Equilibrium Unemployment, Job Flows and Inflation Dynamics*

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Abstract

This paper develops a general equilibrium model to explain a set of facts regarding job flows, unemployment and inflation dynamics. It integrates a theory of equilibrium unemployment into a monetary model with nominal price rigidities. The labor market displays matching frictions and endogenous job destruction. The model can explain the cyclical behavior of unemployment, job creation, job destruction and the joint fluctuations of the labor input along both the extensive and the intensive margin conditional on a shock to monetary policy. Allowing for variation of the labor input at the extensive margin leads to a significantly lower elasticity of marginal costs with respect to output. This helps to explain the sluggishness of inflation and the persistence of output after a monetary policy shock.

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1 Introduction

A classic challenge that macroeconomists face is to explain the cyclical fluctuations of output, unemployment and inflation. Recently, a new generation of monetary optimizing general equilibrium models, often referred to as New Keynesian[1], has made important advances in explaining the links between money and the business cycle. Building on the traditional Keynesian theory of fluctuations, these studies assume that there are barriers to the instantaneous adjustment of nominal prices. The emphasis, then, is on the demand-side transmission mechanism of monetary policy. Although these models are widely used to explain the joint dynamics of output and inflation, they have a great difficulty in explaining why aggregate shocks and policy changes should cause significant fluctuations in equilibrium unemployment.

New Keynesian models abstract from unemployment as they assume a frictionless competitive labor market in which individuals vary the hours that they work, but the number of people working never changes. Even if some workers are leaving their jobs and taking others, this process takes no time and no other resources. In addition, these models do not allow for any heterogeneity among jobs or workers. As a consequence, there is no reason why old jobs should be destroyed and new ones created or why workers should be reallocated from time to time across alternative jobs.

If we want to investigate the effects of monetary policy on unemployment, as well as on job creation and job destruction, we need a richer labor market structure. Such labor market is one where workers look for jobs, hold them and loose them and where existing jobs are continuously replaced by new ones. The search and matching approach to labor market equilibrium, along the lines of the work by Pissarides (1990) and Mortensen and Pissarides (1994), provides a theory of equilibrium unemployment that captures these features of the labor market. In this paper I integrate this approach to equilibrium unemployment into an otherwise standard sticky prices model.

The second reason to study this integrated framework is that labor market search considerations may help to solve the problems that New Keynesian models have in explaining the sluggish response of prices and inflation together with the large, persistent response of output to demand shocks, such as monetary policy shocks. With output being demand-determined, these

[1] For surveys, see Kimball (1995), Goodfriend and King (1997), and Clarida, Galí and Gertler (1999).

models predict that the number of worked hours varies significantly as a consequence of a monetary policy shock. In the absence of an implausibly high labor supply elasticity, this leads to sizeable movements in wages and marginal costs. The large variation in marginal costs induces firms setting their prices to make large price adjustments and causes inflation to respond substantially. A number of recent papers, however, have provided some evidence that following a monetary policy shock inflation varies only by a moderate amount.[2]

With equilibrium unemployment, it turns out that most of the fluctuation in total hours takes the form of fluctuations in the number of workers, the extensive margin, rather than changes in the hours of each individual worker, the intensive margin. Allowing for variations of the labor input at the employment margin leads to a significantly lower elasticity of marginal costs with respect to output. In turn, smaller variations in marginal costs induce smaller adjustments in prices. This raises the sluggishness of the price level to changes in aggregate demand and reduces the volatility of inflation. Finally, the lower sensitivity of the price level to variations in aggregate demand raises the persistence of the response of aggregate demand and output to a monetary shock.

The model I present in this paper is characterized by two main building blocks: nominal rigidities in price setting and search and matching frictions in the labor market. One complication is that when firms set prices as in Calvo the job creation decision becomes highly intractable. To avoid this problem I distinguish between two types of firms: retail firms and intermediate goods firms.[3,4] Firms produce intermediate goods in competitive markets using labor as their only input, and then sell their output to retailers who are monopolistic competitive. Retailers, finally, sell final goods to the households. Then, I assume that price rigidities arise at the retail level, while search frictions occur in the intermediate goods sector.

The main results of the paper can be summarized as follows. First, the response of inflation to monetary shocks is significantly less volatile and more persistent than in the baseline sticky prices model. The response of output is

[2] Bernanke and Gertler (1995), Christiano, Eichenbaum and Evans (1997), Bernanke and Mihov (1998).

[3] For simplicity, I will often refer to retail firms as retailers and to intermediate goods firms as simply firms.

[4] This modelling device has first been introduced by Bernanke, Gertler and Gilchrist (1999) in their study of the financial accelerator mechanism.

also considerably more persistent. Second, the model does a very good job in accounting quantitatively for the estimated response of the US labor market to a monetary policy shock, which I determine using a Vector Autoregressive approach. It accounts for the large, persistent decrease in employment (the extensive margin) together with the small, transitory fall in average hours per worker (the intensive margin) after a contractionary monetary shock. It also reproduces the transitory fall in job creation and the larger, more persistent raise in job destruction.

Several recent papers have considered search and matching in a real business cycle model and showed that this new framework improves the empirical performance of the standard model in several directions (Merz, 1995, Andolfatto, 1996, and den Haan, Ramey and Watson, 2000). These non-monetary models, however, are not suitable to study how search and matching shape the response of the economy to monetary policy shocks. Cooley and Quadrini (1999) integrate a model of equilibrium unemployment with a limited participation model of money. Their model is consistent with evidence about the impact of monetary policy shocks on the economy and can produce labor-market dynamics that fit the data. However, their analysis focuses on the cost channel, or supply-side channel, of monetary transmission and ignores the demand-type channel due to nominal price rigidities. A recent paper by Walsh (2002) also studies (independently) the interaction between price rigidities and labor-market search. This paper, however, considers only the extensive margin, while I consider the intensive as well as the extensive margin. The two models also differ in other important details. Finally, Dotsey and King (2001) show that modifying a benchmark sticky prices model to allow for a number of "supply side" features helps to account for the large and persistent response of output to monetary shocks. In particular, they consider variation of the labor input along the extensive margin by introducing a labor force participation decision in addition to the hours of work decision. Making the supply elasticity of employment much larger than the supply elasticity of hours per worker, they assume that most of the variation of the labor input over the business cycle occurs at the extensive margin, as in the data. In this paper, instead, I investigate whether a fully microfounded specification of the labor market with involuntarily equilibrium unemployment can account for this feature of the data without appealing to high labor supply elasticities.

The remainder of the paper is organized as follows: Section 2 presents some evidence related to the response of output, inflation and the labor market to a monetary shock, Section 3 describes the model, Section 4 presents the dynamics of the model around the steady state, Section 5 describes the calibration, Section 6 discusses the results and Section 7 concludes.

2 Evidence

In this Section I describe a set of stylized facts related to the behavior of output, inflation and a set of labor market variables in face of a monetary shock. More specifically, I use the Vector Autoregressive (VAR) methodology to estimate the dynamic response of the variables of interest to an identified exogenous monetary policy shock.

2.1 Identifying monetary policy shocks

In this subsection I briefly describe the identification strategy. Following Christiano et al. (2000), and others, I assume that the Central Bank conducts its monetary policy following a simple reaction function. More precisely, in each period t, the policymaker sets its instrument - the short-term nominal rate r_t^n - in a systematic way using a simple rule that exploits the available information at time t, Ω_t. The monetary policy rule can be written as:

$$r_t^n = F\left(\Omega_t\right) + \varepsilon_t^m \tag{1}$$

where F is a linear function and ε_t^m is the monetary policy shock. The identification scheme is based on the recursiveness assumption, according to which monetary policy shocks are orthogonal to the information set of the monetary authority, Ω_t.

Let y_t denote the $(n \times 1)$ vector of the variables included in the analysis, i.e., the instrument and the variables in the information set of the monetary authority. The vector y_t is partitioned so that the monetary policy instrument is ordered last, in the n^{th} position. Then, the dynamic behavior of y_t is assumed to be represented by the following VAR of order p:

$$y_t = c + A_1 y_{t-1} + ... + A_p y_{t-p} + B\varepsilon_t \tag{2}$$

or, equivalently,

$$y_t = c + A\left(L\right) y_{t-1} + B\varepsilon_t \tag{3}$$

where c is a vector of constants, $A(L)$ indicates an $(n \times n)$ matrix polynomial of order p in the lag operator L, B is an $(n \times n)$ lower triangular matrix with unit diagonal elements and ε_t is a $(n \times 1)$ vector of mutually and serially uncorrelated structural shocks with zero mean and constant variance. The n^{th} element of ε_t is the monetary policy shock, ε_t^m. The lower-triangularity of B implies that all variables in the information set are assumed to be predetermined with respect to the monetary policy shock. Using OLS, we can estimate the coefficient matrices $A\left(L\right)$, c, B and the variance-covariance matrix of ε_t.

Given these estimates, the impulse responses functions to a monetary shock of the variables belonging to y_t can be obtained from the infinite Moving Average (MA) representation of the structural VAR. This is given by:

$$y_t - y = H\left(L\right)\varepsilon_t \tag{4}$$

or, equivalently,

$$\widehat{y}_t = \varepsilon_t + H_1\varepsilon_{t-1} + H_2\varepsilon_{t-2} + ... + H_s\varepsilon_{t-s} + ... \tag{5}$$

where $y = \left[A\left(L\right)\right]^{-1} c$ is the unconditional mean of y_t, $\widehat{y}_t = y_t - y$ is the deviation of y_t from its unconditional mean and $H\left(L\right) = \left[A\left(L\right)\right]^{-1} B$ embeds the impulse response coefficients. In particular, a plot of the $\left(i, n\right)^{th}$ element of H_s as a function of s is the estimated impulse response function of $\widehat{y}_{it}$ to a monetary shock, for any variable i in y_t.[5] This dynamic path is invariant to the ordering of the variables contained in Ω_t.

2.2 Output, inflation and the labor market

In this subsection I apply to the US data the procedure discussed above. The vector y_t includes measures of output, price level, commodity prices and the Fed funds rate, to which I add four labor market variables. The labor market variables that I include are measures of employment, average hours per worker, job creation and job destruction. The Fed funds rate is taken to be the instrument of monetary policy. I include four lagged values of all variables in the VAR. Estimates are based on quarterly data from 1972:2 to 1993:4.[6]

[5] In practice, the sum in (5) is truncated at a large but finite lag.

[6] The choice of the sample period is explained by the availability of data on job creation and job destruction.

The baseline series for employment is the log of total employees in nonfarm establishments. The baseline series for average hours per worker is constructed by subtracting the previous variable from the log of total employee-hours in nonagricultural establishments. The series for job creation and job destruction are taken from Davis, Haltiwanger, and Schuh, "Job Creation and Destruction" database. They are, respectively, the log of job creation rate for both startups and continuing establishments in the manufacturing sector and the log of job destruction rate for both shutdowns and continuing establishments in the manufacturing sector.

Figure 1 reports the responses of output, inflation and the Fed funds rate to a one standard deviation increase in the Fed funds rate and Figure 2 the responses of employment, average hours per worker, job creation and job destruction to the same shock. The solid lines display the point estimates of the coefficients. The dashed lines are ninety-five percent confidence intervals. The impulse response functions of inflation and the Federal funds rate are reported in percentage points. The other impulse responses are reported in percentage deviations from each variable's unconditional mean.

The results suggested by Figure 1 are standard in the VAR literature on monetary policy. After a contractionary monetary shock there is a large hump-shaped fall in output accompanied by a sluggish persistent decrease in inflation. While the peak fall in output is about 0.4 percent, inflation decreases at most by 0.05 percent points. Existing optimizing monetary general equilibrium models have shown a great difficulty in explaining this joint dynamic behavior of output and inflation.

Figure 2, instead, presents some new results about the response of the labor market to a monetary shock. First, as we can see from the plots, the labor input adjusts along both the extensive and the intensive margin. As a consequence of the tightening in monetary policy, both employment and hours per worker fall. However, while the fall in employment is large and persistent, there is only a small transitory decrease in hours per worker. Therefore, the labor input shows a significantly different cyclical behavior at the extensive and the intensive margin. Second, the response of employment is explained by variations at both the job creation and the job destruction margin. The monetary contraction causes a fall in job creation and a raise in job destruction. The decrease in job creation is transitory with a peak response of about two percent, while the increase in job destruction is larger and more persistent with a peak response of about four percent.

3 The model

The proposed model with nominal price rigidities and search and matching in the labor market has four sectors. The sectors include the households, the (intermediate goods) firms, the retailers and a government. Each sector's environment is discussed in detail below.

3.1 Households

Each household is thought of as a very large extended family which contains a continuum of members with names on the unit interval. In equilibrium, some members will be unemployed while some others will be working for firms. Each member has the following period utility function:

$$u(c_t, c_{t-1}) + v(\psi_t) - g(h_t, a_t), \tag{6}$$

$$u(c_t, c_{t-1}) = \log(c_t - ec_{t-1}),$$

$$v(\psi_t) = \kappa_\psi \log(\psi_t),$$

$$g(h_t, a_t) = \kappa_h \frac{h_t^{1+\phi}}{1+\phi} + a_t,$$

where c_t is consumption of a final good, $\psi_t = \frac{\Psi_t}{p_t}$ denotes real money balances, Ψ_t is nominal money balances and p_t is the aggregate price level. When $e > 0$, the model allows for habit formation in consumption.[7] The variable h_t is the hours of work and a_t is a shock to the disutility from working. The preference shock a_t is idiosyncratic to the individual and is assumed to be independently and identically distributed across individuals and times with cumulative distribution function $F(a_t)$. A high preference shock a_t causes a high disutility from working.[8]

[7] McCallum and Nelson (1999), Fuhrer (2000) and Christiano et al. (2001) claim that habit formation in consumption preferences is important to understand the transmission mechanism of monetary shocks. In particular, it helps to account for the hump-shaped decrease in consumption together with the rise in the real interest rate after a contractionary monetary shock.

[8] Assuming that the idiosyncratic shock enters additively avoids the problem of excessive variation in hours worked across individuals. In particular, since individuals are identical in all aspects other than the preference shock, it will be the case that they all work the same number of hours.

The presence of equilibrium unemployment introduces heterogeneity in the model. In the absence of perfect income insurance, each individual's labor income differs based on his employment status. In this case, the individuals' saving decision would become dependent on their entire employment history. To the purpose of this paper, I avoid these distributional issues by assuming that family members pool their incomes and chose per capita consumption, asset holdings and money balances to maximize the expected lifetime utility of the representative household:[9]

$$E_t \sum_{s=0}^{\infty} \beta^s \left[u(c_{t+s}, c_{t+s-1}) + v\left(\psi_{t+s}\right) - G_{t+s} \right], \tag{7}$$

where $\beta \in (0,1)$ is the intertemporal discount factor, c_t is per capita consumption of each family member and ψ_t is per capita real money balances. The variable G_t denotes the family's disutility from supplying hours of work, i.e., the sum of the disutilities of the members who are employed and supply hours of work. The representative household does not choose hours of work. These are determined through decentralized bargaining between firms and workers. Therefore, for simplicity, I do not make explicit this term at this point.[10]

Households own all firms in the economy. In each period households face the following budget constraint:

$$c_t + \frac{\Psi_t}{p_t} + \frac{B_t}{p_t r_t^n} = d_t + \tau_t + \frac{\Psi_{t-1}}{p_t} + \frac{B_{t-1}}{p_t}. \tag{8}$$

The variable B_t is per capita holdings of a nominal one-period bond and r_t^n is the gross nominal interest rate on this bond, which is certain at the issuing date. The variable d_t is the per capita family income in period t.[11] Finally, τ_t is a per capita real lump-sum transfer from the government.

[9] The same result could be obtained with a more sophisticated variant of the income-pooling hypothesis if the individuals insure one another against the risk of being unemployed. See as an example Andolfatto (1996).

[10] This term is nevertheless important to derive the value of employment and unemployment for a worker from the family problem. See the Appendix for details.

[11] The family income is the sum of the wage income earned by employed family members, the non-tradable output of final good produced at home by unemployed family members and the family share of aggregate profits from retailers and matched firms, net of the family share of aggregate vacancy posting costs incurred by unmatched firms.

The representative household chooses consumption, asset holdings and money holdings to maximize (7) subject to (8). The solution to this problem gives a standard consumption Euler equation:[12]

$$\lambda_t = \beta E_t \left[r_t \lambda_{t+1} \right], \tag{9}$$

where λ_t is the marginal utility of consumption at date t:

$$\begin{aligned} \lambda_t &= \frac{\partial u(c_t, c_{t-1})}{\partial c_t} + \beta E_t \frac{\partial u(c_{t+1}, c_t)}{\partial c_t}, \\ &= \frac{1}{(c_t - e c_{t-1})} - \beta e \frac{1}{(c_{t+1} - e c_t)}, \end{aligned} \tag{10}$$

and r_t is the gross real interest rate:

$$r_t = \frac{p_t}{p_{t+1}} r_t^n. \tag{11}$$

3.2 Firms and the labor market

Firms producing intermediate goods sell their output in competitive markets and use labor as their only input. They meet workers on a matching market. That is, firms cannot hire workers instantaneously. Rather, workers must be hired from the unemployment pool through a costly and time-consuming job creation process. Workers' wages and hours of work are determined through a decentralized bargaining process. Finally, matched firms and workers may decide to endogenously discontinue their employment relationship.

3.2.1 Matching market and production

In order to match with a worker, firms must actively search for workers in the unemployment pool. This idea is formalized assuming that firms post vacancies. On the other hand, unemployed workers must look for firms. I assume that all unemployed workers search passively for jobs.

[12] From the solution of this problem, I could also obtain a money demand equation relating real money balances to consumption and to the nominal interest rate. However, in the presence of an interest rate rule, which I assume below, this additional first order condition simply determines the nominal level of money balances. This is why it can safely be ignored.

Each firm has a single job that can either be filled or vacant and searching for a worker. Workers can be either employed or unemployed and searching for a job.[13] Denote with v_t the number of vacancies posted by firms and with u_t the number of workers seeking for a job at date t.

Vacancies are matched to searching workers at a rate that depends on the number of searchers on each side of the market, i.e., the number of workers seeking for a job and the number of posted vacancies. In particular, the flow of successful matches within a period, denoted with m_t, is given by the following matching function:

$$m_t = m\left(u_t, v_t\right) = \frac{u_t v_t}{\left(u_t^\sigma + v_t^\sigma\right)^{1/\sigma}}, \tag{12}$$

Notice that the matching function is increasing in its arguments and satisfies constant returns to scale.[14] It is convenient to introduce the ratio v_t/u_t as a separable variable denoted with θ_t. This ratio is the relative number of searchers and measures the labor-market tightness.

The probability that any open vacancy is matched with a searching worker at date t is denoted with q_t and is given by:

$$q_t = \frac{m_t}{v_t} = m\left(\frac{1}{\theta_t}, 1\right). \tag{13}$$

This implies that firms with vacancies find workers more easily the lower is the market tightness, that is, the higher is the number of searching workers relative to the available jobs. Similarly, the probability that any worker looking for a job is matched with an open vacancy at time t is denoted with s_t and is given by:

$$s_t = \frac{m_t}{u_t} = m\left(1, \theta_t\right). \tag{14}$$

Analogously, searching workers find jobs more easily the higher is the market tightness, that is, the higher is the number of vacant jobs relative to the number of available workers.

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[13] All unmatched workers are assumed to be part of the unemployed pool, i.e., I abstract from workers' labor force participation decisions.

[14] This specification of the matching function, which departs from the standard Cobb-Douglas form, has been first introduced by den Haan, Ramey and Watson (2000). It has the advantage that it guarantees matching probabilities between zero and one for all values of u_t and v_t.

If the search process is successful, the firm operates a production function $f(h_t) = zh_t$, where z is a technology factor common to the whole intermediate sector and h_t is the time spent working. Employment relationships might be severed for exogenous reasons in any given period. I denote with ρ^x the probability of exogenous separation. Furthermore, a matched pair may chose to separate endogenously. If the realization of the match-specific preference disturbance a_t is above a certain threshold, which I denote $\underline{a}_t$, a firm and a worker discontinue their relationship. The probability of endogenous separation is $\rho_t^n = \Pr(a_t > \underline{a}_t) = 1 - F(\underline{a}_t)$ and the overall separation rate is $\rho_t = \rho^x + (1-\rho^x)\rho_t^n$. If either exogenous or endogenous separation occurs, production does not take place.

Let us now characterize the employment dynamics. First, because job searching and matching is a time-consuming process, matches formed in $t-1$ only start producing in t. Second, employment relationships might be severed for both exogenous and endogenous reasons in any given period, so that the stock of active jobs is subject to continual depletion. Hence, employment n_t evolves according to the following dynamic equation:

$$n_t = \left(1 - \rho_{t-1}\right) n_{t-1} + m_{t-1}, \tag{15}$$

which simply says that the number of matched workers at the beginning of period t, n_t, is given by the fraction of matches in $t-1$ that survives to the next period, $\left(1 - \rho_{t-1}\right) n_{t-1}$, plus the newly-formed matches, m_{t-1}.

The labor force being normalized to one, the number of unemployed workers at the beginning of any given period is $1 - n_t$. This is different from the number of searching workers, u_t, which is given by:

$$u_t = 1 - n_t \left(1 - \rho_t\right), \tag{16}$$

since some of the employed workers discontinue their match and search for a new job in the same period.

3.2.2 Bellman equations

To make the exposition of the following sections easier, I describe here the Bellman equations that characterize the problem of firms and workers.

Denote with J_t the value of a job for a firm measured in terms of current consumption of the final good. This is given by:

$$J_t(a_t) = x_t f(h_t) - w_t(a_t) h_t + E_t \beta_{t+1} \left(1 - \rho_{t+1}\right) \int^{\underline{a}_{t+1}} J_{t+1}(a_{t+1}) \frac{dF(a_{t+1})}{F\left(\underline{a}_{t+1}\right)}. \tag{17}$$

The variables x_t and w_t denote, respectively, the relative price of the intermediate good and the hourly wage rate at date t. Note that the hourly wage rate depends on the idiosyncratic realization of the preference shock. The current value of the job is simply equal to the profits: $x_t f(h_t) - w_t(a_t) h_t$. The future value of the job, instead, can be explained as follows. Next period, with probability $1 - \rho_{t+1}$ the match is not severed. In this event the firm obtains the future expected value of a job, where the expected value is conditional on having the preference shock a_{t+1} below the separation threshold $\underline{a}_{t+1}$. With probability ρ_{t+1}, instead, the match is discontinued in $t+1$ and the firm obtains a future value equal to zero. Finally, the expected future value of the job is discounted according to the factor β_{t+1}, where $\beta_{t+s} = \frac{\beta^s \lambda_{t+s}}{\lambda_t}$.[15]

Denote with V_t the value of an open vacancy for a firm expressed in terms of current consumption. With probability $q_t \left(1 - \rho_{t+1}\right)$ the vacancy is filled in t and it is not discontinued in $t+1$. In this case the vacancy obtains the future expected value of a job. With probability $1 - q_t$ the vacancy remains open with future value V_{t+1}. Finally, with probability $q_t \rho_{t+1}$ the vacancy is filled in t but the new match is discontinued in $t+1$. In this case the future value is zero. Denoting with κ the flow cost of keeping a vacancy open, V_t can be written as:

$$V_t = -\kappa + E_t \beta_{t+1} \left[q_t \left(1 - \rho_{t+1}\right) \int^{\underline{a}_{t+1}} J_{t+1}(a_{t+1}) \frac{dF(a_{t+1})}{F\left(\underline{a}_{t+1}\right)} + (1 - q_t) V_{t+1} \right]. \tag{18}$$

Denote now with W_t and U_t, respectively, the employment and the unemployment value for a worker expressed in terms of current consumption.[16] Consider first the situation of an employed worker. The current value of employment is the labor income net of the labor disutility. Next period,

[15] The use of this discount factor effectively evaluates profits in terms of the values attached to them by the households, who ultimately own firms.

[16] Because there is perfect income insurance it is not straightforward to define these values. In the Appendix W_t and U_t are derived from the family problem.

with probability $1-\rho_{t+1}$ the match is continued and the worker obtains the future expected value of employment. In contrast, with probability ρ_{t+1} the match is severed and the worker becomes unemployed with future value U_{t+1}. Therefore, W_t can be written as:

$$\begin{aligned} W(a_t) &= w_t(a_t)h_t - \frac{g(h_t,a_t)}{\lambda_t} \\ &\quad + E_t\beta_{t+1}\left[\left(1-\rho_{t+1}\right)\int^{\underline{a}_{t+1}}\left(W_{t+1}(a_{t+1})-U_{t+1}\right)\frac{dF(a_{t+1})}{F\left(\underline{a}_{t+1}\right)}+U_{t+1}\right], \end{aligned} \tag{19}$$

where $\frac{g(h_t,a_t)}{\lambda_t}$ is the disutility from supplying hours of work expressed in terms of current consumption.

Finally, consider the situation of an unemployed worker. His current value is equal to the benefit b from being unemployed. I assume that each unemployed individual produces at home a non-tradable output b of the final good. Then, with probability $s_t\left(1-\rho_{t+1}\right)$ the unemployed worker is matched with a firm in period t and continues in the match in $t+1$. In this case he obtains the future expected value of being employed. With probability $1-s_t+s_t\rho_{t+1}$, instead, the worker remains in the unemployment pool. Therefore, U_t is given by:

$$U_t = b + E_t\beta_{t+1}\left[s_t\left(1-\rho_{t+1}\right)\int^{\underline{a}_{t+1}}\left(W_{t+1}(a_{t+1})-U_{t+1}\right)\frac{dF(a_{t+1})}{F\left(\underline{a}_{t+1}\right)}+U_{t+1}\right]. \tag{20}$$

3.2.3 Vacancy posting

In this section I study the opening of new vacancies. Note that opening a new vacancy is not job creation. Job creation takes place when a firm with a vacant job and a worker meet and start producing.

As long as the value of a vacancy V_t is greater than zero, firms will open new vacancies. In this case, however, as the number of vacancies increases, the probability q_t that any open vacancy finds a suitable worker decreases. A lower probability of filling a vacancy reduces the attractiveness of recruitment activities, thus decreasing the value of an open vacancy. In equilibrium, free entry ensures that $V_t = 0$ at any time t. Hence, from (18) the condition for the posting of new vacancies is:

$$\frac{\kappa}{q_t} = E_t \beta_{t+1} \left(1 - \rho_{t+1}\right) \int^{\underline{a}_{t+1}} J_{t+1}\left(a_{t+1}\right) \frac{dF\left(a_{t+1}\right)}{F\left(\underline{a}_{t+1}\right)}. \tag{21}$$

Noting that $1/q_t$ is the expected duration of an open vacancy, equation (21) simply says that in equilibrium the expected cost of hiring a worker is equal to the expected value of a match.

Substituting recursively equation (17) into (21) and using the law of iterated expectations I obtain:

$$\frac{\kappa}{q_t} = E_t \sum_{s=1}^{\infty} \beta_{t+s} \left(\prod_{k=1}^{s} \left(1 - \rho_{t+k}\right) \right) \int^{\underline{a}_{t+s}} \widetilde{\pi}_{t+s}\left(a_{t+s}\right) \frac{dF\left(a_{t+s}\right)}{F\left(\underline{a}_{t+s}\right)}, \tag{22}$$

where the variable $\widetilde{\pi}_{t+s}\left(a_{t+s}\right)$ is the profits of the firm at date $t+s$.

Equation (22) implies that a decrease in the sum of expected future profits must be associated with an increase in q_t on impact. Given the specification of the matching function, this requires either a decrease in the number of vacancies currently posted, v_t, or an increase in the number of currently searching workers, u_t. If job destruction was exogenous, the number of searching workers would not change on impact. In this case, the increase in q_t would be unambiguously associated with a fall in v_t. The decrease in the number of posted vacancies, in turn, would cause a decrease in next period employment, $n_{t+1.}$ With endogenous job destruction, instead, the number of searching workers changes on impact. In particular, if the decrease in profits is caused by a persistent contractionary aggregate shock, as I discuss below, the job destruction rate ρ_t is likely to increase and so is the number of workers currently searching for a job, u_t. However, unless the increase in the number of searching workers is extremely large, the raise in q_t will be associated with a fall in v_t.

Monetary shocks will affect the rate at which vacancies are posted and, consequently, employment through the above mechanism. A persistent raise in the nominal interest rate, which results in an increase in the real interest rate due to price rigidities, modifies the aggregate consumption behavior of the households and diminishes current and future aggregate demand. Since monopolistic competitive retailers produce to meet demand, this reduces their current and future demand for intermediate goods, which they use as inputs. The resulting persistent decrease in the relative price of intermediate goods, x_t, leads to a fall in firms' expected future profits. The fall in profits, finally, decreases the number of posted vacancies and reduces employment next period.

Equation (22) can be rearranged to a first-order difference equation in q_t:

$$\frac{\kappa}{q_t} = E_t\beta_{t+1}\left(1-\rho_{t+1}\right)\int^{\underline{a}_{t+1}} \widetilde{\pi}_{t+1}\left(a_{t+1}\right)\frac{dF\left(a_{t+1}\right)}{F\left(\underline{a}_{t+1}\right)} + E_t\beta_{t+1}\left(1-\rho_{t+1}\right)\frac{\kappa}{q_{t+1}}. \tag{23}$$

3.2.4 Bargaining

In equilibrium, matched firms and workers obtain from the match a total return that is strictly higher than the expected return of unmatched firms and workers. The reason is that if the firm and the worker separate, each will have to go through an expensive and time-consuming process of search before meeting another partner. Hence a realized job match needs to share this pure economic rent which is equal to the sum of expected search costs for the firm and the worker. The most natural way to do this is through bargaining.

Bargaining takes place along two dimensions, the real wage and the hours of work. I assume Nash bargaining. That is, the outcome of the bargaining process maximizes the weighted product of the parties' surpluses from employment:

$$\left(W_t\left(a_t\right)-U_t\right)^{\eta}\left(J_t\left(a_t\right)-V_t\right)^{1-\eta}, \tag{24}$$

where the first term in brackets is the worker's surplus, the second is the firm's surplus, and η reflects the parties' relative bargaining power, other than the one implied by the "threat points" U_t and V_t.[17]

Because the firm and the worker bargain simultaneously about wages and hours, the outcome is (privately) efficient and the wage plays only a distributive role.[18] The Nash bargaining model, in effect, is equivalent to one where hours are chosen to maximize the joint surplus of the match, while the wage is set to split that surplus according to the parameter η.

[17] I will treat η as a constant parameter strictly between 0 and 1.

[18] It must be emphasized that the outcome predicted by the Nash bargaining model is generally *not* efficient from the viewpoint of society as a whole.

Together the firm and the worker choose the wage w_t and the hours of work h_t to maximize (24), taking as given the relative price x_t.

The wage w_t chosen by the match satisfies the optimality condition:

$$\eta J_t(a_t) = (1-\eta)(W_t(a_t) - U_t). \tag{25}$$

As mentioned above, this condition implies that the total surplus that a job match creates is shared according to the parameter η. To see why, let $S_t(a_t) = W_t(a_t) - U_t + J_t(a_t)$ denote the total surplus from a match. Then, from (25) we obtain $W_t(a_t) - U_t = \eta S_t(a_t)$ and $J_t(a_t) = (1-\eta) S_t(a_t)$.

Although (25) explicitly takes into account the dynamic implications of the match, it can be rewritten as a wage equation that only includes contemporaneous variables. To this purpose, substitute (17), (19) and (20) into (25), using also (21) and (26). This gives the following wage equation:

$$w_t(a_t) h_t = \eta \left(x_t f(h_t) + \kappa \frac{s_t}{q_t} \right) + (1-\eta) \left(\frac{g(h_t, a_t)}{\lambda_t} + b \right). \tag{26}$$

Finally, replacing the expressions for $f(h_t)$ and $g(h_t, a_t)$ and using the fact that $\frac{s_t}{q_t} = \theta_t$ from (13) and (14), I obtain:

$$w_t(a_t) h_t = \eta (x_t z h_t + \kappa \theta_t) + (1-\eta) \left(\frac{\kappa_h \frac{h_t^{1+\phi}}{1+\phi} + a_t}{\lambda_t} + b \right), \tag{27}$$

which can be interpreted as follows. The wage shares costs and benefits from the activity of the match according to the parameter η. In particular, the first term on the right-hand side indicates that the worker is rewarded for a fraction η of both the firm's revenues and the saving of hiring costs that the firm enjoys when a job is created[19]. The second term indicates that the worker is compensated for a fraction $1-\eta$ of both the disutility he suffers from supplying hours of work and the foregone benefit from unemployment. Note that a high preference shock a_t causes a high wage.

In a frictionless perfectly competitive labor market, the wage would equal the marginal rate of substitution between consumption and leisure. With bargaining and equilibrium unemployment the wage does not equal (although is related to) the marginal rate of substitution. In particular, from (27) the wage also depends on the state of the labor market as it is measured by the

[19] The term κv_t reflects the total hiring cost in the economy. Then, $\kappa \frac{v_t}{u_t} = \kappa \theta_t$ is the hiring cost per unemployed worker.

exit rate from unemployment or the labor market tigthness, θ_t. In a tight labor market, knowing that finding another job is likely to be easy, workers will only accept a higher wage. Conversely, in a depressed labor market they will be willing to settle for a lower wage. The level of the benefit from unemployment affects the equilibrium wage through a similar channel: the higher the benefit, the lower the cost of being unemployed and the higher the bargained wage. The bargained wage, then, will behave quite differently from the competitive wage.

Let us now turn to the determination of hours. The hours of work, h_t, chosen by the match satisfy the following optimality condition:

$$\eta J_t(a_t)\left(\frac{g_h(h_t,a_t)}{\lambda_t} - w_t(a_t)\right) = (1-\eta)\left(W_t(a_t) - U_t\right)\left(x_t f_h(h_t) - w_t(a_t)\right), \tag{28}$$

which can be simplified, using (25), to:

$$x_t f_h(h_t) = \frac{g_h(h_t,a_t)}{\lambda_t}, \tag{29}$$

where the value of the marginal product of labor is equated to the marginal rate of substitution between consumption and leisure. Thus, the first order condition determining the hours worked is exactly the same as in a competitive labor market. This happens because the correct measure of labor costs to the firm is the marginal rate of substitution, rather than the wage. In other words, the wage only plays a distributive role.

Finally, using the expressions for $f(h_t)$ and $g(h_t,a_t)$, the optimal hours condition is:

$$zx_t = \kappa_h \frac{h_t^{\phi}}{\lambda_t}, \tag{30}$$

where optimal hours do not depend on the realization of the preference shock. Note also that, as previously mentioned, the choice of hours that solves the bargaining problem also maximizes the joint surplus.

3.2.5 Endogenous separation

In this section I study the separation decision of a firm-worker pair. A successful match is endogenously discontinued whenever the realization of the preference shock makes the value of the joint surplus of the match equal to zero or negative. The condition that implicitly defines the threshold value $\underline{a}_t$ is $S_t(\underline{a}_t) = 0$. Because the firm and the worker share the joint surplus according to the bargaining power η, $S_t(\underline{a}_t) = 0$ if and only if $J_t(\underline{a}_t) = W_t(\underline{a}_t) - U_t = 0$. Thus, the job destruction condition can be written as $J_t(\underline{a}_t) = 0$. Using (17) and (21) this condition becomes:

$$\widetilde{\pi}_t\left(\underline{a}_t\right) + \frac{\kappa}{q_t} = 0. \tag{31}$$

Equation (31) implies that a fall in the expected future profits, i.e., a decrease in $\frac{\kappa}{q_t}$, must be associated with an increase in current profits evaluated at $\underline{a}_t$. If the decrease in expected future profits is caused by a persistent contractionary aggregate shock, current profits at any given realization of the preference shock are likely to fall as well. In this case, the increase in $\widetilde{\pi}_t\left(\underline{a}_t\right)$ requires a decrease in $\underline{a}_t$.

Monetary policy shocks will affect the separation decision of firms and workers and, consequently, employment through the above mechanism. As previously discussed, a persistent increase in the nominal interest rate reduces current and future expected profits at any given level of a_t. This, in turn, decreases the value of a_t above which the firm and the worker decide to separate. A lower threshold $\underline{a}_t$ raises the current separation rate ρ_t on impact and decreases employment next period.

3.2.6 Job creation, job destruction and employment

I define labor market flows following den Haan, Ramey and Watson (2000). They begin with the observation that flows of workers out of employment relationships are larger than flows of jobs out of firms. This implies that a fraction of the firms experiencing separations from workers must attempt to refill the jobs left vacant and be successful at doing it within the same period. To take this observation into account, they assume that firms experiencing exogenous separations immediately repost the resulting vacancies, while firms experiencing endogenous separations do not. This implies that $\rho^x n_t$ separations are reposted and $q_t \rho^x n_t$ separations are refilled within the same period. Finally, they assume that a job is neither created or destroyed by a firm that both looses and gains a worker in the same period.

Job creation, then, is defined to be equal to the number of newly-created matches net of the number of matches serving to refill the reposted vacancies. The job creation rate is given by:

$$jc_t = \frac{m_t}{n_t} - q_t \rho^x \tag{32}$$

Job destruction, in turn, is defined as the total number of separations net of the number of separations that are reposted and successfully refilled. The job destruction rate is given by:

$$jd_t = \rho_t - q_t \rho^x \tag{33}$$

Employment variation, finally, is the outcome of job creation and job separation decisions of firms and workers. Substituting (32) and (33) into (15) and rearranging, I obtain:

$$\frac{n_{t+1} - n_t}{n_t} = jc_t - jd_t \tag{34}$$

3.3 Retailers and price setting

There is a continuum of monopolistic competitive retailers indexed by i on the unit interval. Retailers do nothing other than buy intermediate goods from firms, differentiate them with a technology that transforms one unit of intermediate goods into one unit of retail goods, then re-sell them to the households.

Let $y_{i,t}$ be the quantity of output sold by retailer i and let $p_{i,t}$ be the nominal sale price. Final goods, y_t, are the following composite of individual retail goods:

$$y_t = \left[\int_0^1 y_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{35}$$

where ε, which is assumed to be greater than one, is the elasticity of substitution across the differentiated retail goods.

Final output may then be either transformed into a single type of consumption good or used up in vacancy posting costs. In particular, the economy-wide resource constraint can be written as

$$y_t = c_t + \kappa v_t. \tag{36}$$

Given the index (35) that aggregates individual retail goods into final goods, the demand curve facing each retailer is given by:

$$y_{i,t} = \left(\frac{p_{i,t}}{p_t}\right)^{-\varepsilon} y_t. \tag{37}$$

The aggregate price index, which is defined as the minimum expenditure required to purchase retail goods resulting in one unit of the final good, is:

$$p_t = \left[\int_0^1 p_{i,t}^{1-\varepsilon} di\right]^{\frac{1}{1-\varepsilon}}. \tag{38}$$

As in Calvo (1983), I assume that in any given period each retailer can reset its price with a fixed probability $1-\varphi$ that is independent of the time elapsed since the last price adjustment. This assumption implies that prices are fixed on average for $\frac{1}{1-\varphi}$ periods.[20] Then, I follow Galí and Gertler (1999) by assuming that there are two types of retailers that differ in the way they reset prices. A fraction $1-\omega$ of the retailers, which are referred to as "forward-looking", set prices optimally, given the restriction on the frequency with which they can adjust their price. The remaining fraction ω of the retailers, which are referred to as "backward-looking", instead follow a simple rule of thumb.

The average price of the retailers that do not adjust their price can be shown to be simply p_{t-1}. Thus, given (38), the aggregate price level evolves according to the following equation:

$$p_t = \left[\varphi p_{t-1}^{1-\varepsilon} + (1-\varphi)\,\overline{p}_t^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}, \tag{39}$$

where $\overline{p}_t$ is the average of the newly reset prices at date t. Let p_t^{f} be the price set by the forward-looking retailers and p_t^{b} the price set by the backward-looking retailers. The average price $\overline{p}_t$ may then be expressed as follows:

$$\overline{p}_t = \left[(1-\omega)\,p_t^{\mathrm{f}1-\varepsilon} + \omega p_t^{\mathrm{b}1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}. \tag{40}$$

Forward-looking retailers choose their price to maximize expected future discounted profits given the demand for the good they produce and under the hypothesis that the price they set at date t applies at date $t+s$ with probability φ^s. Retailers, then, maximize

[20] The Calvo's model avoids keeping track of every agent's pricing decision when prices are fixed for a certain number of periods.

$$E_t \sum_{s=0}^{\infty} \varphi^s \beta_{t+s} \left[\frac{p_{i,t}}{p_{t+s}} - x_{t+s} \right] y_{i,t,t+s}, \tag{41}$$

where $y_{i,t,t+s}$ denotes the demand for good i at date $t+s$ conditional on the price set at date t. Note that the relative price of intermediate goods, x_t, coincides with the real marginal cost faced by retailers.

The solution to this problem gives the following expression for the optimal reset price, p_t^{f}:

$$p_t^{\mathrm{f}} = \mu E_t \sum_{s=0}^{\infty} \omega_{t,t+s} x_{t+s}^n, \tag{42}$$

where $\mu = \frac{\varepsilon}{\varepsilon - 1}$ is the flexible-price markup and $x_t^n = p_t x_t$ is the nominal marginal cost at date t. The weights $\omega_{t,t+s}$ are given by

$$\omega_{t,t+s} = \frac{\varphi^s \beta_{t+s} R_{i,t,t+s}}{E_t \sum_{k=0}^{\infty} \varphi^k \beta_{t+k} R_{i,t,t+k}}, \tag{43}$$

where $R_{i,t,t+s}$ denotes revenues from good i at time $t+s$ conditional on the price set at date t. Thus, a forward-looking retailer sets its price equal to a markup μ over a weighted average of expected future marginal costs, where the weights represent the relative proportion of expected discounted revenues at each future date.[21]

Backward-looking retailers are assumed to obey the following rule of thumb, as in Galí and Gertler (1999):

$$p_t^{\mathrm{b}} = \overline{p}_{t-1} \pi_{t-1}, \tag{44}$$

where π_t is the gross inflation rate at time t. That is, they set their price equal to the average of the last period reset prices, $\overline{p}_{t-1}$, after applying a correction for inflation. It can be shown that there are not persistent deviations of the rule of thumb from the optimal pricing behavior.

3.4 Government and market clearing

The government conducts both fiscal and monetary policy. I assume that the government rebates lump-sum to the household seigniorage revenues. I

[21] In the limiting case in which retailers are allowed to reset their price every period ($\varphi = 0$), equation (42) reduces to the standard condition that the price is a constant markup over the nominal marginal cost.

also assume that there is not public spending. Then, the government budget constraint is simply:

$$\frac{\Psi_t - \Psi_{t-1}}{p_t} = \tau_t. \tag{45}$$

The government, through a monetary authority, determines Ψ_t indirectly. I assume that the monetary authority conducts monetary policy using the short-term nominal interest rate as the policy instrument and lets the nominal amount of money adjusting accordingly. The gross nominal interest rate r_t^n follows a Taylor-type rule of the following type:

$$r_t^n = \left(r_{t-1}^n\right)^{\rho^m} (\pi_t)^{\gamma_\pi (1-\rho^m)} (y_t)^{\gamma_y (1-\rho^m)} e^{\varepsilon_t^m} \tag{46}$$

The parameter $0 < \rho^m < 1$ measures the degree of interest rate smoothing and is included following the empirical evidence presented in Clarida, Galí and Gertler (2000). The parameters γ_π and γ_y are the long run responses of the monetary authority to deviations of inflation and output from their steady state values and ε_t^m is an i.i.d. monetary policy shock.

Finally, the model is closed by imposing the following market clearing condition in the intermediate good sector:

$$y_t = n_t (1 - \rho_t) f(h_t), \tag{47}$$

where y_t is aggregate demand, $n_t (1 - \rho_t)$ is the number of firms actually producing in t and $f(h_t)$ is each firm's production.

4 Model dynamics

The dynamics of the model are obtained by taking a log-linear approximation of equations (9), (10), (11), (12), (13), (14), (15), (16), (23), (27), (30), (31), (32), (33), (36), (39), (40), (42), (43), (44), (46), (47) around a deterministic steady state, with zero inflation. In what follows variables with a "hat" denote log-deviations from the steady state value, while variables without a time subscript denote steady state values.

Taylor-type interest rate rule

$$\widehat{r}_t^n = \rho^m \widehat{r}_{t-1}^n + (1 - \rho^m) \gamma_\pi \widehat{\pi}_t + (1 - \rho^m) \gamma_y \widehat{y}_t + \varepsilon_t^m. \tag{48}$$

Euler equation

$$\widehat{\lambda}_t = E_t \widehat{\lambda}_{t+1} + \widehat{r}_t. \tag{49}$$

Marginal utility of consumption

$$(1 - \beta e) \widehat{\lambda}_t = \frac{e}{1-e} \widehat{c}_{t-1} - \frac{e(1+\beta e)}{1-e} \widehat{c}_t + \frac{\beta e}{1-e} E_t \widehat{c}_{t+1}. \tag{50}$$

Real interest rate

$$\widehat{r}_t = \widehat{r}_t^n - E_t \widehat{\pi}_{t+1}. \tag{51}$$

Hours per worker

$$\widehat{h}_t = \frac{1}{\phi} \left(\widehat{x}_t + \widehat{\lambda}_t \right). \tag{52}$$

Phillips curve

$$\widehat{\pi}_t = \varphi_x \widehat{x}_t + \varphi_{\mathrm{f}} E_t \widehat{\pi}_{t+1} + \varphi_{\mathrm{b}} \widehat{\pi}_{t-1}, \tag{53}$$

where $\varphi_x = \frac{(1-\beta\varphi)(1-\varphi)(1-\omega)}{\varkappa}$, $\varphi_{\mathrm{f}} = \frac{\beta\varphi}{\varkappa}$, $\varphi_{\mathrm{b}} = \frac{\omega}{\varkappa}$ and $\varkappa = \varphi + \omega \left[1 - \varphi (1 - \beta) \right].$

Resource constraint

$$\widehat{y}_t = \frac{c}{y} \widehat{c}_t + \frac{\kappa v}{y} \widehat{v}_t. \tag{54}$$

Market clearing

$$\widehat{y}_t = \widehat{h}_t + \widehat{n}_t + \eta_{F,\underline{a}} \widehat{\underline{a}}_t, \tag{55}$$

where $\eta_{F,\underline{a}} = \frac{\partial F(\underline{a})/F(\underline{a})}{\partial \underline{a}/\underline{a}}$.

Matching function

$$\widehat{m}_t = \eta_m \widehat{u}_t + (1 - \eta_m) \widehat{v}_t, \tag{56}$$

where $\eta_m = \frac{v^\sigma}{(u^\sigma + v^\sigma)}$.

Transition probabilities

$$\widehat{q}_t = \widehat{m}_t - \widehat{v}_t, \tag{57}$$

$$\widehat{s}_t = \widehat{m}_t - \widehat{u}_t. \tag{58}$$

Market tightness

$$\widehat{\theta}_t = \widehat{v}_t - \widehat{u}_t. \tag{59}$$

Employment

$$\widehat{n}_t = (1-\rho)\,\widehat{n}_{t-1} + (1-\rho)\,\eta_{F,\underline{a}}\widehat{\underline{a}}_{t-1} + \rho\widehat{m}_{t-1}. \tag{60}$$

Searching workers

$$\widehat{u}_t = -\frac{n\,(1-\rho)}{u}\widehat{n}_t - \frac{n\,(1-\rho)}{u}\eta_{F,\underline{a}}\widehat{\underline{a}}_t. \tag{61}$$

Vacancy posting condition

$$\widehat{q}_t = -\zeta_1\left(\widehat{x}_{t+1} + \widehat{h}_{t+1}\right) + \beta\,(1-\rho)\,\eta s\widehat{\theta}_{t+1} + \beta\,(1-\rho)\,\widehat{q}_{t+1} - \zeta_2\widehat{\lambda}_{t+1} + \widehat{\lambda}_t, \tag{62}$$

where $\zeta_1 = \frac{\beta\phi(1-\rho)(1-\eta)qxh}{\kappa(1+\phi)}$, $\zeta_2 = \frac{\beta(1-d)(1-\eta)qH(\underline{a})}{\kappa\lambda}$ and $H(\underline{a}) = \int^{\underline{a}} a dF\,(a)$.

Separation condition

$$\varsigma\left(\widehat{x}_t + \widehat{h}_t\right) - (1-\eta)\,\frac{\underline{a}}{\lambda}\,(\widehat{\underline{a}}_t - \lambda_t) - \frac{\eta s\kappa}{q}\widehat{\theta}_t - \frac{\kappa}{q}\widehat{q}_t = 0, \tag{63}$$

where $\varsigma = \frac{\phi(1-\eta)xh}{(1+\phi)}$.

Job creation rate

$$\widehat{jc}_t = \frac{\rho}{\rho - dq}\left(\widehat{m}_t - \widehat{n}_t\right) - \frac{dq}{\rho - dq}\widehat{q}_t. \tag{64}$$

Job destruction rate

$$\widehat{jd}_t = -\frac{1-\rho}{\rho - dq}\eta_{F,\underline{a}}\left(\widehat{m}_t - \widehat{n}_t\right) - \frac{dq}{\rho - dq}\widehat{q}_t. \tag{65}$$

Average hourly wage

$$\widehat{w}_t = \omega_1 \widehat{x}_t - \omega_2 \widehat{\lambda}_t + \omega_3 \widehat{\underline{a}}_t + \omega_4\left(\widehat{s}_t - \widehat{q}_t\right) - \omega_5 \widehat{h}_t, \tag{66}$$

where $\omega_1 = x(\eta + \frac{1-\eta}{1+\phi})$, $\omega_2 = \frac{(1-\eta)H(\underline{a})}{h\lambda F(\underline{a})}$, $\omega_3 = \omega_2\left(\eta_{H,\underline{a}} - \eta_{F,\underline{a}}\right)$, $\omega_4 = \frac{\eta\kappa s}{hq}$, $\omega_5 = \omega_2 + \omega_4 + \frac{(1-\eta)b}{h}$ and $\eta_{H,\underline{a}} = \frac{\partial H(\underline{a})/H(\underline{a})}{\partial \underline{a}/\underline{a}}$.

The model presented in this paper nests a baseline sticky prices model with a frictionless and competitive labor market and no capital. The baseline model can be obtained as follows. First, assume that the rates of job creation and job destruction are constant at their steady state values. This implies that all labor market variables specific to the search and matching framework are also constant at their steady state values.[22] Second, assume that all output is transformed into the final consumption good. The baseline sticky prices model, then, is described by equations (48), (49), (50), (51), (52), (53), (54) and (55), where in equation (54) $\widehat{v}_t$ is equal to zero and $\frac{c}{y}$ is equal to one and in equation (55) $\widehat{n}_t$ and $\widehat{\underline{a}}_t$ are both equal to zero.[23]

This implies that the two models are easily comparable. In particular, any difference in the dynamics of those variables that belong to both models must be associated with the dynamics of job creation and job destruction that, in turn, determine the dynamics of employment.

[22] These variables are n_t, u_t, m_t, s_t, q_t, $\underline{a}_t$, v_t and θ_t.

[23] The wage equation (66), which is the outcome of the bargaining problem, does not nest the competitive wage equation. However, since the bargained wage is not allocative for hours, this turns out to be irrelevant for the model dynamics.

5 Model calibration

In this section I discuss the calibration of the parameters of the model. I set the quarterly discount factor β to 0.98, which implies a quarterly real rate of interest of approximately 2 percent. The other parameters of the utility function that we need to calibrate are ϕ, κ_h and e. The elasticity of intertemporal substitution in the supply of hours is equal to $1/\phi$. The value of this elasticity has been a substantial source of controversy in the literature. Students of the business cycle tend to work with elasticities that are higher than microeconomic estimates, typically unity and above. Most microeconomic studies, however, estimates this elasticity to be much smaller, between 0.05 and 0.5.[24] I accordingly set ϕ equal to 5, which implies an elasticity of intertemporal substitution of 0.2. I then choose the weight α_h so that the average time spent working, h, is equal to 1/3. Finally, the habit persistence parameter e is set to 0.5, similar to Christiano et al. (2001).

I set the probability that a firm does not change its price within a given period, φ, equal to 0.8, implying that the average period between price adjustments is 5 quarters. The fraction ω of backward-looking firms is set to 0.5. Both values are consistent with the estimates in Galí and Gertler (1999). I assume that, on average, the markup of prices on marginal costs is 20 percent. This amounts to setting ε equal to 6.

The empirical literature provides us with several measures of the US worker separation rate. Davis, Haltiwanger and Schuh (1996) compute a quarterly worker separation rate of about 8 percent, while Hall (1995) reports this rate to be between 8 and 10 percent. Accordingly, I set the overall separation rate ρ to 0.08. In order to distinguish between the exogenous and the endogenous components of the separation rate, I follow den Haan, Ramey and Watson (2000).[25] Based on evidence reported by Davis, Haltiwanger and Schuh, they calculate that the rate at which separations are reposted by firms is equal to 0.68. Moreover, as previously discussed, they assume that only exogenous separations are reposted. This implies that the exogenous separation rate ρ^x can be calculated to be 0.054. The steady state endogenous separation rate ρ^n is then equal to 0.026.

I set the steady state employment rate n to 0.75.[26] Then, I set the steady

[24] For a survey of the literature see Card (1994).

[25] See Section 3.2.6.

[26] Andolfatto (1996) sets n to 0.54, while den Haan, Ramey and Watson (2000) set it to 0.89. These values, which are obviously larger than in the data, can be justified by

state probability that a firm fills a vacancy, q, to be equal to 0.7, as in Cooley and Quadrini (1999) and den Haan, Ramey and Watson (2000). The steady state probability that a worker finds a job, s, is calculated from the steady state relationships to be 0.25. These values imply that the average time a vacancy is filled and a worker finds a job are 1.4 and 4 quarters, respectively. I assume that the worker and the firm have equal bargaining power by selecting $\eta = 0.5$. The distribution F of the idiosyncratic shock is assumed to be lognormal with mean μ_a and standard deviation σ_a. The mean μ_a is set to 1. The standard deviation σ_a and the parameter σ of the matching function are chosen to match as close as possible the volatility of job creation and job destruction in the simulated data with the empirical evidence from the VAR. The parameters κ and b are derived from the steady state calculation.

Finally, I follow the estimates presented in Clarida, Galí and Gertler (2000) and set the interest rate smoothing parameter ρ to 0.9, and the parameters γ_π and γ_y to 1.5 and 0.5.

6 Findings

First, I compare the predictions of the model developed in this paper - which I will refer to, for simplicity, as the search model - with those of the baseline sticky prices model. Figure 3 shows the response of several variables to a monetary shock. The monetary shock is a one standard deviation (18 basis points) increase in the nominal interest rate. For each variable I plot the response in the search model and the baseline model. As can be seen from the figure, output, inflation, marginal costs and total hours have a similar

interpreting the unmatched workers in the model as being both unemployed and partly out of the labor force. This interpretation is consistent with the abstraction in the model from labor force participation decisions. Another way to rationalize a lower value for n is the following. It is assumed in order to capture labor force participation changes. When the steady state fraction of searchers is low, the model implies that a small percentage decrease in the number of employed workers causes a large percentage increase in the numbers of workers looking for a job. This, in turn, raises significantly the probability of filling a vacancy. In reality, however, a lower probability of finding a job reduces the labor force participation. In that case, a decrease in the number of employed people does not necessarily translates in a one-to-one increase in the number of people searching for a job. As a result, the probability of filling a vacancy may increase by a lower amount. A possible way to take this labor force participation effect into account is to assume a higher steady state value for the fraction of searching workers.

qualitative response in the two models. In both models, a raise in the nominal interest rate causes an increase in the real interest rate because there are price rigidities. As a consequence of the raise in the real interest rate, aggregate demand, output of final goods and total hours worked decrease. The fall in output and hours can only occur at decreased marginal costs. Finally, because prices are set based on expected future marginal costs, inflation decreases. Therefore, the two models are observationally equivalent. That is, the introduction of search frictions does not change the nature of the baseline model dynamics. From a quantitative point of view, however, the search and the baseline model behave extremely differently. In the search model the response of inflation is significantly less volatile. The response of output is larger and more persistent. This happens because the search model implies a substantially lower elasticity of marginal costs with respect to output. The figure shows that a given fall in output is associated with a much lower decrease in the level of marginal costs than in the baseline model. In turn, smaller variations in marginal costs induce firms setting their prices to make smaller adjustments in prices. This increases the sluggishness of the aggregate price level to changes in aggregate demand and reduces the volatility of inflation. In particular, while in the baseline model a peak decrease in output of about 0.30 percent is associated with a peak fall in inflation of around 0.20 percent, in the search model output falls by about 0.34 percent and inflation by only 0.08 percent. Finally, the lower sensitivity of the price level to variations in aggregate demand raises the persistence of the response of aggregate demand and output to a monetary shock. In the baseline model output goes back to its steady state value after 6 quarters, while in the search model it takes around 12 quarters.

The elasticity of marginal costs with respect to output is lower in the search model because most of the fluctuation in total hours takes the form of fluctuations in the number of people working rather than changes in the hours by employment workers, as it is assumed in the baseline model. Figure 4 plots the responses of total hours, active employment and hours per worker in the search model. Active employment is the number of people actually working in each period, i.e., the number of employed workers at the beginning of the period whose match is not severed before production starts.[27] The percent change in total hours is the sum of percent changes in active employment and hours per worker. The figure shows that the decrease in the number of

[27] This is equal to $n_t(1-\rho_t)$.

people actually working is significantly larger and more persistent than the fall in the hours per worker.

Changes in the labor input at the extensive margin allow for adjustments in output without changed marginal costs. To see this, write the log-linearized real marginal cost as $\widehat{x}_t = \phi\widehat{h}_t - \widehat{\lambda}_t$, from equation (52). This implies that changes at the intensive margin cause changes in real marginal costs according to the parameter ϕ, while changes at the extensive margin do not affect marginal costs.[28] This happens because variations in hours per worker involve changes in the disutility cost from supplying labor, while changes in employment only represent changes in the economy's capacity level. In the baseline model, instead, all changes in the labor input occur at the intensive margin and affect marginal cost as above, proportionally to ϕ. For further comparison, note first that final output is given by $\widehat{y}_t = \widehat{h}_t$ in the baseline model and $\widehat{y}_t = \widehat{h}_t + \widehat{n}_t^a$ in the search model, with n^a denoting active employment. Substituting, then, hours for final output in the expression for marginal cost gives $\widehat{x}_t = \phi\widehat{y}_t - \widehat{\lambda}_t$ and $\widehat{x}_t = \phi\left(\widehat{y}_t - \widehat{n}_t^a\right) - \widehat{\lambda}_t$, respectively. These expressions imply that a given change in output causes a lower change in marginal cost in the search model. Marginal costs are lower by exactly the change in active employment, weighted by ϕ.

It must be emphasized that I have assumed a degree of intertemporal substitution in the supply of hours that is consistent with microeconomic estimates. Instead, general equilibrium models of the business cycle, among which sticky prices models, tend to assume much higher values of this elasticity, typically unit and above. By doing so, they can approximate some implications of the model with both margins of adjustment. For example, the baseline sticky prices model considered in this paper can approximate the joint dynamics of output and inflation in the search model by assuming an infinite elasticity of intertemporal substitution. Of course, such model cannot explain what drives fluctuations in employment as opposed to hours per worker, why there is unemployment in equilibrium or, more generally, the behavior of the labor market over the business cycle.

Figure 5 presents the dynamics of the labor market in the search model after a monetary policy shock. The response of unemployment is explained by the dynamics of job creation and job destruction. Recall, from equation (34), that employment growth is given by $\frac{n_{t+1}-n_t}{n_t} = jc_t - jd_t$. Thus, em-

[28] Of course, changes at both margins have a second-order general equilibrium effect on the real marginal cost x_t through λ.

ployment falls if job creation is lower than job destruction. As can be seen from the figure, a contractionary monetary shock decreases job creation and raises job destruction. The raise in job destruction is greater than the decrease in job creation. Thus, most of the decrease in employment is due to the response of job destruction, rather than job creation. Moreover, while the reduction in job destruction persists for four periods, job creation raises above the steady state in the second period and above the job destruction rate in the third period. This implies that from the fourth period on employment begins to raise and unemployment to decline. The responses of job creation and destruction, in turn, can be explained as follows. A persistent raise in the nominal interest rate causes a decrease in current and expected future aggregate demand. The fall in aggregate demand, in turn, decreases the demand for intermediate goods and the profits of firms producing them. This diminishes the value of the idiosyncratic shock above which the firm and the worker decide to separate and raises the separation rate. The decrease in profits also reduces the value of opening a vacancy V_t and induces firms to post less vacancies. The decrease in the number of posted vacancies diminishes both the number of new matches and the job creation rate. As a consequence of both job creation and job separation decisions, employment decreases and unemployment increases next period. This causes the relative number of vacancies looking for workers and workers looking for jobs to decrease. Thus, the probability of filling a vacancy q_t raises while the probability of finding a job s_t drops. The higher probability of hiring a worker increases the attractiveness of hiring activities and the expected future value of a match. Therefore, job creation starts to increase and job destruction to fall.

Figure 6 plots the simulated impulse responses to the monetary shock against the estimated impulse responses in the US economy. The solid and dashed lines denote, respectively, the estimated impulse responses and the two standard deviations confidence intervals, while the star lines denote the simulated responses in the model. The model that I have developed in this paper is not able to match the initial delay in the response of output that is observed in the data. As Figure 1 shows, after the tightening in monetary policy output does not move for two quarters. In the model, instead, output moves on impact. In order to reproduce this feature of the data the model should allow for other sources of frictions such as, for example, time to plan consumption. However, this is not the focus of the analysis. Rather, I am interested in exploring whether the model is able to match the comovements of the variables included in the analysis *conditional* on the response of output.[29] Therefore, I plot the model responses against the US estimated responses starting from the third quarter, that is, when output starts to fall. Conditional on the response of output, the model does a good job in accounting for the dynamic response of the US economy to a monetary policy shock. The first dimension in which the model can reproduce the data is the large response of output together with the sluggish, moderate response of inflation. The simulated responses of output and inflation are almost everywhere within the respective confidence intervals. However, while the model generates more persistence in output than the baseline sticky prices model, the figure suggests that output is not yet as persistent as in the data. Second, the model is able to reproduce the quantitative behavior of the variation of the labor input at both margins of adjustment. It generates a small, transitory fall in hours per worker together with a larger, more persistent fall in employment. Likewise the response of output, however, the response of employment is less persistent than in the data. Third, the model explains the joint behavior of job creation and job destruction. In particular, it can account for the larger and more persistence response of job destruction than job creation. Note, finally, that the simulated impulse responses of all four labor market variables are almost everywhere within the respective confidence intervals.

I also evaluate the model in terms of its ability to match some key *conditional* second moments, i.e., second moments conditional on the monetary shock as a source of fluctuations. Table 1 shows the standard deviation ratios of employment, hours per worker, inflation, job creation and job destruction with respect to output, as generated by the model economy and the US economy in the aftermath of the monetary shock. The model is able to match closely the relative volatilities of employment and hours per worker with respect to output and to account for the small volatility of inflation with respect to output, although this value is still higher than in the data. It can also generate the higher volatility of job destruction than job creation that is observed in the data. Table 2 compares the conditional cross correlations at different leads and lags between employment, job creation and job destruction. As the table shows, the model displays a significant capability to reproduce the data, with magnitudes and signs of the cross correlations

[29] In particular, adding such frictions would largely complicate the model without adding any insights regarding the joint dynamics of output, inflation and labor market variables.

being quite close. In both the model and the data job creation tends to lag employment, while job destruction tends to lead employment. That is, employment has a large negative correlation with future job creation and past job destruction. Moreover, the model can account for the negative contemporaneous correlation between job destruction and job creation. Table 3 reports the dynamic conditional correlations of output with employment and hours per worker. The chief discrepancy between the model and the observation is the dynamic path of hours. Although hours tend to lead output in both the model and the data, hours are procyclical in the model while only mildly so in the data. Finally, Table 4 reports the conditional dynamic correlations of inflation with output, employment, job creation and job destruction. As can be observed from the table, the model displays considerable agreement with the data. The model successfully replicates the positive correlations of inflation with current output and employment and the negative correlations with job creation and job destruction, although the magnitudes tend to be higher than in the data.

7 Conclusions

This paper builds on a New Keynesian theory of money and fluctuations and a modern theory of equilibrium unemployment. Both theories have been introduced previously in the macroeconomic literature and extensively used for both normative and positive analysis. But the combination of these theories into a single dynamic general equilibrium model provides new insights on the linkages between money, business cycle fluctuations and the dynamics of the labor market.

There are two basic findings. The first concerns the cyclical behavior of the labor market when money is the driving force behind aggregate fluctuations. The paper shows that the demand side channel of monetary transmission seems to be a good candidate to explain the fluctuations of unemployment and job flows over the business cycle. The second finding concerns the role of labor market dynamics in shaping the joint dynamics of output and inflation. These variables are the focus of the recent literature analyzing monetary policy in the presence of nominal price rigidities. The results indicate that, when labor market search is incorporated into a standard sticky prices model, the ability of the model to explain the response of output and inflation improves along a number of dimensions.

The ultimate objective of developing quantitative monetary general equilibrium models of the business cycle is to design an optimal, or at least desirable, monetary policy. The model developed in this paper could then be used to perform a welfare analysis of the consequences of alternative monetary policies. In particular, the model provides the basis for thinking about the implications of different labor market policy regimes for the optimal monetary policy. I plan to explore these issues in future research.

8 Appendix

Derivation of the surplus from employment for a worker

This Appendix shows how the surplus from employment for a worker - the difference between the employment and unemployment values - can be obtained from the family's problem. In this way, it is possible to rationalize the existence of bargaining between workers and firms when workers are perfectly insured against the risk of being unemployed, as it is assumed in the paper. The argument is based on the assumption that workers value their actions in terms of the contribution these actions give to the utility of the family to which they belong. This implies that the surplus from employment for a worker can be defined as the change in the family's utility from having one additional member employed.

Suppose that there is a continuum of identical families indexed on the unit interval. Each of these families has a continuum of members indexed by $i \in [0,1]$. A fraction n_t^a of these members is employed, while the remaining fraction $1 - n_t^a$ is unemployed. Recall that n_t^a denotes the number of individuals that are actually working in period t. This is different from n_t, the number of individuals that are employed at the beginning of period t, previously to the realization of the idiosyncratic shock. The representative family's optimal value function, denoted with U_t, can be written as:

$$U_t\left(n_t^a\right) = u(c_t, c_{t-1}) + v\left(\psi_t\right) - \int^{n_t^a} g\left(h_t, a_{it}\right) di + \beta E_t\left[U_{t+1}\left(n_{t+1}^a\right) \mid a_{it+1} \leq \underline{a}_{t+1}\right] \tag{67}$$

Note that the family's disutility from having a fraction n_t^a of its members supplying hours of work, previously denoted with G_t, is made explicit in (67) and is equal to $\int^{n_t^a} g\left(h_t, a_{it}\right) di$. The symbol a_{it} denotes the idiosyncratic shocks to the individual i's disutility from working.

Each family faces the following budget constraint:

$$c_t + \frac{\Psi_t}{p_t} + \frac{B_t}{p_t(1+r_t^n)} = \int^{n_t^a} w_t\left(a_{it}\right) h_t di + \left(1 - n_t^a\right) b + \sigma_t + \tau_t + \frac{\Psi_{t-1}}{p_t} + \frac{B_{t-1}}{p_t} \tag{68}$$

where the per capita family's income, previously denoted with d_t, is the sum of the first three terms on the right-hand side of the budget constraint. More precisely, the family obtains income from having a fraction n_t^a of its members working at the hourly wage $w_t(a_{it})$ and a fraction $1 - n_t^a$ producing at home a non-tradable output b of final goods. Finally, σ_t denotes the family's per capita share of aggregate profits from retailers and intermediate goods firms, net of the vacancy posting costs.

The fraction of employed members evolves accordingly to the following dynamic equation:

$$n_{t+1}^a = \left(1 - \rho_{t+1}\right) n_t^a + s_t \left(1 - \rho_{t+1}\right) \left(1 - n_t^a\right) \tag{69}$$

where the representative family takes as given the probability s_t at which the search activity by the unemployed members leads to a job match.

Denote now with $\widetilde{S}_t^w(a_{it})$ the surplus from employment for a worker. As previously said, this is defined as the change in the family's optimal utility from having an additional member employed, that is,

$$\widetilde{S}_t^w(a_{it}) \equiv \frac{\partial U_t(n_t^a)}{\partial n_t^a} \tag{70}$$

Taking the derivative of U_t in (67) with respect to n_t^a subject to equations (68) and (69) gives:

$$\begin{aligned} \frac{\partial U_t(n_t^a)}{\partial n_t^a} &= \lambda_t w_t(a_{it}) h_t - \lambda_t b - g(h_t, a_{it}) \\ &\quad + \beta E_t \left[(1 - s_t)\left(1 - \rho_{t+1}\right) \frac{\partial U_{t+1}\left(n_{t+1}^a\right)}{\partial n_{t+1}^a} \mid a_{it+1} \leq \underline{a}_{t+1} \right] \end{aligned} \tag{71}$$

The surplus from employment, then, is given by the following expression:

$$\begin{aligned} \widetilde{S}_t^w(a_t) &= \lambda_t w_t(a_t) h_t - \lambda_t b - g(h_t, a_t) \\ &\quad + \beta E_t \left[(1 - s_t)\left(1 - \rho_{t+1}\right) \int^{\underline{a}_{t+1}} \widetilde{S}_{t+1}^w(a_{t+1}) \frac{dF(a_{t+1})}{F\left(\underline{a}_{t+1}\right)} \right] \end{aligned} \tag{72}$$

where the index i is omitted for simplicity.

Finally, denote with $S_t^w(a_t)$ the value of the surplus from employment in terms of current consumption of final goods, i.e.,

$$S_t^w(a_t) \equiv \frac{\widetilde{S}_t^w(a_t)}{\lambda_t} \tag{73}$$

After substituting into the above identity the expression for $\widetilde{S}_t^w(a_t)$ and re-arranging, the value of the surplus in terms of current consumption can be written as:

$$\begin{aligned} S_t^w(a_t) &= w_t(a_t)\, h_t - b - \tfrac{g(h_t, a_t)}{\lambda_t} \\ &+ E_t \beta_{t+1} \left[(1 - s_t)\left(1 - \rho_{t+1}\right) \int^{\underline{a}_{t+1}} S_{t+1}^w(a_{t+1}) \tfrac{dF(a_{t+1})}{F\left(\underline{a}_{t+1}\right)} \right] \end{aligned} \tag{74}$$

This equation corresponds to the difference between the value of employment (19) and the value of unemployment (20) that are reported in the paper.

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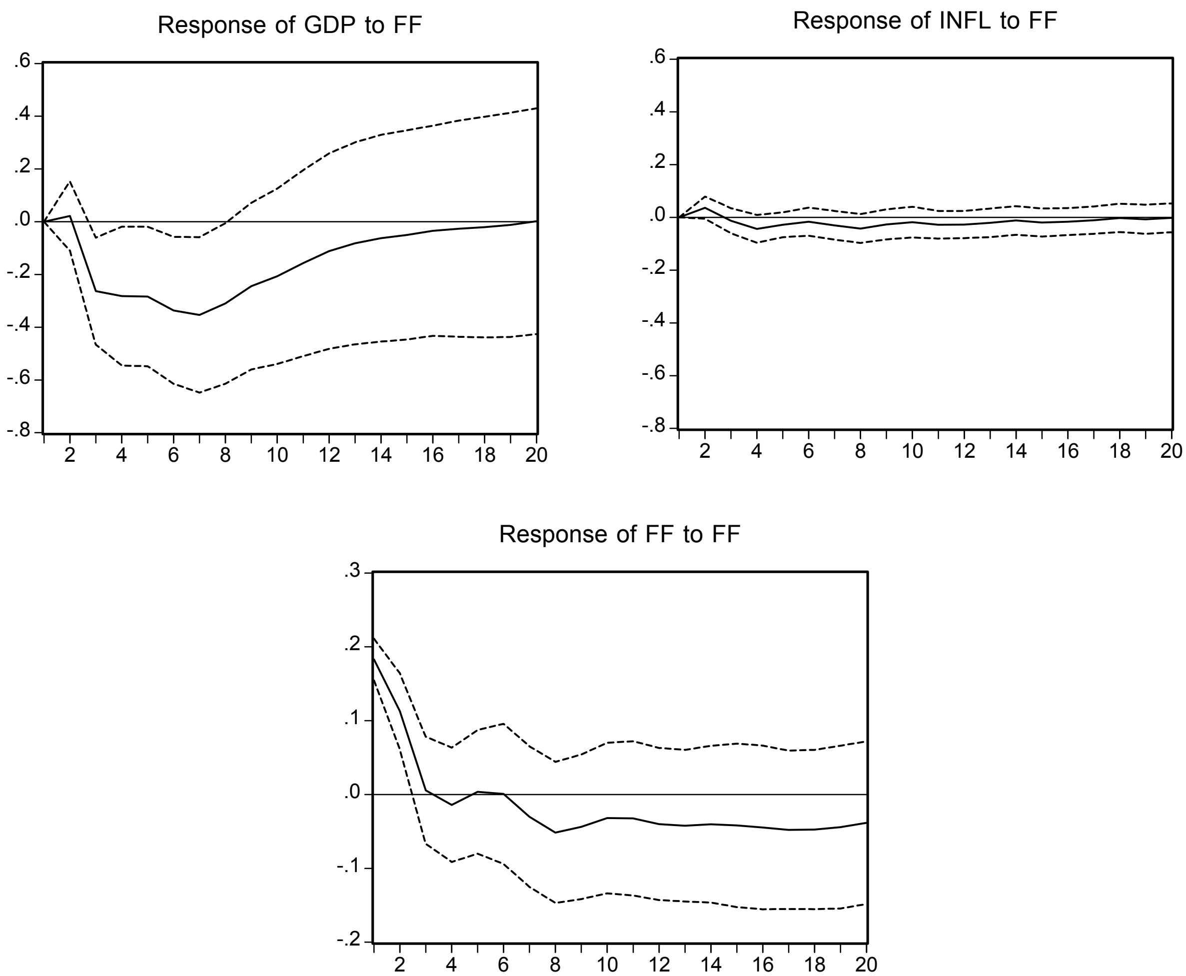
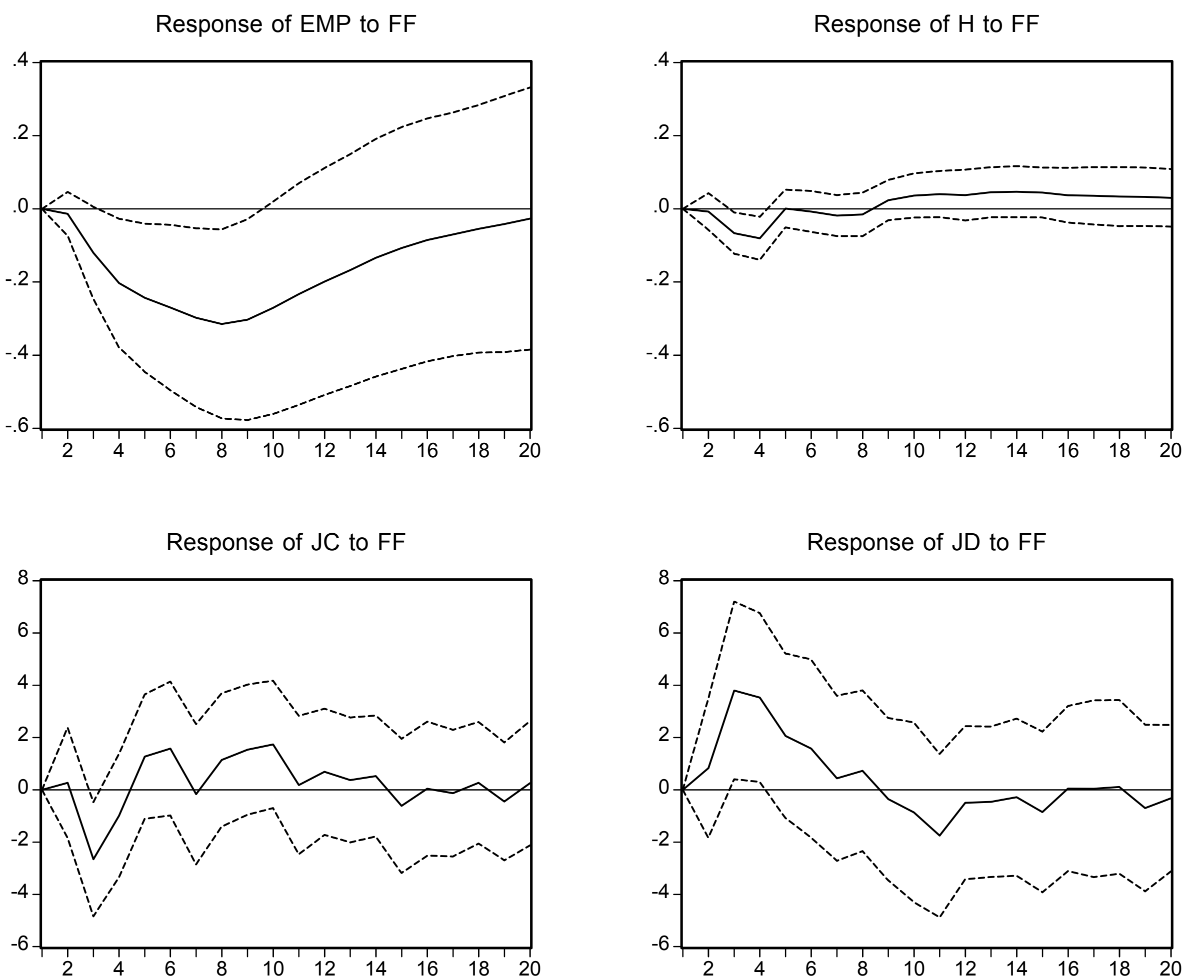
Figure 1 Estimated responses of output, inflation and nominal rate to a monetary policy shock



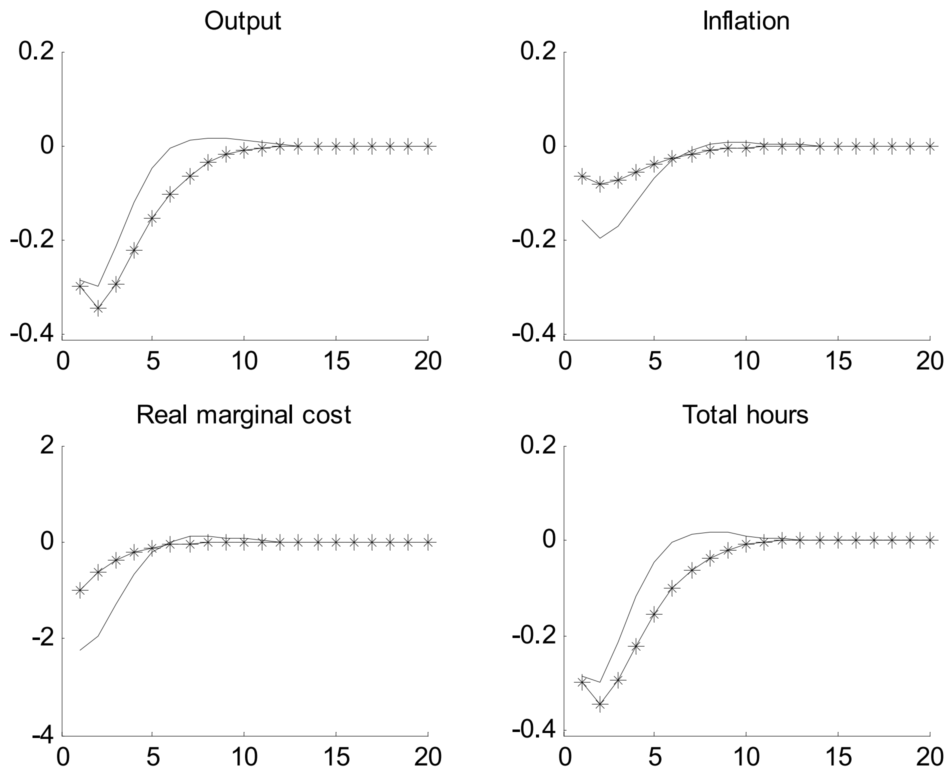
Response to One S.D. Innovations ± 2 S.E.

Figure 2 Estimated responses of employment, hours per worker, job creation and job destruction to a monetary policy shock



Response to One S.D. Innovations ± 2 S.E.

Figure 3 Output, inflation, real marginal cost and total hours



Model with search -*-   Baseline NK model –

Figure 4 Extensive and intensive margin

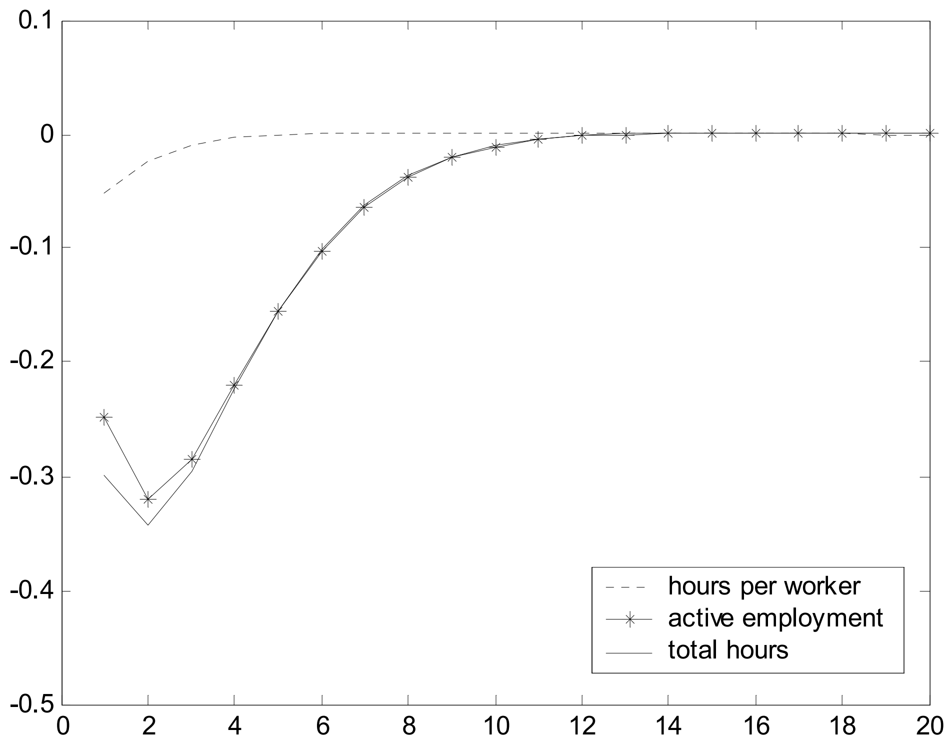


Figure 5 Labor market dynamics

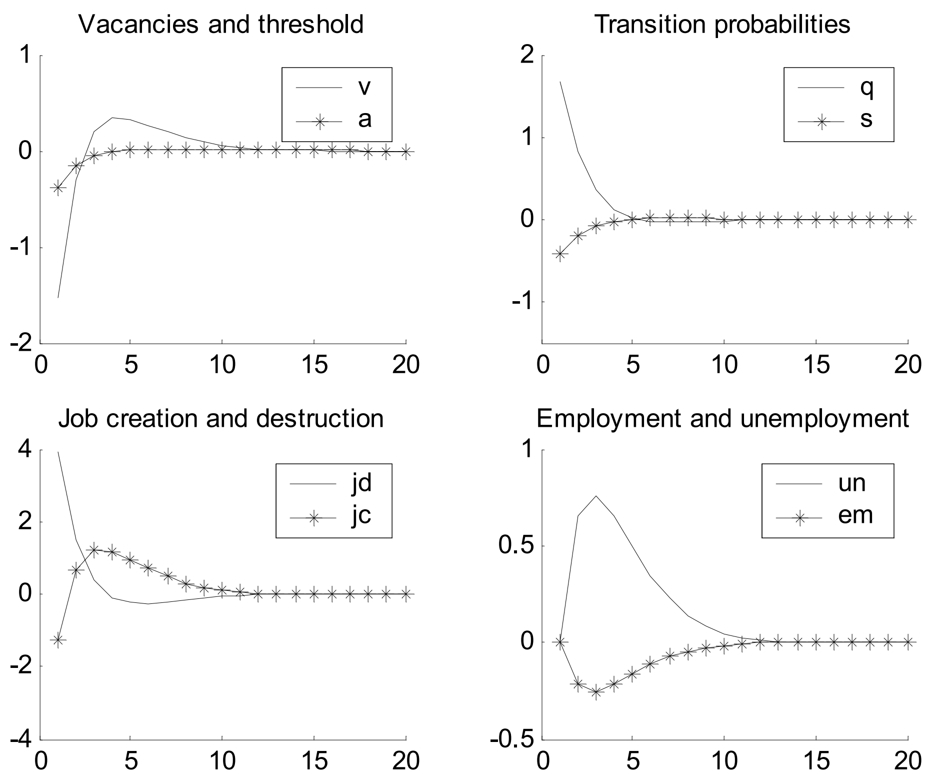
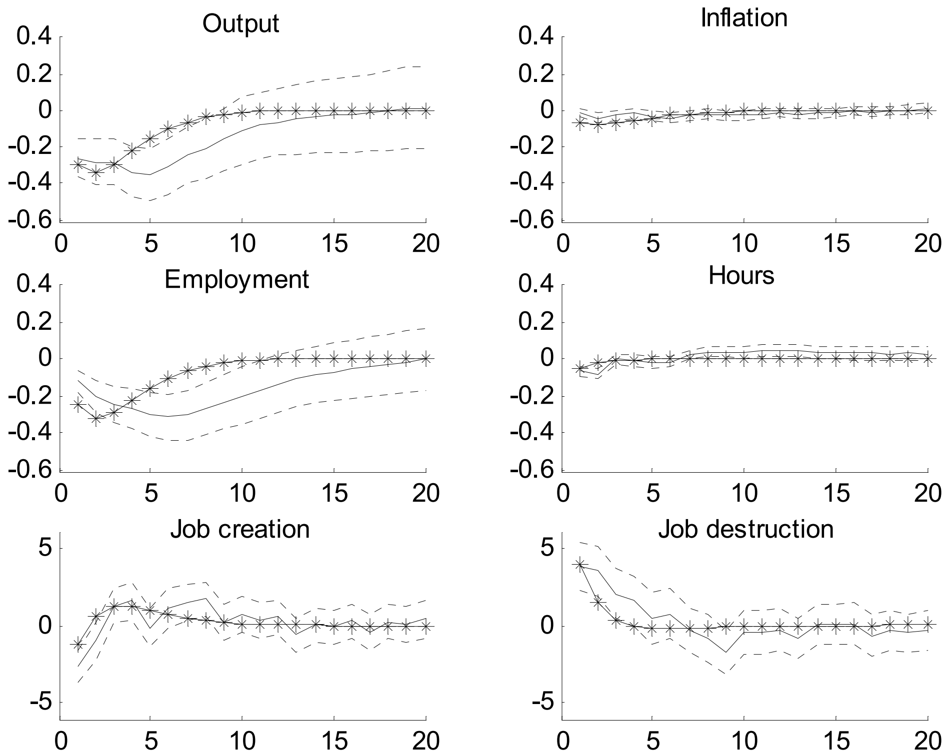


Figure 6 Estimated versus model responses



Model responses -*-   Estimated responses –

Table 1 Conditional standard deviation ratios

	Model economy	US economy
Employment/Output	0.93	0.83
Hours per worker/Output	0.10	0.15
Inflation/Output	0.24	0.11
Job creation/Output	4.15	4.99
Job destruction/Output	6.87	5.62

Table 2 Conditional cross correlations of employment, job creation and job destruction

	t-3	t-2	t-1	t	t+1	t+2	t+3
Model economy							
Employment/Job creation	-0.05	-0.13	-0.27	-0.51	-0.86	-0.82	-0.66
Employment/Job destruction	-0.45	-0.60	-0.69	-0.59	-0.14	0.05	0.11
Job creation/Job destruction	0.56	0.60	0.39	-0.39	-0.24	-0.14	-0.08
US economy							
Employment/Job creation	-0.22	-0.28	-0.34	-0.41	-0.50	-0.49	-0.42
Employment/Job destruction	-0.53	-0.47	-0.38	-0.25	-0.08	0.06	0.14
Job creation/Job destruction	0.34	0.40	0.01	-0.30	-0.47	-0.30	-0.28

Table 3 Conditional cross correlations of output with

	t-3	t-2	t-1	t	t+1	t+2	t+3
Model economy							
Output/Employment	0.43	0.63	0.85	0.99	0.89	0.68	0.48
Output/Hours per worker	0.46	0.62	0.76	0.75	0.31	0.09	-0.01
US economy							
Output/Employment	0.73	0.81	0.88	0.93	0.95	0.94	0.91
Output/Hours per worker	0.13	0.10	0.06	0.02	-0.13	-0.30	-0.36

Table 4 Conditional cross correlations of inflation with

	t-3	t-2	t-1	t	t+1	t+2	t+3
Model economy							
Output	0.50	0.70	0.89	0.99	0.85	0.63	0.44
Employment	0.49	0.68	0.88	0.99	0.88	0.67	0.47
Job creation	-0.08	-0.15	-0.29	-0.51	-0.86	-0.82	-0.66
Job destruction	-0.46	-0.59	-0.67	-0.59	-0.14	0.05	0.11
US economy							
Output	0.35	0.36	0.40	0.37	0.23	0.16	0.09
Employment	0.49	0.52	0.56	0.57	0.51	0.43	0.36
Job creation	-0.30	-0.26	-0.11	-0.19	-0.65	-0.49	-0.20
Job destruction	-0.40	-0.35	-0.36	-0.21	0.06	0.23	0.27