfare is maximized under the policy regime yielding the highest unconditional welfare, i.e., the lowest b and Ω. Figure A.7 shows that the real economy could be more volatile as UI rises or the separation cost declines. The welfare maximizer suggests that the first-order welfare benefit dominates the second-order welfare cost of business cycle fluctuations. The counter-flexicurity regime, i.e., the lowest b and the highest Ω, closely approximates the optimal scheme. Compared to the optimum, the unemployment volatility decreases by 12.8 percent, and output volatility decreases by 2.7 percent. The welfare difference between the optimal and counter-flexicurity regime decreases in a stochastic economy due to the welfare gain from stabilization. In contrast, the flexicurity regime, i.e., generous un-

[36] The policy ranges are restricted to ensure that the deterministic steady-state unemployment rate is no higher than 8 percent.

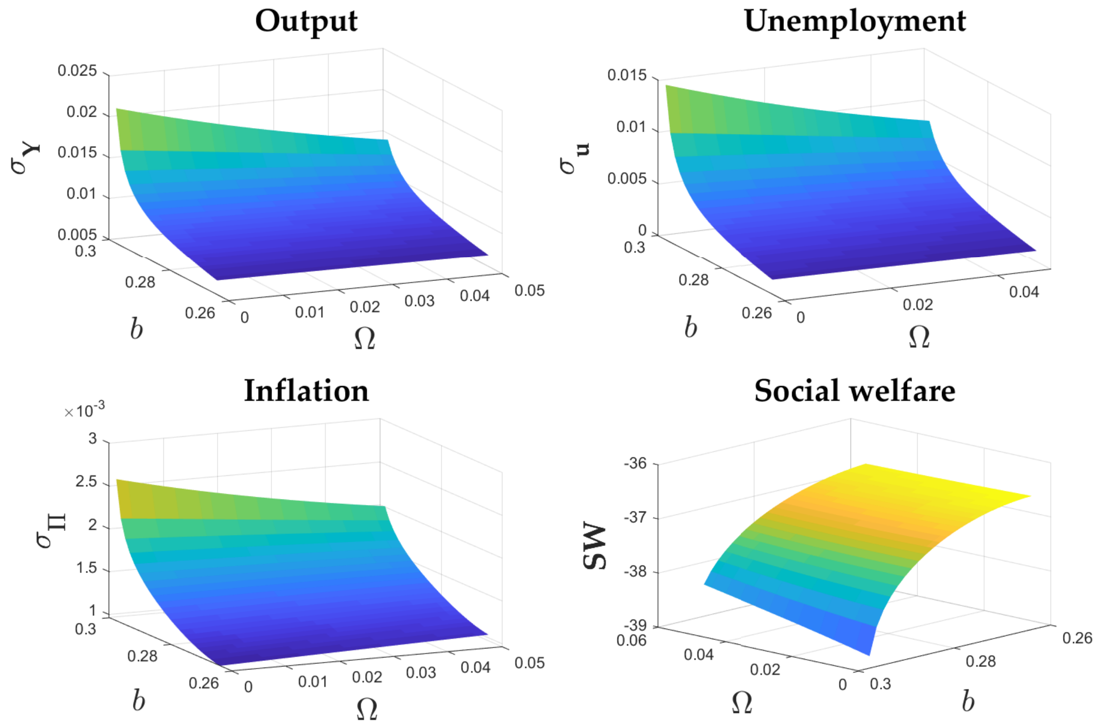


Figure A.7: The volatility and social welfare *w.r.t* the *ex ante* different policies, Nash bargaining

employment insurance and weak employment protection, is inadvisable. This regime not only reduces unconditional welfare but also yields amplified fluctuations over the cycles. For instance, the flexicurity regime yields more than two times higher output volatility relative to the optimal scheme.

Why does the flexicurity regime lead to higher economic volatility? Hagedorn and Manovskii (2008) and Ljungqvist and Sargent (2015) suggest that unemployment volatility depends on the firm's match surplus. If the match surplus is small, the same size shock causes a relatively larger impact on labor demand, resulting in amplified fluctuations in the real economy. Similarly, generous UI provision reduces the firm's match surplus under Nash bargaining due to its cost pressure, and thus, the labor demand is more responsive to business cycle shocks. Furthermore, the amplified unemployment fluctuations lead to less stabilizing or more destabilizing demand feedback due to households' countercyclical precautionary saving demand. Hence, through both the supply and demand channels, generous UI causes the economy to be more unstable. Similarly, the separation cost affects the match surplus. Given the asymmetric separation costs, strict employment protection raises the surplus from incumbent matches but reduces the surplus from job creation. The intuition suggests that strong employment protection could induce the job creation margin to be more volatile, while job destruction would fluctuate less. Because incumbent workers account for a larger part of the total employment and the proportion of incumbent workers increases with the separation cost, economic volatility decreases with the separation cost.

Flexicurity is inadvisable because of the wage-setting assumption in the steady-state equilibrium. For example, if steady-state wages remain constant under different ex-ante policies, I observe that flexicurity policies are welfare-improving. The unconditional welfare of households increases with UI and decreases with the separation cost. Additionally, conditional on the ad hoc wage rule over the business cycles, the real economy would be more stable if UI is structurally more generous or EP is less strict. As a result, the flexicurity policies stabilize the economy and result in superior welfare outcomes. This result suggests that flexicurity policies can be advisable under the following relatively restrictive conditions: (a) the policies barely affect wages in the long-run, and (b) the worker's surplus and transfers have a limited impact on payroll costs at the business cycle frequency. Otherwise, providing generous UI or facilitating layoffs is generally harmful.