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Asymmetric Unemployment Fluctuations and Monetary Policy

Trade-offs

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Abstract

I show that labor market asymmetries are key to generating a quantitatively significant trade-off between inflation and unemployment stabilization in New Keynesian models with search and matching frictions in the labor market. In such an environment, a strong focus on inflation stabilization in response to shocks comes at the cost of larger labor market volatility. Because unemployment fluctuations are asymmetric, it also results in higher average unemployment. The optimal policy responds strongly to both inflation and employment and stabilizes labor market fluctuations. Most of the welfare gains from adopting this policy are accounted for by the increase in average employment relative to the price stability case. When labor market fluctuations are linear, the monetary authority loses its leverage over average unemployment, and a policy of price stability is close to optimal.

Keywords: Optimal monetary policy; unemployment asymmetries; matching frictions

JEL Codes: E24; E32; E52

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1 Introduction

How much weight should policymakers place on inflation, and how much on employment? In practice most central banks seem to assign a non-negligible role to the stabilization of real activity. Most notably, in the United States, the Federal Reserve pursues the dual objective of promoting price stability and maximum sustainable employment. This behavior of central banks is at odds with the recommendations that have emerged from a literature that seeks to describe optimal monetary policy in dynamic stochastic general equilibrium models featuring nominal and real rigidities. These studies generally find that an exclusive focus on inflation stabilization is close to optimal (Walsh 2014).

This conclusion also holds in models with search and matching frictions in the labor market. In this setting, wage distortions create a trade-off between stabilizing inflation and addressing labor market inefficiencies (Faia 2009), but this trade-off was found to be quantitatively small in calibrated models (Faia 2008 and 2009, Thomas 2008, Ravenna and Walsh 2011), unless wages are rigid and labor market volatility is large enough (Ravenna and Walsh 2012). In parallel, several papers have shown that search and matching frictions generate costly asymmetric labor market dynamics in response to shocks (Hairault et al. 2010, Jung and Kuester 2011). This paper studies how these nonlinearities shape the trade-offs faced by the central bank and the optimal conduct of monetary policy. It makes two contributions to the literature. First, it shows that the standard macroeconomic relationship between inflation and unemployment volatility described in Taylor (1994) becomes a relationship between inflation volatility and average unemployment in the presence of unemployment asymmetries. By responding strongly to employment alongside inflation, the monetary authority can reduce unemployment volatility as well as average unemployment. Second, it finds that the quantitatively significant trade-off described in Ravenna and Walsh (2012) depends on the existence of both wage rigidity and labor market asymmetries. Most of the welfare gains from employment stabilization can be traced back to the decrease in average unemployment achieved by the optimal policy. In an environment with linear labor market fluctuations, monetary policy loses its leverage over average unemployment and it becomes much less beneficial to deviate from price stability.

I use a standard model with two essential features. First, inflation volatility is costly as producers face quadratic price adjustment costs. This gives rise to a Phillips Curve that relates firms’ markups to inflation and gives monetary policy some leverage over job creation. Second, unemployment, which results from the presence of
search and matching frictions in the labor market, rises more in a recession than it decreases in an expansion. In the model, fluctuations in technology lead to about symmetric shifts in the job-finding probability. However, because of the negative covariance between the job-finding probability and the unemployment rate, a notable feature of U.S. data, these fluctuations in the job-finding probability have an asymmetric effect on employment. In an expansion, the positive impact on employment of an increase in the job-finding probability is *dampened* by the decrease in the size of the pool of job seekers. In a recession, the negative impact on employment of the decrease in the job-finding probability is *amplified* by the increase in the size of the pool of job seekers. This asymmetric nature of unemployment fluctuations implies that aggregate fluctuations lead to a potentially costly increase in average unemployment. In this setting, the central bank may try to use inflation over the business cycle to influence markups, with the goal of affecting job creation and unemployment volatility.

I find that the adoption of different monetary policy rules leads to different outcomes in terms of average unemployment. In the baseline calibrated version of the model, average unemployment is higher than steady-state unemployment by 0.21 percentage points when the monetary authority responds to both inflation and output growth. However, under a policy of price stability, this gap doubles to 0.42 percentage points. More generally, holding the response to output constant, average unemployment is increasing in the central bank’s response to inflation. The intuition for this result is as follows. When responding mildly to inflation and/or strongly to output, the monetary authority engineers procyclical markups in response to technology shocks. This behavior of markups limits the procyclicality of firms’ real revenues and the volatility of job creation. Under a policy of price stability, markups are constant over the business cycle and real revenues and job creation are accordingly more volatile. This larger volatility of job creation translates in larger unemployment fluctuations, and because the latter are asymmetric, in higher average unemployment. Thus, the standard macroeconomic relationship between inflation and unemployment volatility described in Taylor (1994) and analyzed in a similar estimated model by Sala et al. (2008) becomes a relationship between inflation volatility and average unemployment when unemployment fluctuations are asymmetric.

The presence of this relationship has some implications for the optimal conduct of monetary policy. The design of optimal monetary policy in this paper follows the Ramsey approach, which has been applied in a wide range of New Keynesian models (for example King and Wolman 1999, Khan et al. 2003, Schmitt-Grohe and Uribe 2005, Bilbiie et al. 2014). I find that the central bank should optimally adopt a dual mandate, that is a policy
that features a strong response to employment alongside inflation. The welfare gains of doing so are large and can be decomposed in several terms, including one that captures the average consumption gain obtained by moving along the relationship between inflation volatility and average unemployment. Most of the gains of abandoning the policy of price stability in favor of the optimal policy are driven by this term as the costs of the increase in inflation volatility from 0% to 0.33% are more than offset by the benefits arising from the decrease in average unemployment from 6.42% to 6.12%. Thus, welfare is maximized by tolerating some inflation volatility in order to reduce average unemployment. This shows that labor market asymmetries play a critical role in shaping monetary policy trade-offs. In the absence of such asymmetries, monetary policy would lose its leverage over average unemployment and would have accordingly much less incentives to use costly inflation volatility to reduce labor market volatility. This importance of labor market asymmetries can also be illustrated in a different way, by considering an otherwise identical model with linearized labor market dynamics. While in the baseline model the optimal policy can be well approximated by a rule which responds to inflation and an employment gap with coefficients $\phi_\pi = 3$ and $\phi_N = 1$, in this alternative model the optimal simple rule features an aggressive response to inflation $\phi_\pi = 10$ and no response to real activity.

The nature of monetary policy trade-offs is also highly sensitive to the value of home production for unemployed workers. This parameter has no influence on the cyclical properties of the model. However, it does determine how an increase in mean unemployment translates in a decrease in mean consumption. When it is high, an increase in average unemployment has a limited impact on average consumption. As a result, the monetary authority has little incentives to take advantage of the relationship between inflation volatility and average unemployment and a policy of price stability is nearly optimal. However, when it is low, a similar increase in average unemployment leads to a much larger decline in average consumption. In that case, deviating from price stability to stabilize employment becomes much more beneficial.

As emphasized above, several papers have showed that the asymmetric unemployment dynamics generated by a simple search and matching model of the labor market can lead to substantial business cycle costs (Hairault et al. (2010), Jung and Kuester (2011) and Petrosky-Nadeau and Zhang (2013)). Benigno et al. (2015) show that the relationship between macroeconomic volatility and average unemployment implied by such a model can be found in U.S. data. Ferraro (2017) also documents that the employment rate fluctuates asymmetrically over

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1Iliopulos et al. (2016) show that business cycle costs are substantially larger when labor market search interacts with financial frictions.
the business cycle in the U.S. and proposes an alternative explanation, based on endogenous job destruction and worker heterogeneity in skills. I build on these studies and draw the monetary policy implications of the presence of this costly asymmetry in unemployment fluctuations. My results contribute to a large literature on the optimal design of monetary policy. The conclusion that monetary policy should focus exclusively on stabilizing inflation is robust in the models generally used for monetary policy analysis, regardless of the different frictions that are included (Walsh 2014). A large literature has focused on the specific case of labor market frictions. Faia (2008, 2009) shows that a trade-off between inflation and unemployment stabilization arises in the presence of search and matching frictions as a central bank can use inflation to correct for an inefficient level of labor market activity. However, just like Thomas (2008) and Ravenna and Walsh (2011), she finds that the gains of adopting this policy rather than a policy of price stability are small. Two studies find a quantitatively significant trade-off in the presence of search frictions. In Blanchard and Galí (2010), an exclusive focus on inflation is welfare detrimental because there is a direct utility cost of employment fluctuations. Ravenna and Walsh (2012) show that the incentives to deviate from price stability increase with the degree of wage rigidity and the volatility of labor market variables. While acknowledging that wage rigidities are key, this paper points out that labor market asymmetries are also essential to obtain the quantitatively significant trade-off that these authors describe.

The paper is organized as follows. Section 2 develops the model. Section 3 undertakes a comparative statics exercise to understand the origin of the asymmetry in unemployment fluctuations. Section 4 calibrates the model and shows that the monetary authority faces a long-run relationship between inflation volatility and average unemployment. Section 5 shows that the central bank should optimally take advantage of this relationship to reduce average unemployment, and highlights the role played by labor market asymmetries in shaping monetary policy trade-offs. Section 6 concludes.

2 A New Keynesian model with search and matching frictions

This section develops a model with sticky prices in which monetary policy has a meaningful role to play. It departs from the standard New Keynesian model in several ways. The labor market is not perfectly competitive but is characterized by search and matching frictions. The surplus of a match is divided between the worker and the firm according to an exogenous rule that determines the real wage. The economy consists of two
sectors of production. Wholesale firms operate in perfectly competitive markets. They use labor as the sole input in the production process and have to post vacancies in order to match with workers. Their output is sold to monopolistically competitive retail firms which transform the homogeneous goods one for one into differentiated goods and must pay a quadratic adjustment cost to change their prices.

2.1 Labor market

The size of the labor force is normalized to unity. Workers and firms need to match in order to become productive. The number of matches in period $t$ is given by a Cobb-Douglas matching function $m_t = \chi s_t^\alpha v_t^{1-\alpha}$, $s_t$ being the number of job seekers and $v_t$ the number of vacancies posted by firms. The parameter $\chi$ reflects the efficiency of the matching process and $\alpha \in [0,1]$ is the elasticity of the matching function with respect to unemployment. Define $\theta_t = \frac{v_t}{s_t}$ as labor market tightness. The probability $q_t$ for a firm to fill a vacancy and the probability $p_t$ for a worker to find a job are, respectively, $q_t = \frac{m_t}{v_t} = \chi \theta_t^{-\alpha}$ and $p_t = \frac{m_t}{s_t} = \chi \theta_t^{1-\alpha}$. At the beginning of each period $t$, a fraction $\rho$ of existing employment relationships $N_{t-1}$ is exogenously destroyed. Those $\rho N_{t-1}$ newly separated workers and the $1 - N_{t-1}$ workers unemployed in the previous period form the pool of job seekers $s_t = 1 - (1 - \rho) N_{t-1}$. Job seekers have a probability $p_t$ of finding a job within the period. The law of motion of employment $N_t$ is accordingly given by

$$N_t = (1 - \rho) N_{t-1} + p_t (1 - (1 - \rho) N_{t-1})$$

(1)

The number of unemployed workers in period $t$ is $u_t = 1 - N_t$.

2.2 Households

Household members receive a real wage $w_t$ when employed and a value $b$ when unemployed. $b$ can be interpreted either as home production, or as the value of leisure while unemployed expressed in consumption units. I assume that consumption risks are fully pooled within the household. Household members have expected intertemporal utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_{t}^{1-\sigma}}{1-\sigma}$$

(2)
where $\beta$ is the household’s subjective discount factor, $\sigma$ the coefficient of relative risk aversion and $C_i$ the consumption level of each household member. Households receive profits $\Pi'_t$ from retail firms, pay lump-sum taxes $T_t$, and invest in risk-free bonds $B_{t+1}$ that promise a unit of currency tomorrow and cost $(1 + I_t)^{-1}$ today. They face the following per period budget constraint

$$P_tC_t + (1 + I_t)^{-1}B_{t+1} = P_t[w_tN_t + b(1 - N_t)] + B_t + P_t\Pi'_t - P_tT_t \quad (3)$$

Consumption of market goods is given by $C^m_t = C_t - b(1 - N_t)$. $C^m_t \equiv \left[\int_0^1 C^m_t(j) \frac{\varepsilon - 1}{\varepsilon} d j \right]^\frac{\varepsilon}{\varepsilon - 1}$ is a Dixit-Stiglitz aggregator of the different varieties of goods produced by the retail sector and $\varepsilon$ is the elasticity of substitution between the different varieties. The optimal allocation of income on each variety is given by $C^m_t(j) = \left[\frac{P_t(j)}{P_t}\right]^{-\varepsilon} C^m_t$, where $P_t = \left[\int_0^1 P_t(j) \frac{\varepsilon - 1}{\varepsilon} d j \right]^{\varepsilon/(1-\varepsilon)}$ is the price index and $P_t(j)$ is the price of a good of variety $j$. Households choose bonds holding so as to maximize (2) subject to (3). The household’s optimal consumption path is governed by a standard Euler equation

$$\beta E_t \frac{1 + I_t}{\Pi_{t+1}} \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} = 1 \quad (4)$$

where $\Pi_{t+1} = \frac{P_{t+1}}{P_t}$ is the gross inflation rate between periods $t$ and $t + 1$.

### 2.3 Wholesale firms

A measure one of wholesale firms, indexed by $i$, produce according to the following technology

$$Y^w_{it} = Z_t N_{it} \quad (5)$$

where $Z_t$ is a common, aggregate productivity disturbance. Wholesale firms sell their output in a competitive market at a price $P^w_t$. Posting a vacancy comes at a cost $\kappa$. Firm $i$ chooses its level of employment $N_{it}$ and the number of vacancies $v_{it}$ in order to maximize the expected sum of its discounted profits

$$E_0 \sum_{t=0}^\infty \beta^t \left[ \frac{P^w_t}{P_t} Y^w_{it} - \kappa v_{it} - w_t N_{it} \right] \quad (6)$$

subject to its perceived law of evolution of employment $N_{it} = (1 - \rho)N_{it-1} + v_{it}q(\theta_t)$ and taking the wage schedule as given. Profits are equal to real revenues minus vacancy posting costs and wage payments. They
are discounted using the household’s discount factor $\beta^t \frac{C_t^{-\sigma}}{C_0^{-\sigma}}$ since households ultimately own firms. In equilibrium all firms post the same number of vacancies and employ the same number of workers. I therefore drop individual firm subscripts $i$. After rearranging the first-order conditions, the following job creation equation obtains

$$\frac{\kappa}{q(\theta_t)} = \frac{Z_t}{\mu_t} - w_t + E_t \beta_{t+1} (1 - \rho) \frac{\kappa}{q(\theta_{t+1})}$$

(7)

where $\beta_{t+1} = \beta \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma}$ is the stochastic discount factor of households between periods $t$ and $t+1$ and $\mu_t = \frac{P_t}{P_{t-1}}$ is the markup of retail over wholesale prices. This equation is an arbitrage condition for the posting of vacancies. It states that the cost of hiring, the deadweight cost $\kappa$ divided by the time it takes to fill the vacancy, must be equal to the expected discounted benefit of a filled vacancy. These benefits consist of the revenues from output net of wages and the future savings on vacancy posting costs.

2.4 Retail firms

There is a large number of retailers, indexed by $j$, who buy the goods produced by wholesale firms at a price $P_t^w$ and transform them one for one into differentiated goods. The real marginal cost of production for retailers is given by $mc_t = \frac{P_t^w}{P_t}$. They face quadratic costs of adjusting prices $\Theta_t(j) = \frac{\phi_p}{2} \left( \frac{P_t(j)}{P_{t-1}(j)} - 1 \right)^2 Y_t$, which are measured in terms of aggregate output $Y_t$, and their revenues are subsidized at the constant rate $\tau$. This subsidy is employed in order to ensure that steady-state inefficiencies arise only from search frictions, and not from monopolistic competition. Retail firms choose $P_t(j)$ in order to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{-\sigma}}{C_0^{-\sigma}} \left[ \frac{(1 + \tau)P_t(j) - P_t^w}{P_t} Y_t(j) - \Theta_t(j) \right]$$

subject to the demand for each variety $Y_t(j) = (P_t(j)/P_t)^{-\varepsilon} Y_t^d$ where $Y_t^d$ is aggregate demand for final goods.

Noting that in the symmetric equilibrium $P_t(j) = P_t$, we obtain

$$(1 + \tau)(1 - \varepsilon) + \frac{\varepsilon}{\mu_t} - \phi_p \Pi_t (\Pi_t - 1) + E_t \beta_{t+1} \phi_p \Pi_{t+1} (\Pi_{t+1} - 1) \frac{Z_{t+1} N_{t+1}}{Z_t N_t} = 0$$

(8)

This equation is a nonlinear expectational Phillips Curve linking marginal cost and inflation. Because of the presence of sticky prices, inflation has an influence on markups. Importantly, lower markups (and higher marginal costs) for retail firms imply higher relative prices for wholesale firms and greater benefits from a
filled vacancy. Thus, by engineering an increasing path for inflation, monetary policy can encourage firms to hire more workers and thereby reduce unemployment.

2.5 Wage setting

In order for the costs arising from the asymmetry in unemployment fluctuations to be significant, one needs a model which generates sizeable fluctuations in labor market activity. As first emphasized by Shimer (2005), the Mortensen-Pissarides model is unable to account for the volatility of labor market variables observed in U.S. data. In the case of Nash-bargained flexible wages, the wage is too sensitive to aggregate conditions and “eats” all the incentives of firms to adjust through the employment margin. Several solutions to this problem, involving a different calibration (Hagedorn and Manovskii 2008) or a modification of the wage-setting mechanism (Hall 2005, Hall and Milgrom 2008) have been proposed. I follow the second route and introduce real wage rigidity in my framework in the form of the simple wage schedule proposed by Blanchard and Galí (2010). In appendix 4, I check that my results are confirmed in a model with Nash-bargained wages and a calibration à la Hagedorn and Manovskii (2008). The wage equation is given by

$$w_t = \omega Z_t^\gamma$$

where $\gamma \in [0, 1]$ is the elasticity of wages with respect to technology. When $\gamma < 1$, the wage adjusts only partially to technology shocks. As emphasized by Hall (2005), search frictions create a bargaining set between employer and employee. Thus, any (sticky) wage that remains between the worker’s and the employer’s reservation wages is consistent with the private efficiency of employment relationships. I check in the different simulations conducted in sections 4 and 5 that wages always lie in the bargaining set.

2.6 Monetary policy and equilibrium

It is assumed that monetary policy adjusts interest rates in response to movements in inflation and output growth according to the following rule

$$\log\left(\frac{1+I_t}{1+I}\right) = \phi_r \log(1+I_{t-1}) + (1-\phi_r) \left( \phi_\pi \log(\Pi_t) + \phi_\Delta \log(Y_t/Y_{t-1}) \right)$$

where $\phi_r$, $\phi_\pi$, and $\phi_\Delta$ are parameters.
The economy-wide resource constraint is obtained by aggregating the budget constraints of households. Final output and home production can be used for consumption or to cover the deadweight costs of changing prices and posting vacancies

\[ C_t = Z_t N_t \left( 1 - \frac{\Phi p}{2} (\Pi_t - 1)^2 \right) + b(1 - N_t) - \kappa v_t \]  

(11)

We can now define an equilibrium.

**DEFINITION:** A competitive equilibrium is a set of plans \( \{C_t, I_t, N_t, \mu_t, \pi_t, w_t\} \) satisfying equations (1), (4), (7), (8), (9), (10), and (11) given a specification for the exogenous process \( \{Z_t\} \) and initial conditions \( N_{-1} \) and \( I_{-1} \).

Technology is modeled as a first-order autoregressive process

\[ Z_t - Z = \delta Z (Z_{t-1} - Z) + \epsilon_t Z \]

where \( 0 < \delta Z < 1 \) and \( \epsilon_t Z \sim N(0, \sigma^2 Z) \) is a white noise innovation.

## 3 Steady-state analysis: uncovering the asymmetry in unemployment fluctuations

This section undertakes a comparative statics exercise in order to understand the origin of the asymmetry in unemployment fluctuations. I solve for the zero-inflation steady state equilibrium of the model. In that case, markups are constant and the equilibrium consists of three endogenous variables: labor market tightness, unemployment and consumption. In the following equations, steady-state variables are indicated by the absence of a time subscript. Equilibrium labor market tightness is given by the job creation equation

\[ \frac{\kappa}{q(\theta)} = \frac{1}{1 - (1 - \rho)\beta} \left( \frac{Z}{\mu} - \omega Z^i \right) \]

When \( \alpha = 0.5 \), we have that \( p(\theta) = \frac{\chi^2}{q(\theta)} \), hence the previous equation can be rewritten in the following way

\[ p = \frac{\chi^2}{\kappa (1 - (1 - \rho)\beta)} \left( \frac{Z}{\mu} - \omega Z^i \right) \]

The job-finding probability \( p \) is entirely determined by the level of productivity \( Z \). In the \( (u, p) \) plane of Figure 1, the job creation curve is a horizontal line. Now that we have obtained the job-finding probability, we can
deduce the unemployment rate from the steady-state version of equation (1)

\[ p = \frac{\rho(1-u)}{1-(1-\rho)(1-u)} \]

Figure 1: Steady-state equilibrium of the model. The solid blue line represents the steady-state version of the employment-flow equation. The red dashed line represents the steady-state version of the job creation equation for \( Z = 1 \). The red circled line represents the steady-state version of the job creation equation for \( Z = 1.025 \). The red pointed line represents the steady-state version of the job creation equation for \( Z = 0.975 \). The calibration required to obtain the figure is detailed in section 4.1.

This employment-flow curve is decreasing and convex in the \((u,p)\) plane of Figure 1.

We can see that shifts in productivity lead to almost symmetric shifts in the job-finding probability, but asymmetric shifts in unemployment. When \( Z = 1 \), steady-state unemployment is equal to 6%. When productivity increases by 2.5%, steady-state unemployment decreases by 4%. However, when productivity decreases by 2.5%, steady-state unemployment increases dramatically and reaches 14.5%. The intuition behind this result is simple. In an expansion, the impact on unemployment of an increase in the job-finding probability is \textit{dampened} by the fact that the pool of job seekers is shrinking. In a recession, the impact on unemployment of a decrease in the job-finding probability is \textit{amplified} by the fact that the pool of job seekers is expanding. In other words,
in a search and matching model of the labor market, unemployment losses in recessions tend to be greater than unemployment gains in expansions. Unemployment fluctuations are asymmetric, and mean unemployment is higher in an economy with business cycles than in steady state. Following Jung and Kuester (2011), we can obtain an analytical expression for $E(u_t) - u$, where $E(u_t)$ denotes the unconditional average of unemployment in an economy with aggregate fluctuations. Assuming that all variables in the employment-flow equation are covariance stationary, $E(u_t) - u$ is given by

$$
E(u_t) - u = -\frac{1 - \rho}{\rho + (1 - \rho)\rho} \left[ \text{cov}(p_t, u_{t-1}) + \left( \frac{\rho}{1 - \rho} + E(u_t) \right) (E(p_t) - p) \right]
$$

The proof of this result is presented in appendix 2. The covariance between the job-finding probability and the unemployment rate captures the asymmetry in unemployment fluctuations brought about by symmetric shifts in the job-finding probability. The second term $E(p_t) - p$ captures the extent to which fluctuations in the job-finding probability are asymmetric. In this comparative statics example, fluctuations in the job-finding probability are symmetric only if $\gamma = 0$. Out of steady state, fluctuations in the stochastic discount factor and markups will also drive a wedge between $E(p_t)$ and $p$. However, the following sections show that the bulk of the unemployment losses due to business cycles is accounted for by the negative covariance between the job-finding probability and the unemployment rate.

The analysis carried out so far suggests that an increase in the volatility of the job-finding probability leads to higher average unemployment. Through its influence on firms’ markups, monetary policy has the ability to influence job creation and labor market volatility. The next section explores in a quantitative manner how different monetary policy rules can lead to different outcomes in terms of mean unemployment.

4 Monetary policy, labor market volatility and mean unemployment

4.1 Calibration and solution method

I calibrate the model to U.S. data. I take one period to be a quarter. Table 1 gives a summary of parameter values.
A few parameters are calibrated using conventional values. The discount factor is set to $\beta = 0.99$, which yields an annual interest rate of 4%. The elasticity of substitution between goods is set to $\varepsilon = 6$ and the subsidy $\tau$ is fixed to ensure that the steady-state markup is equal to 1. I choose a coefficient of relative risk aversion $\sigma = 1.5$. The price adjustment cost parameter $\phi^p$ is chosen according to the following logic. The linearized Phillips Curve of the model is observationally equivalent to the one derived under Calvo pricing, and structural estimates of New Keynesian models find an elasticity of inflation with respect to marginal cost $\omega$ of 0.5 (Lubik and Schorfheide 2004). In my model $\omega = \frac{(\varepsilon - 1)(1 + \tau)}{\phi^p}$, which implies that $\phi^p = 12$. Alternatively, assuming an average contract duration of 4 quarters, the coefficient $\omega$ under Calvo pricing would be equal to 0.0858. This implies $\phi^p = 70$. I choose an intermediate value $\phi^p = 40$. This is also the value chosen by Krause and Lubik (2007).

Next, I calibrate labor market parameters. I set the elasticity of matches with respect to unemployment at $\alpha = 0.5$, within the range of plausible values proposed by Petrongolo and Pissarides (2001). I set the steady-state values of unemployment and labor market tightness to their empirical counterparts. I use the seasonally-adjusted monthly unemployment rate constructed by the Bureau of Labor Statistics (BLS) from the Current Population Survey (CPS). Labor market tightness is computed as the ratio of a measure of the vacancy level to this measure of unemployment. The measure of the vacancy level is obtained by merging the vacancy data of the Conference Board help-wanted advertisement index for 1951-2001 and the seasonally-adjusted monthly vacancy level constructed by the BLS from JOLTS for 2001-2012. Over the period 1951-2012, the mean of the unemployment rate is 5.8% and the mean of labor market tightness is 0.61. For practical purposes, my targets will be 6% and 0.6 respectively. The separation probability is set to 0.08. These targets imply through the steady-state employment flow equation a quarterly job-finding probability of 0.56, and through the definition of the job-finding probability, a matching efficiency of 0.7181. Silva and Toledo (2009) report that hiring costs amount to about 14% of quarterly employee compensation when expenses such as advertisement costs, agency fees, or travel costs for applicants are accounted for on top of the number of hours spent by company employees on recruiting. Thus, the vacancy posting cost is assumed to be equal to $\kappa = 0.14qw$. This results in vacancy posting costs $\kappa \nu$ equal to 1.1% of output in steady-state. I can then back out the steady-state value of the real wage from the job creation equation. I obtain $\omega = \frac{1}{1 + 0.14(1 - \beta(1 - \rho))} = 0.9877$ and $\kappa = 0.1282$. Pissarides (2009) and Haefke et al. (2013) emphasize that job creation depends on the expected net present value of wages over the entire duration of the newly created jobs. Since wages in existing matches are known to be
unresponsive to changes in aggregate conditions, it is the elasticity of the wages of new hires with respect to technology that matters for job creation. Following estimates in Haefke et al. (2013), I set this elasticity \( \gamma \) to 0.8. Finally, I choose a value of home production \( b \) equal to 0.4 in the baseline calibration. However, given the uncertainty surrounding the precise value of this parameter, I also report results for alternative values in section 5.

The parameters of the technological process, \( \delta_Z \) and \( \sigma_{\epsilon Z} \), are chosen in order to match U.S. labor productivity standard deviation and persistence. Finally, estimates from Galí and Rabanal (2004) are used to fix the parameters of the monetary policy rule, \( \phi_r = 0.69 \), \( \phi_\pi = 1.35 \) and \( \phi_{\Delta y} = 0.26 \).

The model is solved by taking a second-order approximation to the equilibrium conditions around the deterministic steady state. The solution method is explained in Schmitt-Grohé and Uribe (2004). Using a second-order approximation to the equilibrium conditions rather than a first-order approximation is crucial to capture the nonlinearities induced by matching frictions. However, perturbation methods may not be appropriate if the lower-order derivatives evaluated at the deterministic steady state do not accurately capture the global behavior of the policy functions that are solved for. For this reason, I also solved the model with a projection method (the algorithm that is used is presented in appendix 5). I find that the results obtained with this method are qualitatively and quantitatively similar to the ones obtained with the second-order perturbation method. Thus,
in the following sections, I report the results obtained with the perturbation method.

## 4.2 Labor market volatility and unemployment losses in the baseline economy

Table 2 presents the simulated moments of several labor market variables in the model when monetary policy is conducted according to the rule specified in the previous section. We can see that the model does a fairly good job at amplifying technology shocks and generating a significant amount of labor market volatility. It also reproduces the strong negative correlation between unemployment and vacancies – the Beveridge Curve.

<table>
<thead>
<tr>
<th></th>
<th>$u$</th>
<th>$v$</th>
<th>$\theta$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard deviation - Taylor Rule</td>
<td>0.139</td>
<td>0.145</td>
<td>0.196</td>
<td>0.098</td>
</tr>
<tr>
<td>Mean - Taylor Rule</td>
<td>0.0621</td>
<td>0.0805</td>
<td>0.5886</td>
<td>0.5479</td>
</tr>
</tbody>
</table>

Table 2: Moments of several labor market variables. Simulated from the model. All standard deviations are reported in logs as deviations from an HP trend with smoothing parameter $10^5$.

The second line in Table 2 presents the simulated means of the variables in the model. Unemployment losses due to business cycles are modest in the baseline economy – average unemployment is only 0.21 percentage points higher than steady-state unemployment. As expected from the analysis carried out in section 3, this is due to two factors. First, the model generates a negative covariance between the unemployment rate and the job finding probability equal to $-4.15$, measuring both rates in percentage points. Second, the mean job-finding probability in the fluctuating economy is lower than the steady-state job-finding probability $p = 0.5562$. The latter result can be understood by deriving an analytical expression for the average job-finding probability. Define $x_t = \frac{Z_t}{\mu_t}$ as real revenues and assume all variables in the job creation equation (7) are covariance stationary. Under the maintained assumption that $\alpha = 0.5$, we can write

$$E(p_t) = \frac{\chi^2}{\kappa(1 - (1 - \rho)E(\beta_t))} \left[ E(x_t) - E(w_t) + (1 - \rho)\frac{\kappa}{\chi^2}cov(\beta_t, p_t) \right]$$ (13)

A positive technology shock raises labor productivity but results in a fall in marginal cost. This negative comovement between labor productivity and marginal cost tends to reduce average real revenues ($E(x_t) < x$). This effect has a negative impact on job creation. However, two other effects tend to favor job creation. First, since wages are a concave function of technology, we have that $E(w_t) < w$. Second, the stochastic discount factor, which is inversely related to consumption growth, co-moves with the job finding rate. That is, firms put a larger weight on the future in expansions when the future gains of creating a vacancy today are high than they
do in recessions, when those gains are low. Quantitatively, the negative impact of lower average real revenues on job creation dominates and we have that \( E(p_t) < p \). The job-finding probability is lower in an economy with business cycles than in steady state.

### 4.3 A relationship between inflation volatility and average unemployment

<table>
<thead>
<tr>
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<th>( u )</th>
<th>( \nu )</th>
<th>( \theta )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard deviation - Price Stability</td>
<td>0.301</td>
<td>0.189</td>
<td>0.306</td>
<td>0.153</td>
</tr>
<tr>
<td>Mean - Price Stability</td>
<td>0.0642</td>
<td>0.0812</td>
<td>0.6175</td>
<td>0.5536</td>
</tr>
</tbody>
</table>

Table 3: Moments of several labor market variables. Simulated from the model. All standard deviations are reported in logs as deviations from an HP trend with smoothing parameter 10^5.

Table 3 presents some simulated moments of the model under a policy of price stability (that is, \( \phi_r = \phi_{\Delta y} = 0 \) and an arbitrarily large weight is put on inflation).

The labor market is much more volatile under this policy. The standard deviation of unemployment doubles and mean unemployment is higher by about 0.42 percentage points than in steady state. This increase in average unemployment is essentially accounted for by the increase in the volatility of the job-finding probability. Indeed, the value of the covariance between the job-finding probability and the unemployment rate jumps at \(-14.9\). The asymmetry in job-finding rate fluctuations does not contribute to the increase in average unemployment. Because markups are constant under price stability, average real revenues are not affected by business cycles and the average job-finding probability is actually higher than in the baseline economy.

We can understand why hiring is more volatile under a policy of price stability by solving forward the job creation equation

\[
\frac{\kappa}{q(\theta_t)} = \sum_{j=0}^{\infty} E_t \beta^j \left( \frac{C_{t+j}}{C_t} \right)^{-\sigma} (1 - \rho)^j \left( \frac{Z_{t+j}}{\mu_{t+j}} - \omega Z_{t+j}^\gamma \right)
\]

This equation states that vacancy posting today is driven by the sum of future expected discounted real revenues minus wage payments. Since the paths of labor productivity and real wages are identical under all policies, the differences in vacancy posting activity must come from differences in the path of markups. As emphasized previously, markups are influenced by monetary policy as they depend on current inflation and future expected inflation. Thus, through its impact on markups, monetary policy has some control on the reaction of labor market activity to technology shocks.
A positive technology shock leads to a decrease in marginal cost. Under price stability, the monetary authority reacts aggressively by cutting interest rates. This leads to an expansion in aggregate demand and forces firms to hire more workers in order to meet demand. This increase in hiring activities raises marginal cost back to its previous level. Firms do not have to adjust prices and markups remain constant. Under the Taylor rule considered in the baseline economy, the monetary authority does not cut interest rates as aggressively as under price stability. As a result, the expansion in aggregate demand is limited. Since firms can now produce the same level of output with less workers, they actually cut employment on impact. Markups go upwards at the time of the shock because marginal cost decreases and firms are unable to decrease prices as much as they would like to. In the periods following the shock, firms start adjusting prices and employment increases, but much less than under price stability. Figure 2 illustrates this graphically by plotting the response of markups, inflation, labor market tightness and employment both under price stability and under the baseline Taylor rule following a positive productivity shock of one standard deviation.
Thus, by engineering procyclical markups, the monetary authority can limit the impact of technology shocks on hiring. This will tend to reduce the magnitude of fluctuations in the job-finding probability and the unemployment rate, and because unemployment fluctuations are asymmetric, lead to lower average unemployment. However, in order to generate procyclical markups, the central bank must tolerate deviations from price stability. Therefore, this analysis suggests that the monetary authority faces a trade-off between inflation volatility and average unemployment. This intuition can be confirmed with a simple exercise. I assume that the monetary authority responds to inflation with coefficient $\phi_\pi$ and to deviations of employment from steady-state with coefficient $\phi_N$ and compute $E(u_t)$ for different values of $\phi_\pi$ ranging from 1.5 to 10 and $\phi_N$ ranging from 0 to 1. I thus consider both policies of price stability, for which $\phi_\pi = 10$ and $\phi_N = 0$, and policies that put a heavy emphasis on limiting employment volatility (for example $\phi_\pi = 1.5$ and $\phi_N = 1$). Figure 3 plots the standard deviation of inflation and average unemployment under those different monetary rules. It shows that there is a clear relationship between inflation volatility and average unemployment. A higher standard deviation of inflation is associated with a lower level of unemployment.

The next section undertakes a more normative analysis. It studies the characteristics of the optimal policy and the role played by labor market asymmetries in shaping monetary policy trade-offs. Notably, it tries to answer the following question: should the central bank take advantage of the relationship between inflation volatility...
and average unemployment?

5 Optimal policy: the role of labor market asymmetries

In standard New Keynesian models, wage distortions create a trade-off between stabilizing inflation and real activity (Blanchard and Galí 2007). This conclusion carries out to a framework with search and matching frictions in the labor market. As shown by Faia (2009), whenever wage distortions are present, the monetary authority has an incentive to deviate from price stability to stabilize labor market activity. This trade-off is, however, not quantitatively significant unless wages are rigid and labor market volatility is large enough (Ravenna and Walsh 2012). I find that this last result also owes to the presence of labor market asymmetries. Section 5.1 shows that the optimal policy problem can be seen as a problem of picking a point on the average unemployment - inflation volatility relationship described above. Section 5.2 shows that this relationship disappears either when labor market fluctuations are linear or when wages are perfectly flexible. In those two cases, policies of price stability are close to optimal. Sections 5.3 highlights that monetary policy trade-offs depend on a key parameter, the flow value of unemployment. Section 5.4 concludes with a comparison to the literature.

5.1 The optimal policy: choosing a point on the $E(u_t) - \sigma(\Pi_t)$ relationship

I compute conditional welfare $V_0$, the unconditional average of unemployment $E(u_t)$, and the unconditional standard deviation of inflation $\sigma(\Pi_t)$ for each monetary policy rule considered in section 4.3, that is for different combinations $(\phi_\pi, \phi_N)$ with $\phi_\pi \in [1.5, 10]$ and $\phi_N \in [0, 1]$. Welfare $V_0$ is characterized conditional upon the initial state in $t = 0$ being the deterministic steady state. Since the deterministic steady state is the same in all regimes, this ensures that the economy begins from the same initial point under each policy and that the welfare measure takes into account the transition path to the stochastic steady state associated with each policy. I start by running the following regression

$$V_0 = c_1 + c_2 * E(u_t) + c_3 * \sigma(\Pi_t)$$  \hspace{1cm} (14)

\(^{2}\)This demonstration is available in appendix 3.1.
The coefficient of determination $R^2$ of this regression is equal to 0.998. When $E(u_t)$ is removed as an explanatory variable, it drops to 0.756. When $\sigma(\Pi_t)$ is taken out, it decreases to 0.974. While (14) is not structural in nature and cannot be used as a guide to set policy optimally, it does show that observing two outcomes, average unemployment and inflation volatility, is sufficient to characterize welfare outcomes with precision. Alternatively, a more structural relationship between welfare, average unemployment, and inflation volatility, can be derived using the resource constraint of households (11) and a second-order approximation to the utility function (2) around the deterministic steady state. Such an approximation gives the following expression for the level of welfare attained in the stochastic steady state $E(V_t)$

$$
\frac{E(V_t) - V}{V} = \frac{U'(C)}{V(1 - \beta)} \left[ E(N_t) \left( 1 - \frac{\phi \beta}{2} \text{Var}(\Pi_t) - b \right) - N(1 - b) - \kappa(E(V_t) - v) \right] - \sigma \frac{\text{Var}(C)}{C^2}
$$

(15)

where terms of order higher than two have been ignored. $E(V_t)$ and $V_0$ differ insofar as $V_0$ also captures the transition path between the deterministic steady state and the stochastic steady state. In general, however, both measures of welfare are very close and $E(V_t)$ can therefore be seen as a good approximation of $V_0$\(^3\). Equation (15) shows that deviations of average welfare from its deterministic steady-state value can be decomposed in four parts. The first term reflects the fact that increases in average employment lead to increases in average consumption, while inflation volatility is costly as it reduces the amount of output that is available for consumption. An increase in vacancy posting costs also reduces the amount of output available for consumption, as shown in the second term. The third term indicates that, for a given level of average employment, average output increases when employment is high in times of high labor productivity and low in times of low labor productivity. Finally, the fourth term indicates that consumption volatility is costly since the utility function of households is concave in consumption.

The first term can be maximized by picking optimally a point on the $E(u_t) - \sigma(\Pi_t)$ relationship. Obviously, such a choice has an impact on the other terms, but any variation in these components is generally of second-order importance for welfare compared to the first-order effects of movements in average unemployment and

\(^3\)In the hundred simulations conducted above, conditional welfare is systematically higher than average welfare, but average welfare is at most 0.008% lower than conditional welfare.
inflation volatility. This is shown in Figure 4, which plots the contribution of the four terms to deviations of average welfare from steady-state welfare for each combination \((\phi_\pi, \phi_N)\) considered above. The results have been sorted depending on the extent of inflation volatility. The leftmost points correspond to economies with the lowest inflation volatility and the rightmost points to economies with the highest inflation volatility. It is possible to see that average vacancy posting costs barely vary with inflation volatility. Moreover, the reduction in employment volatility brought about by higher inflation volatility leads to a decrease in consumption volatility, which is beneficial for welfare, and a decrease in the covariance between productivity and employment, which is welfare detrimental. These two effects are of limited magnitude and roughly cancel each other. Most of the welfare gains of inflation volatility come through an increase in average employment, as is reflected in the marked decline of the first term when net inflation volatility goes from 0% to 0.5%. Thus, the relationship between average unemployment and inflation volatility is central in shaping welfare outcomes. The monetary authority can maximize welfare by taking advantage of it.

Figure 4: Contribution of each term in equation (15) to the percentage deviation of average welfare \(V_t\) from steady-state welfare \(V\) in the baseline model. A positive value indicates a loss while a negative value indicates a gain.
<table>
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<tr>
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<th>$u$</th>
<th>$v$</th>
<th>$\theta$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard deviation - Optimal policy</td>
<td>0.077</td>
<td>0.048</td>
<td>0.078</td>
<td>0.039</td>
</tr>
<tr>
<td>Mean - Optimal policy</td>
<td>0.0612</td>
<td>0.0806</td>
<td>0.5952</td>
<td>0.5529</td>
</tr>
</tbody>
</table>

Table 4: Moments of several variables. Simulated from the model. All variables are reported in logs as deviations from an HP trend with smoothing parameter $10^5$.

I now check whether the optimal policy actually does so. I derive the Ramsey optimal policy, defined as the process $\{I_t\}$ associated with the competitive equilibrium that yields the highest level of welfare, and study its properties. Appendix 3 provides details about the derivations. Table 4 reports the simulated moments of selected variables of the model under the optimal policy.

Figure 5: Impulse responses of selected variables to a positive productivity shock of one standard deviation under different rules: (1) Baseline, (2) Ramsey policy, (3) Price Stability. The IRFs that are reported are average IRFs. I compute different IRFs for different initial conditions and different sequences of future shocks and average them.

Labor market volatility is much lower than under a policy of price stability. This lower volatility is reflected in the value of the covariance between the unemployment rate and the job-finding probability, which stands at $-0.98$. Because the average job-finding probability is sensibly equal to its value under price stability, the
unemployment losses due to business cycles are much lower – average unemployment is equal to 6.12%. This reduction in average unemployment compared to the price stability case is achieved by allowing the standard deviation of net inflation to rise to 0.33%. Figure 5 compares the reaction of markups, inflation, labor market tightness and employment to a positive productivity shock under three different monetary policies - the baseline Taylor rule, the optimal policy, and the policy of price stability. The behavior of markups is smoother under the optimal policy than under a Taylor rule and this enables the Ramsey planner to avoid the large drops in labor market tightness and employment in the first period after the shock. However, the procyclicality of markups still helps cushion the effects of the shock on hiring. As a result, the responses of labor market tightness and employment are lower than under price stability. This smooth, yet procyclical, behavior of markups helps explain why labor market volatility is much lower than under the two policies considered in section 4.

Thus, the central bank optimally decides to allow for some inflation volatility in order to reduce average unemployment. Adopting such a policy can generate substantial welfare gains. The welfare cost of adopting a regime of price stability instead of the Ramsey regime $\lambda$, measured as the fraction of the Ramsey consumption process that a household would be willing to give up to be as well-off under the price stability regime as under the Ramsey regime, is equal to 0.17% in the baseline calibration\(^4\).

### 5.2 The role of labor market asymmetries

In the previous section, I showed that deviating from price stability is welfare improving insofar as it enables to achieve a significant increase in average employment. This outcome is closely linked to the presence of unemployment asymmetries. By deviating from price stability, the monetary authority reduces unemployment volatility. Since unemployment fluctuations are asymmetric, this leads to a decrease in average unemployment. Thus, intuitively, it seems that in a world with linear labor market fluctuations, monetary policy would lose its leverage over average unemployment and the central bank would have much less incentives to deviate from price stability. This conjecture can be checked by considering an alternative model M2 (as opposed to the baseline model M1) in which the employment-flow equation (1) and the job creation equation (7) have been linearized. In the two models, the only distortions in the flexible price equilibrium arise from wage setting. They also share the same deterministic steady state and second-order moments. The only difference is that, in M2, fluctuations in labor productivity leave the average levels of the job-finding probability and of

\(^{4}\)A detailed exposition of the way in which $\lambda$ is computed can be found in appendix 3.3.
unemployment unchanged.

In this new model, the relationship between average unemployment and inflation volatility is nearly vertical. I simulate the model for the same combinations \((\phi_\pi, \phi_N)\) than in the previous section. Figure 6 plots the contribution of the four terms in equation (15) to deviations of average welfare from steady-state welfare in each of these simulations. Just as in the baseline model, average vacancy posting costs do not differ significantly from steady-state vacancy posting costs and do not vary with inflation volatility. Similarly, consumption volatility and the covariance between productivity and employment both decrease as inflation volatility increases. The main difference with M1 owes to the behavior of the first term, which reflects the changing nature of the trade-off between inflation volatility and average unemployment. This term now increases sharply with inflation volatility, indicating a welfare loss. Indeed, in M2, inflation volatility comes with larger resource costs but no benefits in terms of average employment. Thus, in this model with linear labor market fluctuations, Figure 6 suggests that welfare can be maximized by focusing on price stability.

I now search the grid of parameters \(\{\phi_\pi, \phi_y, \phi_N, \phi_{\Delta y}\}\) over the intervals \([1.5, 10]\) for \(\phi_\pi\) and \([0, 1]\) for \(\phi_N, \phi_y, \phi_{\Delta y}\), where \(\phi_y\) is the deviation of output from steady state, for the parameter combination that yields the highest...
level of welfare. In Model 1, the optimal policy can be well approximated by a policy rule featuring a moderate response to inflation $\phi_{\pi} = 3$ and a significant response to the deviation of employment from its steady-state value $\phi_N = 1$. In Model 2, the optimal rule responds only to inflation with a coefficient $\phi_{\pi} = 10$. This confirms that the presence of labor market asymmetries is key to generate a dual focus on price stability and labor market stabilization for the monetary policymaker. This does not mean, however, that wage rigidities are inconsequential for this result. If wages were perfectly flexible (if $\gamma$ was equal to 1), the economy would feature little labor market volatility in response to shocks and mean unemployment would be very close to its value in the deterministic steady state, even in the presence of labor market asymmetries. In that case, there would again be little incentives for the central bank to deviate from price stability to stabilize labor market activity. Thus, the conclusion from this analysis is that both wage rigidity and labor market asymmetries are necessary to generate a significant monetary policy trade-off.

5.3 Monetary policy trade-offs and the flow value of unemployment

Equation (15) suggests that the welfare gains of a given increase in average employment are tightly linked to the flow value of unemployment $b$. This parameter can be interpreted either as the value of home production or as the value of the extra leisure enjoyed by workers when unemployed expressed in consumption units. Since the wage is exogenous, the cyclical properties of labor market variables and the average levels of employment and vacancies are independent of the value of $b$. Therefore, the costs arising from the level effect on employment should be a decreasing function of the value of home production. Indeed, a given decrease in average employment leads to a much larger decrease in average consumption when $b$ is low than when it is high.

It follows that the Ramsey planner should have more incentives to take advantage of the relationship between inflation volatility and average unemployment when $b$ is low. This is indeed the case. The standard deviation of inflation under the Ramsey regime is multiplied by about five when $b$ goes from 0.9 to 0. At the same time, the welfare gains of adopting the optimal policy rather than the policy of price stability $\lambda$ go from 0.002% when $b = 0.9$ to 0.4% when $b = 0$. Figures 8 to 10 at the end of the paper plot the level of conditional welfare according to the response of monetary policy to inflation and employment for different values of $b$. It shows that a policy of price stability is close to optimal when unemployed household members generate about as

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5 It cannot be interpreted as unemployment benefits. These wouldn’t show up in any of the equilibrium conditions of the model since the wage is exogenous.
Figure 7: Contribution of each term in equation (15) to the percentage deviation of average welfare $V_t$ from steady-state welfare $V_0$ in the baseline model when $b = 0$. A positive value indicates a loss while a negative value indicates a gain.

much revenues as if they were employed. However, a mild response to inflation alongside a strong response to employment is warranted for low values of home production.

I now once again simulate the baseline model with $b = 0$ for different combinations $(\phi_\pi, \phi_N)$ with $\phi_\pi \in [1.5, 10]$ and $\phi_N \in [0, 1]$ and decompose the deviations of average welfare from steady state welfare according to equation (15). Figure 7 presents the results. As in the two previous cases, average vacancy postings costs are not affected by inflation volatility, and both consumption volatility and the covariance between productivity and employment decrease as inflation volatility increases. The reduction in consumption volatility and the resulting welfare gains are larger than in section 5.1 as a given reduction in employment volatility brings a much larger reduction in consumption volatility when $b = 0$ than when $b = 0.4$. However, most of the welfare gains of inflation volatility still come through the increase in average employment. These gains are larger than in section 5.1 since a given increase in average employment brings a larger increase in average consumption when $b = 0$ than when $b = 0.4$. The majority of welfare gains achieved by the monetary authority result from allowing some inflation volatility in order to prop up average employment.
5.4 Relation to the literature

This paper builds on a very rich literature that has endeavoured to introduce the modern theory of unemployment in dynamic stochastic general equilibrium models and study how monetary policy should trade off between inflation and unemployment stabilization. A robust result of this literature is that a trade-off between these two objectives arises when job creation is inefficient, but that this trade-off is not quantitatively meaningful unless real wages are rigid. The aim of this section is to relate the results presented in this paper to this existing body of literature.

First, an important number of papers rely on first-order approximations to the equilibrium conditions when solving the model. This is the case of papers by Thomas (2008) and Ravenna and Walsh (2011) who follow the linear quadratic approach to studying optimal monetary policy. By using first-order approximations, one suppresses by construction any non-linearity from the analysis. In that case, the unconditional mean of a variable in the stochastic steady state is not different from its deterministic steady-state value, and the way monetary policy is conducted has no influence on mean unemployment. I have argued in the previous section that most of the welfare costs of a policy of price stability are due to mean effects. Thus, it is not surprising that those papers find very small costs of price stability when real wages are rigid. However, Thomas (2008) and Blanchard and Galí (2010) do find significant costs of price stability when nominal wages are staggered or when there is a direct utility cost of employment fluctuations. This suggests that adding those ingredients in the analysis could potentially strengthen the case for stabilizing employment.

Other papers such as Faia (2008, 2009) and Ravenna and Walsh (2012) have relied on second-order approximations to the equilibrium conditions. Therefore, they must capture the nonlinear labor market dynamics that are the focus of this paper. As emphasized in section 3, the size of the employment losses due to business cycles depends on the volatility of the job-finding probability. This implies that the model must generate enough amplification in response to technology shocks for the cost of unemployment fluctuations to be substantial. It has been well known since at least Shimer (2005) that models with search and matching frictions and flexible wages generate very little volatility in labor market variables. Following a shock, the immediate adjustment of the wage does not leave any incentive for firms to adjust through the employment margin. Thus, in the flexible wage model of Faia (2009), mean unemployment must be very close to its steady-state value. Not
surprisingly, in her baseline calibration, the optimal deviations from price stability are negligible. Ravenna and Walsh (2012) use a similar framework with wage rigidity and find that the gains from deviating from price stability are larger in economies with more volatile labor flows. The contribution of this paper is to show that, while wage rigidities are indeed a critical ingredient, this result also hinges on the presence of labor market asymmetries. The optimal policy is able to achieve a significantly higher level of welfare by exploiting the long-run relationship between average unemployment and inflation volatility. Such a relationship, and the resulting incentives to deviate from price stability, would not exist in an environment with linear labor market fluctuations.

6 Conclusion

An important literature seeks to describe optimal monetary policy in dynamic economies featuring nominal and real rigidities. This paper adds to this literature by showing that, in combination with wage rigidities, the non-linear nature of labor market dynamics creates a quantitatively significant trade-off between stabilizing inflation and real activity. In the presence of unemployment asymmetries, the central bank faces a long-run relationship between inflation volatility and average unemployment. Policies of price stability exacerbate unemployment volatility in response to shocks, and because unemployment fluctuations are asymmetric, lead to higher average unemployment. This increase in average unemployment brings about large welfare losses, which the monetary authority can partially offset by deviating from price stability. In that case, a dual mandate such as the one of the Fed is optimal. This result is reversed in the absence of labor market asymmetries. In that case, average employment is not affected by the conduct of monetary policy and it is preferable for the central bank to focus solely on inflation stabilization in response to shocks.

In this paper, I have assumed that households are able to insure their members against consumptions risks associated with unemployment. Several authors (Faia 2008, Walsh 2014 among others) have speculated that limited risk sharing within the household should increase the cost of unemployment fluctuations and reinforce policymakers’ incentives to stabilize labor market variables. In the appendix, I check that my results are robust to the inclusion of this feature. Interestingly, I also find that the welfare costs of price stability increase as the

However, it is worth noting that only a small degree of wage rigidity is necessary for the model to amplify shocks and for average unemployment to differ significantly from its steady-state value. Indeed, in my analysis, the elasticity of wages with respect to technology is set to 0.8, in line with empirical estimates in Haefke et al. (2013).
ratio of the consumption level of unemployed workers to the consumption level of employed workers decreases. This suggests that there might be strong complementarities between labor market policies aiming at bringing income support for the unemployed and the conduct of monetary policy. I leave such an analysis for future research.
References


7 Additional figures

Figure 8: Conditional welfare according to the response to inflation and employment when $b = 0.4$. 
Figure 9: Conditional welfare according to the response to inflation and employment when $b = 0$. 
Figure 10: Conditional welfare according to the response to inflation and employment when $b = 0.8$. 