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Monetary Shocks in a Model with Loss of Skills[*]

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Abstract

This paper studies the effects of a monetary shock on real and nominal variables, such as output, inflation and especially unemployment, within a framework which combines a New Keynesian business cycle model model with microfounded labor market in the style of the search and matching literature. We assume that unemployed workers can lose their skill over time and show that this mechanism helps explain the slugish response of unemployment to monetary shocks observed in the data, while also replicating the behavior of output, inflation and employment.

Keywords: Business Cycles, Search and Matching, Loss of Skill, Monetary Policy
JEL Classification: E32, J41, J31, E52

1   Introduction

In recent research advances, a new emphases has been placed on the need to study deeper the link between labor market variables, real variables and nominal shocks (Cooley and Quadrini (1999), Trigari (2003)). Models in which labor markets are not developed, like the ones where only hours vary but not the number of workers employed, cannot capture the sluggishness with which output and inflation respond to shocks. A successful candidate to enrich the labor market description in real business cycle models seems to be the search and matching framework a la Mortensen and Pissarides (1994). Several papers consider search and matching in a real business cycle model and are able to improve the performance of the standard model when compared with the empirical evidence (Merz (1995), Andolfatto (1996) and den Hann, Ramey and Watson (2000)). Two papers which are closely related to ours are Cooley and Quadrini (1999), who integrate a search and matching model with a limited partecipation model, and Trigari (2003), who integrates a neokeynesian model with a search model. The latter is particularly successful at replicating the respose of several real

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and nominal variables after a monetary shock. Her framework allows her to analyze the variations of the labor market's extensive margin, number of workers employed, and the intensive margin, number of hours, as well as the performance of output and inflation. A similar framework is also used by Walsh (2003).

There is also part a different set of papers which claim that the persistence of business cycles and in particular of unemployment, is due to heterogeneities existent in the unemployment pool. One such heterogeneity is the lengh of the unemployment spell, which some empirical studies connect with the probability of finding job. Jackman and Layard (1991) find that the exit rate from unemployment decreases when there is a higher proportion of long term unemployed. Bover, Arellano and Bentolila (2002) show that for the Spanish economy the probability to find a job decreases with the duration of unemployment. Moreover, due to the fact that long term unemployed are detached from a productive environment for long periods, there seems to be a positive correlation between the length of the unemployment spell and the probability to lose the skill.

The loss of the skill mechanism has been used to explain the differences between the European and US labor market. In particular Sargent and Liungquist (1997) explain the importance of different labor market institutions that enhance the probability to lose the skill for long term unemployed. More recently Esteban-Pretel (2004) shows that a real business cycle model with microfunded labor market composed by workers with two different skills can generate a sluggish behavior in the real variables after a TFP shock. The probability to lose the skill and the cost for a firm to retrain a worker makes the low skill unemployed less attractive and drives these longer cycles. The author shows that the model is even more fitted to explain economies in which the ratio between low and high skilled workers is high [1]. The model used does not incorporate money and pricing decisions. Hence monetary policy is non-existent.

In this paper we extend the work of Esteban-Pretel to account for a richer business cycle economy in order to study the effects of monetary policy on real and nominal variables. We present an economy composed by infinitely lived risk-averse individuals, which decide how to best allocate their wealth between consumption, savings and money holdings, which they will need to make their transactions. They supply labor to intermediate goods firms, which produce an homogenous good to be sold to the retailers. Firms in the latter sector operate in monopolistic and price their good over their marginal cost. However they are constraint in how often they can change their prices, behavior which follows a Calvo type rule. These retail goods are ultimately purchased by consumers. The monetary authority sets the nominal interest rate following a taylor rule.

We calibrate the model to match the main features of the US labor market, then we simulate the responses of output, inflation and employment and different types of unemployement to an interest rate shock and we compare them with what happens in the data. The model matches closely the shape and magnitude of the response of output, inflation and unemployment and it improves the performance in the persistence of these variables after a nominal shock with respect to the results of the literature. The loss of skill mechanism, combined with the nominal and real rigidities, helps the model to match the response of the labor market variables. In particular unemployment and its long and short-term components.

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[1] He shows that calibrating the model to match some empirical facts of Spanish and US labor markets, the effect of the loss of skill creates longer cycles for the Spanish than for the US economy, as seen in the data.

The model abstracts from the possibility of having labor force participation decisions, which is a natural extension to model. Letting the workers decide whether to actively search for a job or be inactive would improve the persistent reaction of the economy to nominal and real shocks

The remainder of the paper is organized as follows. Section 2 describes the VAR approach considered and analyzes the responses of output, inflation and some labor market variables.to a federal fund shock; section 3 develops the model; section 4 illustrates the results of the simulations of the model and compares them to the empirical evidence and section 5 concludes.

2 The empirical evidence

In this section we discuss the strategy used to estimate the effects of a monetary policy shock and we describe the effects of a nominal shock on output, inflation, unemployment (such as total unemployment rate, long term and short term unemployment rate) and the employment rate.

2.1 VAR approach

In our estimation analysis we make the assumption that the monetary authority uses the following rule to set its instrument:

$$S_t = f(\Omega_t) + \varepsilon_t^s$$

where S_t is the instrument of monetary policy, $f(\Omega_t)$ a linear function of the information set available to monetary authority in a given period t and ε_t^s is the monetary shock (the standard deviation is assumed to be 1). In order to determine the effects of monetary policy we base our estimation strategy on the recursiveness assumption (Christiano, Eichenbaum and Evans (2000)) according to which monetary policy shocks are orthogonal to the information set of the monetary authority.

Define Z_t as the vector of all the variables under consideration. A reduced form VAR for a k-dimensional vector Z_t is given by:

$$Z_t = B_1 + B_2 Z_{t-1} + B_3 Z_{t-2} + ... + B_{q+1} Z_{t-q} + u_t \tag{1}$$

Consistent estimates of B_i can be obtained running a OLS equation by equation of (1). Since each element of u_t reflects the effects of all fundamental economic shocks, there is no need to identify one particular element of u_t as a monetary shock. In order to identify the shocks, the relationship between the VAR disturbances and the fundamental economic shocks, ε_t, is assumed to be $A_0 u_t = \varepsilon_t$, where A_0 is a $k \times k$ invertible matrix. Premultiplying eq.(1) by A_0 we obtain:

$$A_0 Z_t = A_1 + A_2 Z_{t-1} + A_2 Z_{t-2} + ... + A_{q+1} Z_{t-q} + \varepsilon_t$$

where $B_i = A_0^{-1} A_i$. Define γ_h the response of Z_{t+h} to a unit shock in ε_t and it can be computed as the solution of the difference equation:

$$\gamma_h = B_1 + + B_2 \gamma_{h-1} + B_3 \gamma_{h-2} + ... + B_{q+1} \gamma_{h-q}, \ h = 1, 2...$$

with initial condition $\gamma_0 = I_k$

Then
$$\widetilde{\gamma}_h = \gamma_h A_0^{-1}, \ h = 1, 2...$$
is the impulse response function of the elements of Z_t to the elements of ε_t. In order to compute the impulse response it is necessary to know A_0 and in particular it is necessary to impose some restriction on A_0.

Partition Z_t into three blocks:
$$Z_t = \begin{pmatrix} X_{1t} \\ S_t \\ X_{2t} \end{pmatrix}$$
where X_{1t} of k_1 variables whose contemporaneous values appear in the information set Ω_t, S_t, the instrument of monetary policy and X_{2t} of k_2 variables which appear only with a lag in Ω_t.

Under the recursiveness assumption it is sufficient to restrict A_0 to be lower triangular with positive terms on the diagonal to identify the dynamic responses of Z_t to a monetary policy shock.

2.2   To the data

In this subsection we take a VAR to the data. We choose X_{1t} to be composed by measures of output, inflation, short term unemployment rate, long term unemployment rate, total unemployment rate and employment rate. S_t is the nominal interest rate of the US economy (federal funds rate). We set $X_{2t} = 0$ and the make the assumption that the monetary policy can have a complete information of the economy observing all the variables at the same time when the monetary policy is chosen.

The time sample is from the first quarter of 1979 to the third quarter of 2003. We have chosen this sample because it has been estimated that since the Volker's appointment, the FED followed a stabilizing forward looking Taylor rule using the federal fund rate as an instrument of monetary policy (Clarida et al 2000). The series for output is the log of the real gdp, the one for inflation is the annualized quarterly change of the log of the implicit gdp deflator. The interest rate is the quarterly average of the annualized monthly federal fund rate. Long term unemployment rate is the log of the percentage of the people that have been unemployment for more than 6 months over the total labor force. Short term unemployment rate is the log of the percentage of people over the labor force that have been unemployed for less than 6 months. Total unemployment rate is the log of the sum of the two previous series and total employment rate is the log of the ratio of total employment and total labor force. We have chosen these last series to be a rate rather than a level in order to compare more closely the performance of the model with the data results. For the sample period that we study, the average unemployment rate is 6.3 percent and roughly 15 percent of total unemployment is long-term.

Given the data, we estimate a seven variables VAR and we examine the behavior of the variables after a one percent increase in the federal fund rate. Figure 1 and 2 show the impulse responses of real and nominal variables of the US economy to a 100 basis points positive shock to the interest rates. The confidence intervals are obtained by bootstrapping.

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Figure 1: Impulse Responses of Output, Inflation and Fed. Funds Rate of the US economy to a 100 basis points positive shock to the Fed. Funds Rate.
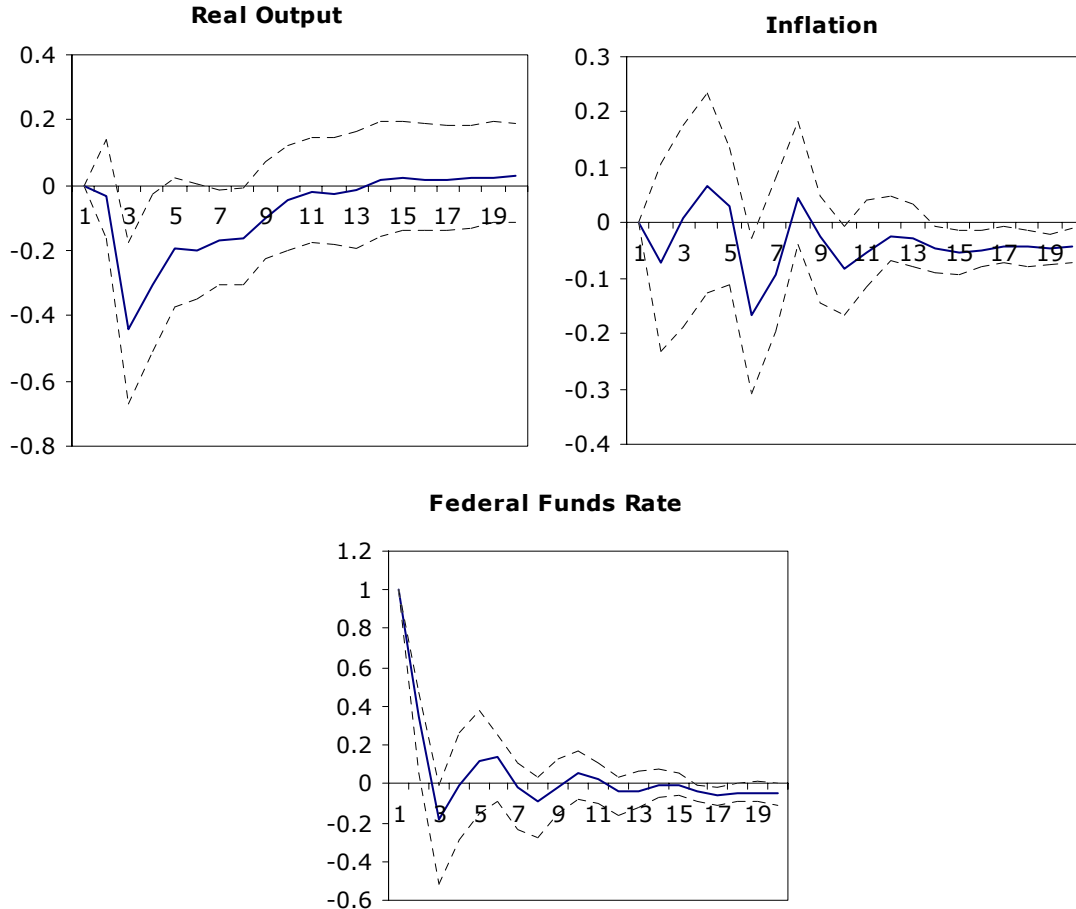
Real Output

Inflation

Federal Funds Rate

Figure 1 shows the well known behavior of output an inflation to a shock to interest rate. They move only in the second period since we made the restriction that monetary policy can affect only with the lag the variables of the economy. Output drastically declines by 0.44 percent in the second period after the shock and inflation rate by 0.16 percent in the fifth period after the shock. Both move back slowly to the steady state.

Figure 2 shows the effects of the contractionaly monetary policy on the labor market variables. Long-term unemployment suffers the biggest change following an increase in the federal funds rate and also shows the higher persistence. It peaks in the sixth quarter, where the increase is 2.5 percent, and it takes longer than output to go back to the steady state. Short term unemployment has its maximum in the fourth quarter, where the increase is 1.16 percent. Total unemployment follows very closely the behavior of the short term unemployment, which is intuitive given that US unemployment is mostly composed by workers who find a job before the sixth month of unemployment. Total employment shows, as expected, a decrease (0.13 percent) and the mimimun point

coincides with the peak of total unemployment, the forth quarter.

Figure 2: Impulse Responses of Employment and Unemployment of the US Economy to a 100 basis points positive shock to the Fed. Funds Rate.
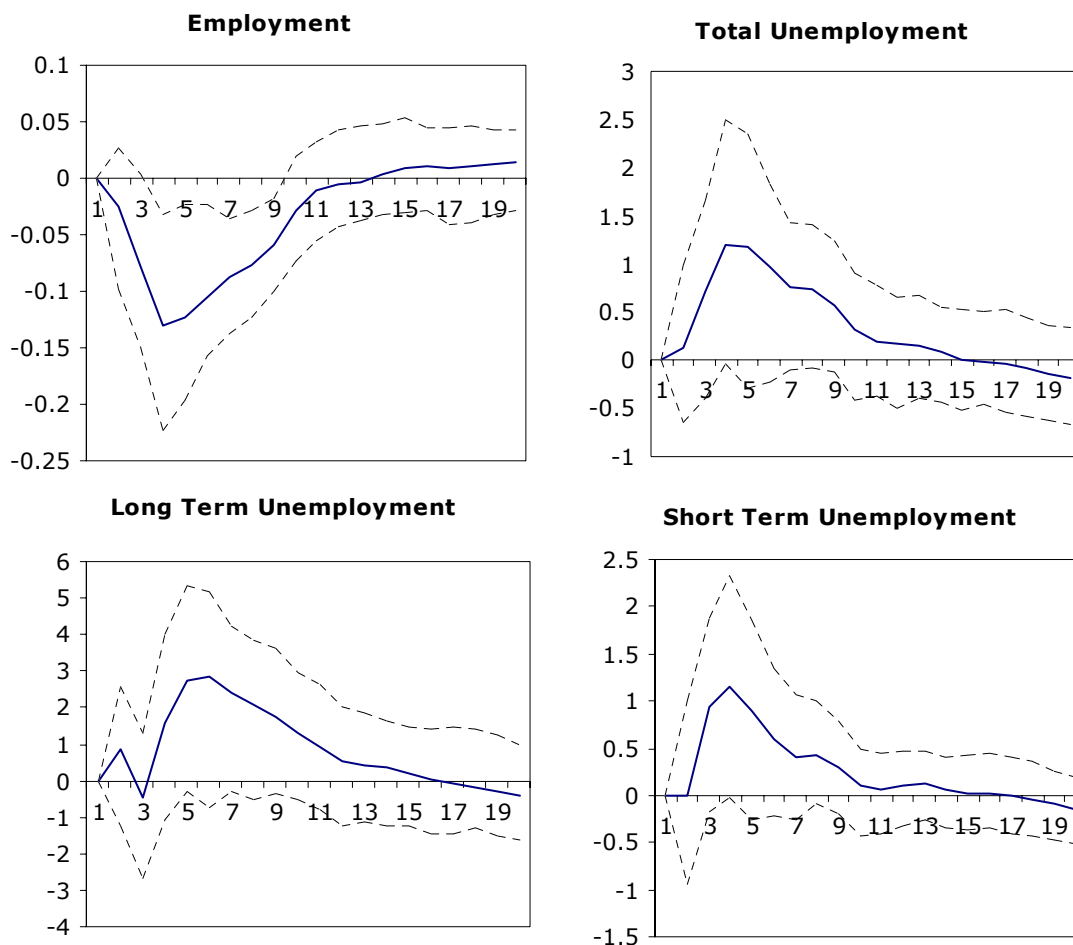
One thing to note is that the VAR literature has not tradinionally used labor market variables in its analysis. This paper has the aim to verify if a new Keynesian model augmented with a microfounded labor market, is able to explain the behavior of these variables. In the next sections we set up the model and compare the results with the evidence illustrated in this section.

3   The Model

We use a discrete time, dynamic general equilibrium model with four types of infinitely lived agents. Consumers/workers, intermediate goods firms, retail firms and the monetary authority. The problem faced every one of them is explained in more detailed below.

3.1 Consumers

Consumers are infinitely lived, risk averse agents. They are all assumed to belong to a big family, which provides perfect self-insurance against variations in employment status and personal wealth. This lets the problem of the consumer be solved as the one of a representative agent.

Every period the family chooses the level consumption, money holdings and bonds, to maximize its life-time utility. Per period utility is a function of consumption, leisure and the utility obtained by unemployed individuals, which can be interpreted as utility derived from home production. We assume that there is persistence in the consumption of the family, which is modeled so that its utility not only depends on the utility of the present period, but also on how much it changes from the previous period.

We assume that the household needs money to make its transactions during the period. It needs money to consume, buy bonds and pay the cost of the opened vacancies[2]. It finances these expenditures with the money it carries from the previous period and from the interest on the bonds from the previous period. At the end of the period wages are paid and profits rebated, since firms are own by the family. These resources will be transformed into money, which will be carried into the following period.

Following Rotemberg and Woodford (1997), we make the assumption that the household makes its optimal decision every period with the information set of two periods before. This is consistent with the assumptions made in the identification of the VAR and is needed to match the delays in the response to a monetary shock of ouput, employment and unemployment observed in the data.

Therefore, the household will choose $\{C_{t+i}, M_{t+i+1}B_{t+i+1}\}_{i=0}^{\infty}$ to max

$$E_{t-2}\left\{\sum_{i=0}^{\infty}\beta^i\left[\frac{1}{1-\gamma_c}\left(C_{t+i}-eC_{t+i-1}\right)^{1-\gamma_c}-n_{t+i}g\left(L_{t+i}\right)+\left(1-n_{t+i}\right)b_{t+i}\right]\right\} \tag{2}$$

subject to

$$P_{t+i}C_{t+i}+B_{t+i+1}+kv_{t+i} \leq M_{t+i}+\left(1+r_{t+i-1}^n\right)B_{t+i}$$
$$P_{t+i}C_{t+i}+B_{t+i+1}+M_{t+i+1} \leq M_{t+i}+P_{t+i}w_{t+i}^T L_{t+i}+P_{t+i}\Pi_{t+i}+\left(1+r_{t+i-1}^n\right)B_{t+i}$$
$$Y_{t+i} = n_{t+i}A_{t+i}L_{t+i}^{\alpha_y}$$
$$\text{for } i = \{0,...,\infty\}$$

where $\beta \leq 1$ is the discount rate of the economy; $\gamma_c < 1$ and $\gamma_n > 0$ are the coefficients of risk aversion to fluctuations in consumption and hours worked; $e \leq 1$, is the habit persistence coefficient in consumption. n_t is the number of employed workers, $n_t = n_{lt} + n_{ht}$; $g\left(L_{t+i}\right)$ is the disutility obtained by the family for supplying L_{t+i} units of labor. b is the home production of those individuals who are not working; B_t is the number of nominal bonds purchased, and r_t^n the nominal interest rate in the economy. M_t are the nominal holdings of money. w_t^T are the total amount of wages paid to the workers. v_t are the number of vacancies opened and k the flow

---

[2]Firms are own by the consumers, so it is them who ultimately pay for the posting of vacancies.

cost of every one of them. $\Pi_{t+i} = \Pi^f_{t+i} + \Pi^r_{t+i}$ are the profits rebated to the consumers from the intermediate goods firms and the retailers[3].Y_t is the production of a single firm. and finally A_t is the level of technology in the economy.

The problem of the household yields the following optimal conditions:

Euler equation, which shows how in equilibrium the household is indifferent between saving or consuming one more unit, since the marginal utility today equals the discounted marginal utility tomorrow.

$$E_{t-2}\phi_t = \beta E_{t-2}(1+r_t)\phi_{t+1} \tag{3}$$

$$\text{where } (1+r_t) = \frac{P_t}{P_{t+1}}(1+r^n_t) \tag{4}$$

$$\text{and } \phi_t = (C_t - eC_{t-1})^{-\gamma} - \beta e(C_{t+1} - eC_t)^{-\gamma}$$

Cash in advance constraint, which

$$P_t C_t + P_t k v_t = M_t \tag{5}$$

---

[3] As will be better understood when the problem of the firms is set up in the following sections, the profits of the firms are

$$\Pi^f_{t+i} = x_{t+i}Z_{t+i} - \eta^T_{t+i} - w^T_{t+i}L_{t+i} - kv_{t+i} - t_{t+i}u_{lt+i-1}q^w_{t+i-1}F(\bar\eta_{lt+i})$$

$$\Pi^r_{t+i} = \int_0^1 \left(\frac{P_{it+i}}{P_{t+i}} - x_{t+i}\right) Y_{it+i} di$$

where w^T_{t+i} is the sum of all the wages paid in the economy,

$$w^T_{t+i} = \int_{\eta_{min}}^{\bar\eta_{ht+i}} n_{ht+i}(\eta_{t+i}) w_{ht+i}(\eta_{t+i}) d\eta_{t+i} + \int_{\eta_{min}}^{\bar\eta_{lt+i}} n_{lt+i}(\eta_{t+i}) w_{lt+i}(\eta_{t+i}) d\eta_{t+i}$$

$$w^T_{t+i} = n_{ht+i}\tilde w_{ht+i} + n_{lt+i}\tilde w_{lt+i}$$

where

$$\tilde w_{jt+i} = \frac{1}{F(\bar\eta_{jt+i})} \int_{\eta_{min}}^{\bar\eta_{jt+i}} w_{jt+i}(\eta_{t+i}) dF(\eta_{t+i}) \text{ for } j \in \{h.l\}$$

$\hat\eta_{t+i}$ is the sum of the intermediate inputs paid by the productive firms,

$$\eta^T_{t+i} = \int_{\eta_{min}}^{\bar\eta_{ht+i}} n_{ht+i}(\eta_{t+i}) \eta_{t+i} d\eta_{t+i} + \int_{\eta_{min}}^{\bar\eta_{lt+i}} n_{lt+i}(\eta_{t+i}) \eta_{t+i} d\eta_{t+i}$$

$$\eta^T_{t+i} = n_{ht+i}\tilde\eta_{ht+i} + n_{lt+i}\tilde\eta_{lt+i}$$

where

$$\tilde\eta_{jt+i} = \frac{1}{F(\bar\eta_{jt+i})} \int_{\eta_{min}}^{\bar\eta_{jt+i}} \eta_{t+i}(\eta_{t+i}) dF(\eta_{t+i}) \text{ for } j \in \{h.l\}.$$

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Budget Constraint - Money Demand

$$M_{t+1} = P_t Y_t - P_t \hat{\eta}_t - P_t t_t n_{lt} \tag{6}$$

3.2 Intermediate goods firms and workers

Intermediate goods firms produce goods which are sold to the retailers. They are price takers and in order to produce, they need to engage in employment relationships with workers. These relationships are composed of one firm and one worker.

Unemployed workers are assumed to be either high or low skilled. Workers who have just lost their job retain their skill for some time. The loss of skill, which only happens while being out of work, will occur with probability λ for the high skilled unemployed workers who have not matched with a firm.

Firms can hire either type of unemployed worker. Both types are equally productive, although the low skilled has to be trained during the first period of employment. Training has a cost t, which is shared between the worker and the firm. After the period of training the worker becomes high skilled.

Vacant firms and unemployed workers meet randomly according to a matching function $m(u_t, v_t)$, where $u_t = u_{lt} + u_{ht}$, u_t is total unemployment, u_{lt} and u_{ht} are low and high skilled unemployment respectively, and v_t is the number of vacancies. The matching function is assumed to be constant returns to scale, which implies

$$m(u_t, v_t) = m\left(1, \frac{v_t}{u_t}\right) u_t = m(\theta_t) u_t$$

$$\text{where } \theta_t = \frac{v_t}{u_t} \text{ is the markettightness of the labor market.}$$

Hence, the arrival rate of low and high skilled workers for firms is respectively $\dfrac{m(u_t, v_t)}{v_t} \dfrac{u_{lt}}{u_t} = \dfrac{m(\theta_t)}{\theta_t} \dfrac{u_{lt}}{u_t}$ and $\dfrac{m(\theta_t)}{\theta_t} \dfrac{u_{ht}}{u_t}$ .The arrival rate of firms for workers is $\dfrac{m(u_t, v_t)}{u_t} = m(\theta_t)$.

If the search process is successful, firms produce output according the production function $Y_t = A_t L_t^v$ where A_t is the level of technology of the economy and L_t the number of hours worked by the employee. The costs of production for the firm are the wages, the cost of training if the worker is low skilled and a fixed cost η_t. This fixed cost, which can be interpreted as the cost of intermediate inputs other than labor, is idiosyncratic to the firm and independent and identically distributed across firms and time, with distribution function $F : [0, \infty] \to [0, 1]$.A new cost is drawn every period by the firm, and if the cost is high enough it may be beneficial for the firm and the worker to discontinue the employment relationship. The value of η_t which dissolves the match is denoted by $\bar{\eta}_t$ and in principle is different for firms which hire high or low skilled workers, since the latter have to pay the extra cost of training. Therefore the probability of job destruction is $1 - F(\bar{\eta}_{ht})$ and $1 - F(\bar{\eta}_{lt})$ for high and low skilled workers respectively.

Wages are determined as a Nash bargaining process over the surplus of the match, where β_w is the share of the surplus for the worker. The cost of training, which reduces the surplus of the match with low skilled workers, is shared in the same manner.

As in the case of consumers, firms and workers take their decisions at period t using the information available at t-2. Again, this assumption is made to be consistent with empirical evidence presented earlier.

Let's analyze now the present value of the different states in which firms and workers can be.

3.2.1 Value of posting a vacancy

Firms post vacancies in the labor market and, when matched with a worker, implement optimal production plans in order to maximize their profits. Posting vacancies has a flow cost of k for the firm. A vacant firm will match with a worker of type $i \in \{l, h\}$ with probability $q_{it}^f = \dfrac{m(\theta_t)}{\theta_t} \dfrac{u_{it}}{u_t}$. If the firm is matched, and the idiosyncratic shock is low enough, the following period the firm will obtain the value of being filled by a worker of type i, otherwise it will remain as a vacancy. Denote by V_t and $J_{it}(\eta_t)$ the values, measured in terms of consumption, of having a vacancy opened and of a match for a firm which hires worker of type i. Hence the value of a vacancy is

$$
\begin{aligned}
V_t &= -k + \beta_t E_{t-2} \left[q_{lt}^f \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} J_{lt+1}(\eta_{t+1}) \, dF(\eta_{t+1}) + \right. \\
&\quad \left. + q_{ht}^f \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}) + \left(1 - q_{lt}^f F(\bar{\eta}_{lt+1}) - q_{ht}^f F(\bar{\eta}_{ht+1})\right) V_{t+1} \right].
\end{aligned} \tag{7}
$$

where $\beta_t = \beta \dfrac{\lambda_{t+1}}{\lambda_t}$.

Free entry of firms is assumed in equilibrium, which implies that the value of a vacancy must be zero. Therefore:

$$
0 = -k + \beta_t E_{t-2} \left[q_{ht}^f \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}) + q_{lt}^f \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} J_{lt+1}(\eta_{t+1}) \, dF(\eta_{t+1}) \right]. \tag{8}
$$

3.2.2 Value of a filled job for a firm

The value for the firm with a high skilled worker is

$$
J_{ht}(\eta_t) = E_{t-2} \left\{ \beta_t \frac{P_t}{P_{t+1}} \left[x_t A_t L_t^{\alpha_y} - \eta_t - w_{ht}(\eta_t) L_t \right] + \beta_t \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}) \right\} \tag{9}
$$

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The interpretation of the previous equation is as follows. During the current period, given the firm's idiosyncratic cost of intermediate inputs, η_t, it produces output, sells it to the final good firms at price x_t and pays wages and the cost of these inputs. Since it all happens at the end of the period and will only give utility to the consumers in the following period, in order to obtain their present value, we discount by the increase in prices and by the ratio and marginal utilities. The following period, if the idiosyncratic intermediate input cost is below the threshold, the match will still be productive, with a value of $J_{ht+1}(\eta_{t+1})$, otherwise the match will be destroyed and it will become a vacancy, which has value zero.

Similar present value has a firm which hires a low skilled worker. It only differs in the fact that it has to pay its share of the cost of training, t_t^f, which also implies a different wage. Note that the continuation value is the same as the one for the high skilled firm, since the worker becomes high skilled after the first period.

$$J_{lt}(\eta_t) = E_{t-2}\left\{\beta_t \frac{P_t}{P_{t+1}}\left[x_t A_t L_t^{\alpha_y} - \eta_t - t_t^f - w_{lt}(\eta_t) L_t\right] + \beta_t \int_{\eta_{\min}}^{\bar\eta_{ht+1}} J_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1})\right\} \quad (10)$$

Consider now the side of the worker. Denote by U_{it} and $N_{it}(\eta_t)$ the value, in terms of consumption, of being unemployed and being matched with a firm for a worker of type $i \in \{l, h\}$.

3.2.3 Value of Unemployment

A high skilled unemployed worker obtains b_t utility from home production. If it matches with a firm, which happens with probability q_t^w, and the intermediate input cost for the firm is below the threshold, $\bar\eta_{ht+1}$, he will become a productive worker the following period. If the search process is not succesful, he may lose the skill, event which occurs with probability λ, and become low skilled unemployed. If he does not enter into an employment relationship with a firm and does not lose the skill, he will remain a high skilled unemployed. Hence, the value of being high skilled unemployed at period t is:

$$U_{ht} = b_t + E_{t-2}\beta_t \left[q_t^w \int_{\eta_{\min}}^{\bar\eta_{ht+1}} N_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}) + \right. \quad (11)$$

$$\left. + \left(1 - q_t^w F(\bar\eta_{ht+1})\right) \lambda U_{lt+1} + \left(1 - q_t^w F(\bar\eta_{ht+1})\right)(1-\lambda) U_{ht+1}\right] \quad (12)$$

Similarly, a low skilled unemployed worker receives utility from the home production. He can meet a firm and if the idiosyncratic shock to the firm is favorable will start producing the following

period. Otherwise he will remain a low skilled unemployed.[4]

$$U_{lt} = b_t + E_{t-2}\beta_t \left[q_t^w \left(\int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} N_{lt+1}\left(\eta_{t+1}\right) dF\left(\eta_{t+1}\right) \right) + \left(1 - q_t^w F\left(\bar{\eta}_{lt+1}\right)\right) U_{lt+1} \right] \quad (13)$$

3.2.4 Value of Employment

As in the case of the firm, the value of a match for a worker is a function of the idiosyncratic shock η_t. It also depends on the skill of the worker. The value of employment for a high skilled worker is composed by the high skilled wage, the disutility in terms of consumption from supplying labor and the continuation value, which is the value of being employed if the match is not destroyed or the value of being high skilled unemployed, if the intermediate input cost is too high.

$$
\begin{aligned}
N_{ht}\left(\eta_t\right) &= -\frac{g\left(L_t\right)}{\phi_t} + E_{t-2}\beta_t \left[\frac{P_t}{P_{t+1}} w_{ht}\left(\eta_t\right) L_t + \right. \\
&\quad \left. + \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} N_{ht+1}\left(\eta_{t+1}\right) dF\left(\eta_{t+1}\right) + \left(1 - F\left(\bar{\eta}_{ht+1}\right)\right) U_{ht+1} \right]
\end{aligned}
\quad (14)
$$

If the worker came from the low skilled unemployment pool, the value is very similar and only differentiated by the wages and the cost of training.

$$
\begin{aligned}
N_{lt}\left(\eta_t\right) &= -\frac{g\left(L_t\right)}{\phi_t} + E_{t-2}\beta_t \left[\frac{P_t}{P_{t+1}} w_{lt}\left(\eta_t\right) L_t - \frac{P_t}{P_{t+1}} t_t^w + \right. \\
&\quad \left. + \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} N_{ht+1}\left(\eta_{t+1}\right) dF\left(\eta_{t+1}\right) + \left(1 - F\left(\bar{\eta}_{ht+1}\right)\right) U_{ht+1} \right]
\end{aligned}
\quad (15)
$$

3.2.5 Surplus of a match

When an employment relationship takes place it creates a surplus which is shared between the firm and the worker. The surplus of the match is defined as the sum of the values of a filled job for a firm and a worker minus their outside options, which are the value of a vacancy and the value of unemployment respectively. Since there is free entry of firms, the expression for the surplus is $S_{it}\left(\eta_t\right) = J_{it}\left(\eta_t\right) + N_{it}\left(\eta_t\right) - U_{it}$. The sharing rule for the surplus is obtained optimally as a Nash bargaining process which results in a constant fraction for both parties. If β_w is the bargaining

---

[4]Note that the threshold for the intermediate input cost which makes the match unproductive is different from the one for the high skilled worker. During the first period of the match, the low skilled unemployed needs to be trained and its cost will lower the acceptable intermediate input cost, that is, the cost which will make the surplus equal to zero.

power of the worker, then $N_{it}(\eta_t) - U_{it} = \beta_w S_{it}(\eta_t)$ and $J_{it}(\eta_t) = (1 - \beta_w) S_{it}(\eta_t)$. Combining these two expressions with equations (9) to (15) the surplus in terms of units of consumption for a high and low skilled match can be expressed as:

$$
\begin{aligned}
S_{ht}(\eta_t) &= -\frac{g(L_t)}{\phi_t} - b_{ht} + E_{t-2}\beta_t \left[\frac{P_t}{P_{t+1}} \left(x_t A_t L_t^{\alpha_y} - \eta_t \right) + \right. \\
&\qquad \left. + (1 - q_t^w \beta_w) \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} S_{ht+1} dF(\eta_{t+1}) - \left(1 - q_t^w F(\bar{\eta}_{ht+1})\right) \lambda E_t (U_{lt+1} - U_{ht+1}) \right]
\end{aligned}
\tag{16}
$$

$$
\begin{aligned}
S_{lt}(\eta_t) &= -\frac{g(L_t)}{\phi_t} - b_{lt} + E_{t-2}\beta_t \left[\frac{P_t}{P_{t+1}} \left(x_t A_t L_t^{\alpha_y} - \eta_t - t_t \right) - E_t (U_{lt+1} - U_{ht+1}) + \right. \\
&\qquad \left. + \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} S_{ht+1} dF(\eta_{t+1}) - q_t^w \beta_w \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} S_{lt+1} dF(\eta_{t+1}) \right]
\end{aligned}
\tag{17}
$$

An employment relationship is terminated when the idiosyncratic intermediate input cost to the firm is so high that it drives the surplus to zero. This determines the threshold cost above which both worker and firm will agree to dissolve the match and search for better options. Using equation (16) and (17) and equating them to zero we obtain the expressions for the low and high skill thresholds:

$$
\begin{aligned}
\bar{\eta}_{ht} &= E_{t-2} \left\{ \beta_t \frac{P_t}{P_{t+1}} x_t A_t L_t^{\alpha_y} - \frac{g(L_t)}{\phi_t} - b_{ht} + \right. \\
&\qquad \left. + \beta_t E_t F(\bar{\eta}_{ht+1}) (1 - q_t^w \beta_w) \tilde{S}_{ht+1} - \beta_t \left(1 - q_t^w F(\bar{\eta}_{ht+1})\right) \lambda E_t (U_{lt+1} - U_{ht+1}) \right\}
\end{aligned}
\tag{18}
$$

$$
\begin{aligned}
\bar{\eta}_{lt} &= E_{t-2} \left\{ \beta_t \frac{P_t}{P_{t+1}} \left(x_t A_t L_t^{\alpha_y} - t_t \right) - \frac{g(L_t)}{\phi_t} - b_{lt} + \right. \\
&\qquad \left. + \beta_t E_t F(\bar{\eta}_{ht+1}) \tilde{S}_{ht+1} - \beta_t q_t^w E_t F(\bar{\eta}_{lt+1}) \beta_w \tilde{S}_{lt+1} - \beta_t (U_{lt+1} - U_{ht+1}) \right\}
\end{aligned}
\tag{19}
$$

where $\tilde{S}_{it}$ is the average surplus for a productive firm of type i in period t.

3.2.6 Wages

The division of the surplus between firm and worker yields the wage paid to the employee. The expressions for the wages paid to a high and low skilled worker are respectively:

$$w_{ht}(\eta_t) L_t = \beta_w E_{t-2}\beta_t \left[\frac{P_t}{P_{t+1}} \left(x_t A_t L_t^{\alpha_y} - \eta_t \right) + q_t^w E_t \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1} dF\left(\eta_{t+1}\right) \right] + \tag{20}$$

$$+ \left(1 - \beta_w\right) \left[\frac{g\left(L_{t+i}\right)}{\phi_t} + b_t - E_{t-2}\beta_t \left(1 - q_t^w F\left(\bar{\eta}_{ht+1}\right)\right) \lambda E_t \left(U_{ht+1} - U_{lt+1}\right) \right]$$

$$w_{lt}(\eta_t) L_t = \beta_w E_{t-2}\beta_t \left[\frac{P_t}{P_{t+1}} \left(x_t A_t L_t^{\alpha_y} - \eta_t \right) + q_t^w E_t \int_{\eta_{\min}}^{\bar{\eta}_{ll+1}} J_{lt+1} dF\left(\eta_{t+1}\right) \right] \tag{21}$$

$$+ \left(1 - \beta_w\right) \left[\frac{g\left(L_{t+i}\right)}{\phi_t} + b_t - E_{t-2}\beta_t E_t \left(U_{ht+1} - U_{lt+1}\right) \right]$$

The worker is compensated for a fraction β_w of the production of the firm net of intermediate input cost, and for a measure of the saved cost of searching for new matches. He is also compensated for a fraction $(1 - \beta_w)$ of the disutility from supplying labor, and the forgone home production. The last term of the expression reflects the fact that by being hired in a firm, a high skilled worker avoids the risk of becoming low skilled and a low skilled increases his value of unemployment once the match is destroyed.

3.2.7 Optimal Labor

Maximise the surplus with respect to the number of hours.

$$L_t = \left(\frac{x_t \upsilon A_t \phi_t}{(1 + r_t)} \right)^{\frac{1}{1 - \alpha_y + \gamma_n}} \tag{22}$$

3.2.8 Flows

Finally, the flows in and out of the different states for the workers are:

$$u_{ht} = \left(1 - q_{t-1}^w F\left(\bar{\eta}_{ht}\right)\right)\left(1 - \lambda\right) u_{ht-1} + \left(1 - F\left(\bar{\eta}_{ht}\right)\right)\left(n_{lt-1} + n_{ht-1}\right) \tag{23}$$

$$u_{lt} = \left(1 - q_{t-1}^w F\left(\bar{\eta}_{lt}\right)\right) u_{lt-1} + \left(1 - q_{t-1}^w F\left(\bar{\eta}_{ht}\right)\right) \lambda U_{ht-1} \tag{24}$$

$$n_{ht} = F\left(\bar{\eta}_{ht}\right)\left(n_{lt-1} + n_{ht-1}\right) + q_{t-1}^w F\left(\bar{\eta}_{ht}\right) u_{ht-1} \tag{25}$$

$$n_{lt} = q_{t-1}^w F\left(\bar{\eta}_{lt}\right) u_{lt-1} \tag{26}$$

$$1 = u_{lt} + u_{ht} + n_{lt} + n_{ht} \tag{27}$$

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3.3   Retailers

There is a continuum of retail firms which opertate in monopolistic competition. They buy intermediate goods from firms in the intermediate goods sector, transform them into retail goods through a technology which transform them one to one, and then sell them to the consumers.

Define the quantity sold of retailer good i as Y_{it} and let P_{it} be its nominal price. Then the final good purchased by the consumer, Y_t, which is a composite of the individual retail goods produced in the economy, can be expressed as:

$$Y_t = \left[\int_0^1 Y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{28}$$

where ε is the elasticiy of substititution between retail goods and is assumed to be greater than one.

Given the previous expression for the total ouput, the demand for retail good i is:

$$Y_{it} = \left(\frac{P_{it}}{P_t} \right)^{-\varepsilon} Y_t \tag{29}$$

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

$$P_t = \left[\int_0^1 P_{it}^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}} \tag{30}$$

Retailers are constraint in the way they can change prices. Following Calvo (1983), every period only a fraction $(1 - \varphi)$ can change prices. The remaing φ fraction of them keep the price they had the previous period. Hence, the aggregate price can be expressed as

$$P_t = \left[\varphi P_{t-1}^{1-\varepsilon} + (1-\varphi) \tilde{P}_t^{-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{31}$$

where $\tilde{P}_t$ is the price set by the firms which can change it. A proportion ϕ of those firms are assumed to be "forward looking" price setters, whereas a proportion $1 - \phi$ set their prices by adjusting last period's prices by inflation last period and are labeled as "backward looking" price setter. Hence

$$\tilde{P}_t = \left[(1-\phi) P_t^{f1-\varepsilon} + \phi P_t^{b1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{32}$$

Those firms which look forward to set their prices will choose the price to maximize the expected future discounted profits. Their problem is therefore:

$$\max_{P_{it}} E_{t-2} \sum_{s=0}^{\infty} (\varphi\beta)^s \left[\frac{P_{it}^f}{P_{t+s}} - x_{t+s} \right] Y_{it,t+s}$$

which yields the following optimal condition on price setting:

$$P_t^f = \mu E_t \sum_{s=0}^{\infty} \varpi_{t,t+s} x_{t+s}^n \tag{33}$$

where $\mu_\varepsilon = \frac{\varepsilon}{\varepsilon-1}$ is the flexible price markup, $x_t^n = p_t x_t$ the nominal marginal cost and

$$\varpi_{t,t+s} = \frac{(\varphi\beta)^s R_{it,t+s}}{E_t \sum_{k=0}^{\infty} (\varphi\beta)^k R_{it,t+k}} \tag{34}$$

and where $R_{it,t+s}$ denotes the revenues from good i at thime t+s conditional on the price set at date t.

"Backward looking" price setters pricing rule is:

$$P_t^b = \pi_{t-1} P_{t-1} \tag{35}$$

and $\pi_{t-1} = \dfrac{P_t}{P_{t-1}}$.

3.4 Monetary authority

The monetary authority sets the nominal interest rate in the economy. To do so, it follows a Taylor rule, which implies thatit increases nominal interest rates whenever ouput or inflation are above their steady state levels, which in the case of inflation is assumed to be zero. Nominal interest rates also depend on past interest rates and can be shocked by an iid monetary policy shock, ϵ_t^m

$$r_t^n = \varphi_r \left(r_{t-1}^n\right)^{\rho_m} E_t \left(\frac{P_{t+1}}{P_t}\right)^{\gamma_\pi(1-\rho_m)} \left(\frac{Y_t}{Y}\right)^{\gamma_y(1-\rho_m)} e^{\epsilon_t^m} \tag{36}$$

3.5 Equilibrium

An equilibrium in this economy is a recursive general equilibrium composed by the set of variables:
   - unemployment rates, employment rates and vacancies u_{lt}, u_{ht}, n_{lt}, n_{ht}, v_t,
   - values of a match for a firm, $J_{ht}(\eta_t)$, $J_{lt}(\eta_t)$, for a worker, $N_{ht}(\eta_t)$, $N_{lt}(\eta_t)$; and value of unemployment, U_{ht}, U_{lt},
   - wages, $w_{ht}(\eta_t)$, $w_{lt}(\eta_t)$, and number of hours of work supplied, L_t,
   - intermediate input cost thresholds, $\bar{\eta}_{ht}$, $\bar{\eta}_{lt}$,
   - price of intermediate goods, x_t,
   - output, Y_t, consumption, C_t, nominal and real interest rate, r_t^n, r_t, inflation[5] π_t
   which satisfy the following conditions:

---

[5] The variable that is solved for is $\pi_t = \dfrac{P_{t+1}}{P_t}$, which in the steady state is equal to one, and in log-deviations from the steady state is $\pi_t = p_{t+1} - p_t$.

- flows in the labor market, (23) to (27),
- value functions in the problem of the firm and the worker, (9) to (15),
- nash bargaining over the surplus to determine wages, (20) and (21), and optimal labor supply, (22),
- zero surplus conditions, (18) and (19),
- optimal equations in the problem of the household, Euler equation, (3), real interest rate (4), cash in advance constraint (5), budget constraint, (6) and the aggregate production, (28),
- the equations which determine the price level, (31) to (34),
- and the Taylor Rule (36).

4 Calibration

In this section we explain the parametrization of the model.

The parameters are chosen to match the empirical evidence on the long run values of the variables in the model, which would correspond to the steady state of the model.

The length of a period is one quarter. The discount factor of the economy is $\beta = 0.98$, which implies a quarterly real interest rate of 2 percent.

The production function is assumed to be constant returns to scale, so $\alpha_y = 1$. It seems reasonable to think that increases in the amount of hours worked will produce proportional increases in output. The results of the simulations are robust to changes in this parameter. Setting it equal to 66 percent, as in a standard production function with capital, does not change the main results. The steady state labor supply is assumed to be $L = 1/3$, which implies that on average 8 hours per day are devoted to work. The last parameter in the production function is the level of technology, A , which is calibrated using the optimal labor supply (equation (22)) and the steady state value of consumption implied by the equations in the model.

Home production is assumed to be 20 percent of the firm's production, and its steady state value is $b = 0.0045$. This parameter alters the volatility of unemployment, but not its persistence.

Following Mortensen & Pissarides (1994), the bargaining power of the worker is set to $\beta_w = 0.5$.

The parameters in the utility function are $\gamma_c = 0.5$ and $\gamma_n = 1$, which imply decreasing marginal utility of consumption and quadratic disutility from labor supply.

The matching function is assumed to be constant returns to scales $m(u_t, v_t) = \mu_m u_t^{\alpha_m} v_t^{1-\alpha_m}$. Following Mortensen & Pissarides (1994) we set $\alpha_m = 0.5$. μ_m is jointly calibrated with other parameters and steady state values of variables of the model in the following manner. Following Cooley & Quadrini (1999), the probability of leaving unemployment is set to 0.7, and the probability of a vacancy being filled is assumed to be 0.8. Looking at quarterly data from 1979 to 2003,[6] the unemployment rate is set to 6.25 percent and the proportion of low skilled unemployed to 15 percent of total unemployment, which is the proportion of long-term unemployed among the US unemployed population. Using these two probabilities and the steady state flow equations from the model we can estimate the steady state values loss of skill, $\lambda = 0.2$, destruction rate, $1 - F(\bar{\eta}_h) = 0.05$, market tightness, $\theta = 0.85$, and the scaling parameter in the matching function, $\mu_m = 0.68$.

---

[6]Federal Bank of St Louis FRED II, and CPS.

Bover, Arellano & Bentolila (2002) estimate the probability of exiting unemployment as a function of unemployment duration. They estimate that for the Spanish economy this probability is reduced in half for workers who have been unemployed for a whole year. This estimate is consistent with the findings of Jackman & Layard (1991) for the British economy. Therefore we will assume that, since the matching probability is the same for both types of workers and the difference in the transition from unemployment to employment for low skilled workers is marked by the cost of training, this cost will be set so that the probability of a successful match for a low skilled worker is half of that for a high skilled.

We set the probability of changing prices for the retailers to 0.85 and the proportion of backward-looking variables to 0.5, which are both consitent with the estimates of Gali and Gertler (1999). The steady state mark-up of the intermediate goods firms is $\mu_\varepsilon = 0.2$, which implies an elasticity of substitution between intermediate goods of $\varepsilon = 6$.

The monetary shock follows an iid process $\epsilon_t^m \sim N\left(0, \sigma_z^2\right)$, where the value σ_z^2 does not affect the impulse responses of the model. The parameters in the Taylor rule are consistent Clarida, Gali and Gertler (2000) and set to $\rho_m = 0.85$, $\gamma_\pi = 1.5$, $\gamma_y = 0.5$. $\varphi_r = 0.5578$ is chosen so that the nominal interest rate in the steady state is equal to the real rate.

For simplicity, the idiosyncratic shock to the firm is assumed to be distributed as an exponential $\eta \sim \dfrac{1}{\psi} e^{-\frac{\eta}{\psi}}$, where ψ is jointly estimated along with all remaining steady state variables of the economy through the steady state equilibrium of the model.

Table 1 summarizes the main parameters of the model.

Table 1: Parameters of the Model

Exogenous parameters			
$\beta = 0.98$	$\gamma_c = 0.5$	$\gamma_n = 1$	$\alpha_y = 1$
$\alpha_m = 0.5$	$\beta_w = 0.5$	$\varphi = 0.85$	$\phi = 0.5$
$\mu_\varepsilon = 0.1$	$\rho_m = 0.85$	$\gamma_\pi = 1.5$	$\gamma_y = 0.5$
Endogenous parameters			
$\lambda = 0.2$	$t = 0.035$	$k = 0.0028$	$b = 0.0045$
$A = 0.046$	$\mu_m = 0.51$	$\psi = 0.0045$	

5   Results

In this section we compare the results of the simulation of the model with the empirical evidence. In particular we compare the VAR examined in section 2 and the responses of the model to a 100 basis points increase in the annualized interest rate. Figure 3 and 4 show the results of the VAR and the model's simulation. The dotted line represents the respose of the model to the monetary shock, the solid line the response in the data and the dashed line the 95 percent confidence intervals.

As one can observe in Figures 3 and 4, all the variables respond to the monetary shock in the expected way. After an increase in the nominal interest rate, consumers face a higher tradeoff between present and future consumption due to the increased returns on savings. Some of today's consumption is delayed to the future, which creates a drop in demand. Hence, output decreases and

so do profits. Reduced profits will lower the profitability of matches, which decreses the creation of jobs, along with making some of the previous matches unsustainable, which imply an increase in destruction of matches. These will reduce employment and increase unemployment. The higher unemployment population, together with the reduced profits for the firms, decrease the probability of unemployed workers to match with firms. Over time, some of the high skilled workers see their skills deteriorate and become low skilled, state in which they have even a lower probability of finding work. Meanwhile, some of the effects of the initial shock are undone by the monetary authority. The use of the Taylor rule allows the monetary authority to close the gap in output and in inflation generated by the increase in the interest rates. We can see that high skilled unemployment peaks before low skilled and converges faster to the steady state. This is due to the fact that some of the high skilled unemployed workers will become low skilled over time. Now it is more difficult to find a job, and hence high skilled unemployment decreases and low skilled and total unemployment becomes more sluggish.

Figure 3: Impulse Responses of Output, Inflation and Fed. Funds Rate of the US Economy and of the Model to a 100 basis points positive shock to the Fed. Funds Rate.
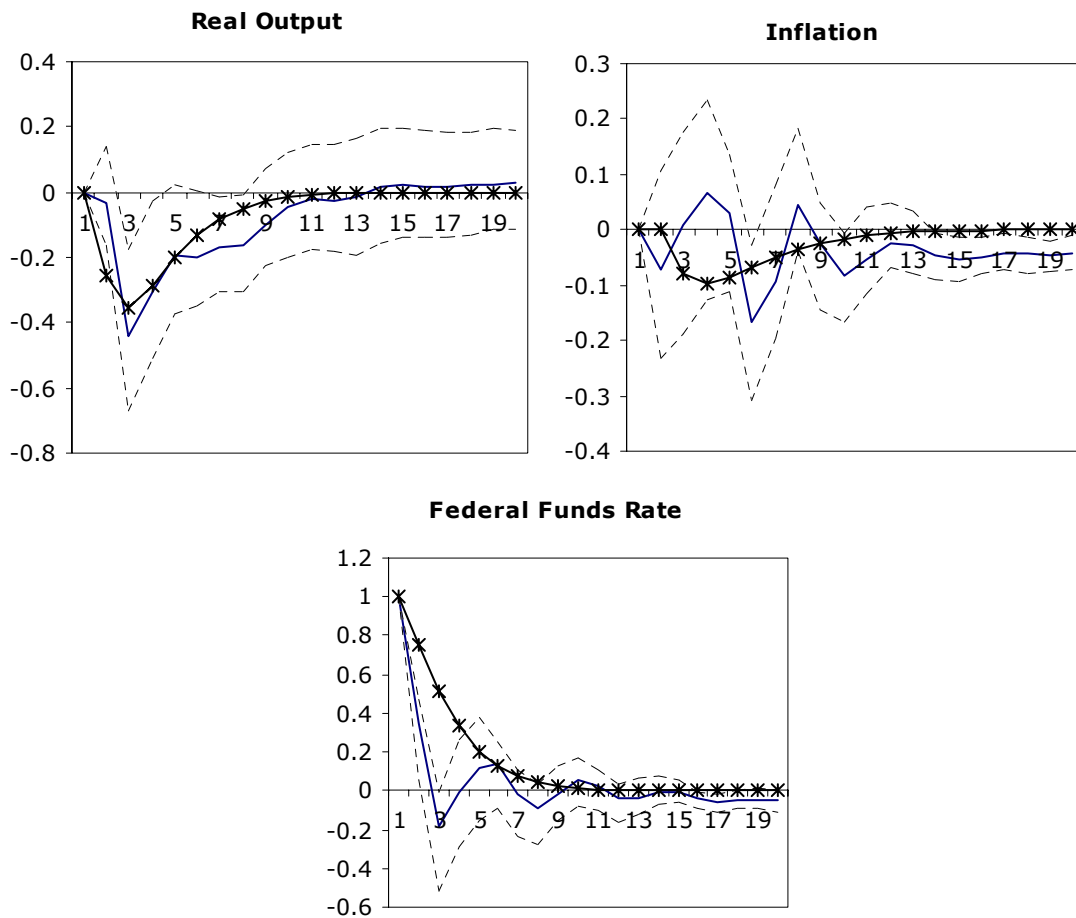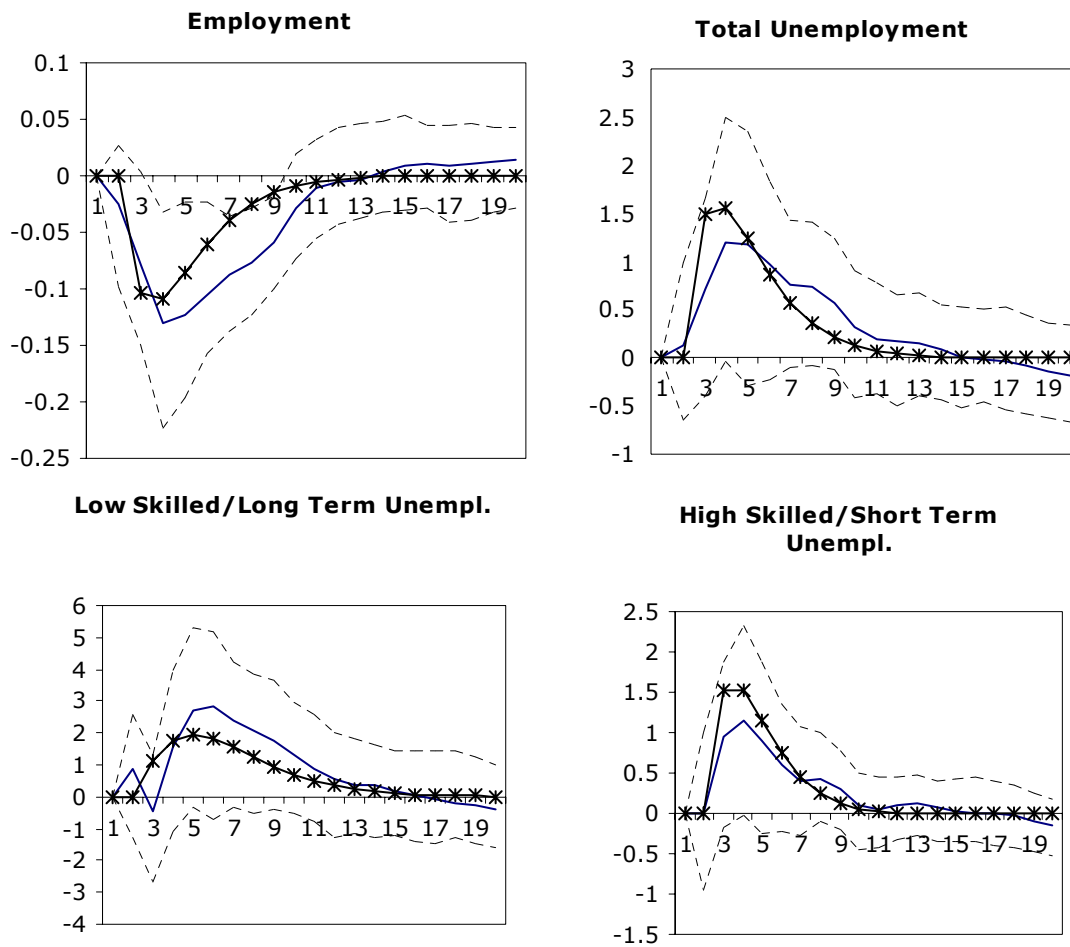
Figure 4: Impulse Responses of Employment and Unemployment of the US Economy and of the Model to a 100 basis points positive shock to the Fed.

Employment

Total Unemployment

Low Skilled/Long Term Unempl.

High Skilled/Short Term Unempl.

In general, we can see that the model is able to closely replicate the behavior observed in the data for the variables analyzed nd in general, all the responses are significant, staying within the 95 percent confidence intervals. The model tracks the response of output well, although the second period response is within the confidence bands. Output peaks in the third period and dies out in the same period in which the empirical response crosses the zero axes. Although the resonpose of output in the model lacks some persistence, it improves in this dimension compared with the other results in the literature. Simulated inflation does also a good job, and although it is not as volatile as in the standard new Keynsian model without a microfunded labor market, the magnitude of its response is close to the one of the data.

The most interesting part of the results are the responses of the labor market variables. Employment and the three kinds of unemployment are close to the empirical evidence. Simulated employment is close to the data in magnitude and in persistence. After a monetary shock employ-

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ment decreases sharply and recovers slowly. As explained before, this is due to the fact that the decrease in demand reduces profits and it is sufficient to have small idiosyncratic shocks to make the match unprofitable. Over time profits start increasing again and employment increases along with the decrease in unemployment.

The unemployment variables are the closest to the data. Most of the magnitudes and the persistence observed in the VAR are matched by the simulations. Short term unemployment is the one that matches best the data, especially in the persistence dimension, although the intitial response is not big enough. We can also see that both short-term and total unemployment slightly overshoot the response of the data in theit initial response to the shock, but after that they track well the VAR response

Finally we would like to compare our results with the ones obtained in other recent studies. The first thing to note is that steady state unemployment has been calibrated to be 6.3 percent, which implies an employment rate of 94.7 percent, in contrast to other studies where they assume a lower employment rate (Andolfatto (1996), de Haan et al (2000), Trigari (2004)). The reason behind this assumption in these other papers have to do with workers out of the labor force who, even if not officially searching for jobs, end up finding them and moving back to employment. However this assumption prevents these papers from studying the response of unemployment after shocks to the economy, whereas we are able to do so. Another reason why we abstract from the presence of agents outside the labor force is because, as Flinn and Heckman (1983) point out, unemployment and out of the labor force are two statistically different states for agents. Hence, since agents in different labor force stati behave differently during the business cycle due to factors such as sex, age, marital status and education, one should be consider them separetely. The lack of enough data on workers out of the labor force who are willing to work, together with the fact that the heterogeneity of the population plays a big role in the searching behavior and in the participation decisions of the agents (Pissarides(2000)) made us decide to not include this group of workers in this paper.

However, it seems a natural choice to extend the model to introduce a labor force participation decisions. This improvement can explain even more the slagguinshness in the response of the real variables. Workers that have been unemployed for a long time can prefer to leave the labor force and don't look for a job. These agents take more time to reenter the labor force and find a job slowing down the process of ricovery of the economy.

Moreover separations in a search and matching model are always efficient, there is no delay in separations when the surplus is discovered to be zero. This implies that the separation are istantaneous when the monetary shock hits the economy. In the data it is evident that distruction takes time as well as creation. It is necessary to introduce a mechanism that can slow down the distruction mechanism.

6   Concluding remarks

This paper develops a new Keynsian model enriched with a search and matching labor market. We introduce two kinds of rigidities in the model, Calvo price setting for retail firms and search frictions in the labor market. One innovative feature of the model is the inclusion in the labor

market of two types of unemployed workers, high and low skilled, which transition from the former the latter when unemployed for an extended period of time.

The claim of the paper is that the loss of skill mechanism helps explain the persistence in the reaction of real and nominal variables to a monetary policy shock. To prove our claim we estimate a VAR following Christiano, Eichenbaum and Evans (2000) approach, where we assume that the moneary policy instrument is the federal fund rate, and we compare the responses of the simulations of our model with the ones of the data. Analyzing the results, we can see that the model is able to match the magnitude and the persistence of the responses of output, inflation unemployment and employment to a monetary shock.

These results drive three main conclusions. First, it is necessary to microfund labor markets in order to have a better undestanding of the economy. Second, the demand side trasmission channel of monetary shocks can explain the fluctuations in labor market, output and inflation. Third, the loss of skill mechanism is important to better understand the fluctuations of output and unemployment over the business cycle, especially their perstitence.

Finally, it should be clear from this paper that the study of the heteogenity of the labor force is important to explain business cycle fluctuations. One such heterogeneity, to be explored in future research, is the one generated by workers out the labor force, whose participation decision can alter the dynamics of the economy and hence have an impact on the business cycle.

7   References

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