CIRJE-F-380

Monetary Shocks in a Model with Loss of Skills

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October 2005; Revised in February 2009

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January 2009

Abstract

Unemployment shows persistent and long lasting responses to nominal and real shocks. Standard real business cycle models with search frictions but homogeneous labor force are able to generate some persistence, but not enough to match the empirical evidence. Moreover, empirical studies emphasize the importance of the heterogeneity of the unemployment pool to fully understand unemployment dynamics. In particular, in most European countries the incidence of long term unemployment is big and well known. One of the causes/consequences of long-term unemployment is the skill deterioration of the unemployment pool. In this paper we introduce the loss of skill mechanism, and therefore an heterogeneous labor force, in a New Keynesian framework with search frictions. Calibrating the model to the Spanish economy, we show that the loss of skill mechanism helps to explain the persistence in the response of unemployment to monetary shocks.

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

1 Introduction

There is a vast literature documenting the response of macroeconomic variables such as output, inflation, monetary aggregates, and interest rates to nominal shocks[1]. However, only in the last few years have scholars started to study the effects of such shocks on labor market variables. Among others, Merz (1995) and more recently Walsh (2005) show that standard business cycle models that focus solely on the intensive margin lack the level of detail needed to understand the linkage between labor market variables and nominal shocks. In order to improve the understanding of this linkage, a growing number of papers utilize the search and matching framework of Mortensen and Pissarides (1994) to introduce frictions in the labor market. Merz (1995), Andolfatto (1996), and den Haan, Haefke and Watson (2000) all show that the introduction of search frictions not only generates important differences in the dynamics of employment and hours worked, but also helps to explain the observed persistence in labor market variables. More recently, Cooley and Quadrini (1999), Walsh (2005), and Trigari (2009) have introduced nominal features into these models in order to analyze the interaction between monetary policy and labor markets.

Most of these studies, however, focus primarily on employment and hours, with little emphasis on the response of unemployment to such nominal shocks. The study of the response of unemployment is important, since it is not simply the counterpart to the response of employment. These two pools of workers can show different dynamics due to the presence of institutions as well as the different risks and incentives they face.

Moreover, all of the papers mentioned above assume that all of the workers are homogeneous except in their employment statuses. In understanding the dynamics of labor markets, however, a number of authors stress the importance of accounting for the heterogeneity of the unemployment pool. In particular, recent research has claimed that part of the persistence of the cycles is due to this heterogeneity. Machin and Manning (1999) provide an extensive analysis of the causes and dynamics of long-term unemployment in Europe. Long-term unemployed are workers who suffer from prolonged unemployment spells; the length of an unemployment spell significantly decreases the probability of finding a new job at the individual level. Bover, Arellano and Bentolila (2002) show that for the Spanish economy, the probability of finding a job decreases with the duration of unemployment. Moreover at the macro level, Jackman and Layard (1991) find that the exit rate from unemployment decreases when there is a higher proportion of long-term unemployed workers. Part of the literature stresses the role of institutions as the cause of long-term unemployment in

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[1]See Christiano, Eichenbaum and Evans (2000) for a review of this literature.

aspects such as replacement ratio, benefit duration, union coverage, and coordination. In the present paper, we focus on the mechanism of skill loss. Prolonged detachment from a job can cause the skill deterioration of the worker. In turn, skill deterioration renders workers less attractive to firms because of their lower productivity or need to be retrained. This vicious cycle exacerbates the duration of unemployment.

The loss of the skill mechanism has been used to analyze the differences between the European and U.S. labor markets. In particular Ljungqvist and Sargent (2004) and den Haan, Haefke, and Ramey (2005) study the extent to which an increase in workers' loss of skill could account for the high increase in unemployment experienced in Europe during the 1980s. Though drawing different conclusions, both agree on the importance in studying the loss of the skill mechanism for European countries. Pissarides (1992) develops a search model with overlapping generations that embeds the loss of the skill mechanism. He finds that skill loss can help to enhance the impact of temporary shocks to the labor market.

Following this last reference, the focus of this paper is on the transitional effects of skill loss on the real and nominal variables of the economy due to a temporary nominal shock. We first study the empirical response of unemployment to a nominal shock, estimating a vector autoregression (VAR) following Christiano, Eichenbaum, and Evans (2000) identification procedure using Spanish data. The high incidence of long-term unemployment in Spain makes this economy an excellent candidate to test our model. We then develop a model that, taking into account the unemployment heterogeneity mentioned earlier, is able to closely reproduce the empirical VAR responses. In particular, we extend the model developed in Esteban-Pretel (2005) to include some of the standard features of the New-Keynesian framework. We present an economy composed of infinitely lived risk-averse individuals, who decide how to best allocate their wealth between consumption and savings. 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 competition and price their goods over their marginal cost. They change their prices following a Calvo type rule. The monetary authority sets the nominal interest rate following a Taylor rule. Workers are heterogeneous in their skill level, which can be high or low. The deterioration of skill is modeled as a constant probability of losing the skill in every period in which the worker is unemployed, and the upgrade takes place during employment at the firm. Labor markets are modeled following a search and matching framework [2].

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[2]Recently, the use of search and matching models to study business cycle fluctuations has been heavily criticized. Shimer (2005) and Hall (2005) show that these types of models fail to reproduce the empirical volatility of the vacancy-unemployment ratio due to the high variablility of wages. More recently, Andres, Domenech and Ferri (2006) show that a New Keynesian business cycle model with search frictions and staggered prices is able to reconcile the theory

In order to assess the performance of our model, we provide two sets of results. Firstly, we show how a model with skill loss compares to a model with only one skill and to the data. We show that our model generates a bigger and more persistent response of the variables to a nominal shock than a model with one skill. The loss of skill mechanism, combined with the nominal and real rigidities, helps the model to improve its match to the response of the labor market variables, in particular unemployment. The intuition for the extra persistence delivered by the two-skills model lies in the lower probability of re-employment for the low-skilled workers. When a negative nominal shock hits the economy, profits are reduced, unemployment increases, and the number of vacancies posted drops. These effects decrease the probability of workers to find jobs, which in turn implies that with time some of the high-skill workers lose their skill and enter the low-skill pool, where they have an even lower probability of being hired. The increase in unemployment together with the bigger proportion of low-skill unemployed workers greatly decreases the chances of re-employment and increases the persistence of the response of the variables to the shock. Secondly, we perform some robustness checks in order to understand the sensitivity of the results to changes in important parameters in the model, such as the probability of losing the skill, the habit persistence in consumption, and the persistence of the monetary authority instrument. We find that changing these parameters alters the dynamic responses of the variables to some extent, but that the model with two skills still generates more persistent responses to monetary shocks in unemployment and output.

The remainder of the paper is organized as follows: Section 2 highlights the relevant empirical facts of unemployment in Spain and describes the impulse responses of some nominal and real variables to a monetary shock. Section 3 outlines the model. Section 4 explains the calibration. Section 5 describes the results, and Section 6 concludes.

2   Spanish empirical evidence

The Spanish labor market has been widely studied by scholars. The change in institutions and the impact of different shocks has deeply changed the composition of the unemployment pool. Most of the studies concentrate on the role of institutions to understand the long-term unemployment phenomenon (see Manchin and Manning (1999) for a comprehensive review). In this paper, we do

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with the empirical evidence of the volatities mentioned earlier. The key mechanism in generating the higher volatilities in Andres et al. (2006) is the sluggishness of price adjustments, a feature that our model also contains. Hence it is possible that our model does not fail in the aspects noted by Shimer and Hall. However, since the focus of our paper is the dynamic response of unemployment to monetary shocks and how this response is improved by modeling skill loss, we do not pursue this issue further.

not wish to explain the evolution of unemployment in Spain. We use the Spanish example to support our claim that in macroeconomic models, it is necessary to account for the heterogeneity in the labor market to better understand the impact of nominal shocks on the economy. In particular we are interested in studying the composition of the unemployment pool with respect to the duration of unemployment and possible skill deterioration.

We concentrate our analysis on the sample from the third quarter of 1989, after the entrance of Spain into the Exchange Rate Mechanism (ERM), to the last quarter of 2000, before the structural changes in the unemployment survey of the "Instituto Nacional de Estatistica". We classify as long-term unemployed those workers who have been seeking a job for more than one year. The complement is classified as short-term unemployed. The data are converted from monthly to quarterly and are seasonally adjusted. In the last two decades, the unemployment rate reached as high as 23 percent, and dropped to as low as 10 percent. Long-term unemployment rate is the predominant part of total unemployment for most of the sample. Only in recent years has short-term unemployment exceeded long-term. This last effect is likely due to the recent surge in the use of short-term contracts (Bentolila and Jimeno (2006)).

In comparison, when we study the decomposition of unemployment by duration for the U.S., we find a completely different picture. The Bureau of Labor Statistics (BLS) provides a categorization of unemployment by duration that distinguishes between those unemployed for more or less than 6 months. Given this classification, we find that what we label as "long-term unemployment" (workers who have been unemployed for more than six months) was at a maximum 25 percent of total unemployment at the beginning of the 1980s in a sample spanning from the first quarter of 1979 to the last quarter of 2003, when the average unemployment rate was 6 percent. This analysis shows that Spain, and the European countries in general, are better candidates for analyzing the impact of monetary policy shocks on the composition of the unemployment pool. Moreover, Blanchard and Jimeno (1999) study Okun's law for the Spanish economy and show that the effect of a change in output on the change of unemployment is high.

At a more micro level, Bover et al. (2002) show that for the Spanish economy, the probability of finding a job decreases with the duration of unemployment. This is due to the fact that the long-term unemployed are detached from a productive environment for long periods, which suggests a positive correlation between the length of the unemployment spell and the probability of losing skill. Hence, the length of the unemployment spell seems a good approximation of the skill deterioration in the unemployment pool. This loss of skill mechanism forms the core of our model.

In order to evaluate the effects of a monetary policy shock on the economy, we estimate a VAR.

We follow the approach of Christiano et al. (2000) to identify the monetary policy shocks according to which these are orthogonal to the information set of the monetary authority. We estimate two different VARs. The first includes the log of the real GDP, the annualized change in the log of the GDP deflator, the log of the total unemployment rate and the log of the total hours worked per worker. The monetary policy instrument is the three month interbank rate. In the second VAR we replace the unemployment rate with two variables: the log of the long-term unemployment rate and of the short-term unemployment rate. The source of the data is EUROSTAT, except for unemployment and its disaggregation which, as stated above, were provided by the Spanish "Instituto Nacional de Estatistica", and for total hours worked that are provided by the OECD.

Figures 1 and 2 show the responses of the real and nominal variables to a 100 basis points shock to interest rates. The dotted lines are the two standard deviations confidence intervals. Since the responses of GDP, inflation, hours, and interest rates are similar in the two estimations, we only show that obtained by the first VAR. We can see that following an increase in the nominal interest rates, output decreases, as do inflation and total hours. Total unemployment increases. The effects on both output and unemployment take some time to fade, 13 quarters and 16 quarters, respectively. When we examine the response of long-term and short-term unemployment rates, we notice that these two variables respond differently. Long-term unemployment peaks later than short-term, in the eighth and fifth periods, respectively. Furthermore, long-term unemployment displays a more persistent response than the short rate.

Figure 1

Figure 2

3 The Model

The previous section shows the persistent response of unemployment and other macroeconomic variables to monetary shocks. We now explain the model that we use to assess the role of the loss of skill of unemployed workers in accounting for these persistent responses.

We use a discrete time, dynamic stochastic general equilibrium model with four types of infinitely lived agents: consumers/workers, intermediate goods firms, retail firms and the monetary authority.

The population is composed of consumers organized in households. Each member of a household can be employed and work in an intermediate goods firm, or unemployed and produce a home good. Employed and unemployed individuals can be high skilled or low skilled. When high-skilled workers

become unemployed, they face a positive probability of becoming low-skilled. The labor market in the style of Mortensen and Pissarides (1994).

Firms that produce the intermediate goods can hire both types of workers. When they hire a low-skilled worker they pay a cost to train him to become high-skilled. The training cost is shared between the worker and the employer. We follow den Haan et al. (2000) and assume that an employment relationship can be terminated because of causes exogenous to the match and because of causes endogenous to the employer worker relationship. Retailers buy intermediate goods from the intermediate firms, transform them into retail goods and sell them to the consumers. The monetary authority sets the nominal interest rate of the economy.

We assume that consumers and firms in the economy make their decisions subject to the information set of the previous period. This is consistent with the assumptions made in the identification of the monetary shocks in the empirical VAR.

3.1 Consumers

The economy is composed of a continuum of individuals of mass one, who consume and supply labor to firms. Each individual has the following per period utility:

$$u(C_t, C_{t-1}) - h(L_t), \tag{1}$$

where

$$u(C_t, C_{t-1}) = \frac{1}{1 - \gamma_c} (C_t - eC_{t-1})^{1-\gamma_c} \tag{2}$$

and

$$h(L_t) = a_n \frac{1}{1 + \gamma_n} L_t^{1+\gamma_n}. \tag{3}$$

C_t is the level of consumption and L_t the hours worked in period t. $\gamma_c, \gamma_n > 0$ are the coefficients of risk aversion to fluctuations in consumption and hours worked. We assume that there is persistence in the consumption of the individuals. $e \leq 1$ is the habit persistence coefficient in consumption. $a_n > 0$ is the weight on the disutility from supplying labor.

We assume that all of the individuals belong to a large family in which earnings from working and nonwork activities are pooled together as an insurance mechanism[3]. Firms are owned by this large household, and all of their profits are distributed to it. In every period, consumers have the opportunity to save by buying a one period risk-free bond, B_t, that pays $(1 + r_{t-1}^n)$ in t, where r^n

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[3]This assumption, which is standard in the literature, allows the model to overcome the heterogeneity problems resulting from the employment status of the agent.

is the nominal interest rate. The household decides the level of consumption and savings in order to maximize its lifetime utility.

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

$$E_{t-1}\left\{\sum_{i=0}^{\infty}\beta^i\left[u\left(C_{t+i}, C_{t+i-1}\right) - H_{t+i}\right]\right\}, \tag{4}$$

subject to

$$
\begin{aligned}
P_{t+i}C_{t+i} + B_{t+i+1} &\leq P_{t+i}\Pi_{t+i} + P_{t+i}W_{t+i} + \left(1 + r^n_{t+i-1}\right)B_{t+i} + \left(1 - n_{t+i}\right)P_{t+i}b - P_{t+i}t^w_t n_{lt} \\
\text{for } i &= \{0, ..., \infty\},
\end{aligned}
$$

where $\beta \leq 1$ is the discount rate of the economy. H_t is the disutility suffered by the household from the hours supplied by its working members[4]. Hours of work do not appear explicitly, since they are not chosen by the household but by decentralized bargaining between each firm and worker. P_t is the price level in the economy. $\Pi_t = \Pi^f_t + \Pi^r_t$ are the profits rebated to the consumers from the intermediate goods firms and the retailers. W_t is the sum of all the real wages paid to the workers. n_t is the number of employed workers. b is home production of those individuals who are not working. $t^w_t n_{lt}$ is the share of all the training costs which are paid by the workers, where t^w_t is the training cost per worker and n_{lt} the number of low-skilled workers.

The problem of the household yields the following optimal conditions:

$$E_{t-1}\phi_t = \beta E_{t-1}\left(1 + r_t\right)\phi_{t+1} \tag{5}$$

$$C_t \leq \Pi_t + W_t + \left(1 - n_{t+i}\right)b + t^w_t n_{lt}, \tag{6}$$

$$\text{where } \left(1 + r_t\right) = \frac{P_t}{P_{t+1}}\left(1 + r^n_t\right) \tag{7}$$

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

Bonds do not appear in Equation (6) since in equilibrium they are in zero net supply.

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.

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[4]As we show later, hours of work are the same for all workers. The relationship between individual and total disutility from work is hence $H_t = n_t h\left(L_t\right)$, where n_t is total employment in the economy, which is the sum of the high and low-skill employment levels.

As explained before, unemployed workers can be of two types, high or low-skilled. A worker who has just been separated from a firm retains the high skill for some time, and is therefore classified as high-skilled unemployed. While unemployed, high-skilled workers face a positive probability, λ, of losing the skill and becoming low-skilled. Firms can hire either type of worker. Both types of workers are equally productive, although the low-skilled employed must be trained, at a total cost t, when hired. This cost is shared between the worker and the firm. Training takes one period, after which the worker becomes high-skilled.

Vacant firms and unemployed workers meet randomly according to a constant return to scale 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 (l) and high (h) skilled unemployment, respectively, and v_t is the number of vacancies. For later use, we denote market tightness of the labor market as $\theta_t = \frac{v_t}{u_t}$.

If the search process is successful, firms produce output according to the production function $y_t = AL_t^{\alpha_y}$ where y_t is the output level, A is the level of technology of the economy, and $\alpha_y \in [0, 1]$.

The costs of production for the firm are the wages paid to the worker, the training cost, and a fixed cost η_t. This latter cost, which can be interpreted as the cost of intermediate inputs other than labor, is idiosyncratic to the firm, independent, and identically distributed across firms and time, with distribution function $F : [\eta_{\min}, \eta_{\max}] \to [0, 1]$. A new cost is drawn every period by the firm.

Employment relationships are dissolved either exogenously, which occurs with probability ρ_x, or endogenously, if the cost of intermediate inputs is too high, and both firm and worker decide to discontinue the relationship and explore other options. The value of η above which the match is dissolved is denoted by $\bar{\eta}_t$. There exists a different threshold cost for high-skilled matches, $\bar{\eta}_{ht}$, and low skilled matches, $\bar{\eta}_{lt}$, since both types of matches face different costs and benefits. For simplicity, we assume that newly formed matches are subject to endogenous but not exogenous destruction.

The timing of the labor market is as follows. At the beginning of every period, a proportion ρ_x of matches which have been productive during the previous period are destroyed for exogenous reasons. The remaining matched firms draw an intermediate input cost. This new cost, along with the other determinants of the surplus (i.e. interest rate, price of the good, general price level, level of technology), determine the new threshold of endogenous destruction $\bar{\eta}_{it}$ with $i \in \{l, h\}$ and establishes total destruction. After destruction takes place, the levels of employment and high and low-skilled unemployment are determined.

Value of posting a vacancy

Posting vacancies has a flow cost of k for the firm. A vacant firm matches 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, in the following period the firm obtains the value of being filled by a worker of type i, otherwise it remains as a vacancy. Let V_t and $J_{it}(\eta_t)$ be the values, measured in terms of consumption, of a vacancy and of a job filled by a worker of type i. Hence the value of a vacancy is

$$
\begin{aligned}
V_t = & -k + E_{t-1}\beta_t \left[q_{ht}^f \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}) \right. \\
& \left. + q_{lt}^f \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} J_{lt+1}(\eta_{t+1}) \, dF(\eta_{t+1}) + \left(1 - q_{ht}^f F(\bar{\eta}_{ht+1}) - q_{lt}^f F(\bar{\eta}_{lt+1})\right) V_{t+1} \right],
\end{aligned}
\tag{8}
$$

where $\beta_t = \beta \dfrac{\phi_{t+1}}{\phi_t}$ is the effective discount factor, since firms are ultimately owned by households.

Free entry of firms is assumed in equilibrium, which implies that the value of a vacancy must be zero in every period, $V_t = V_{t+1} = 0$.

Value of a filled job for a firm

The value for a firm which hires a high-skilled worker is

$$
J_{ht}(\eta_t) = x_t A_t L_t^{\alpha_y} - \eta_t - w_{ht}(\eta_t) L_t + E_{t-1}\beta_t (1 - \rho_x) \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}).
\tag{9}
$$

During the current period, given the firm's idiosyncratic cost of intermediate inputs, η_t, it produces output, sells it to the final goods firms at price x_t, and pays wages and the cost of these inputs. The following period, if the match survives the exogenous destruction, the firm draws a new intermediate input cost. If the new cost is below the threshold, $\bar{\eta}_{ht+1}$, the match is still productive, with a value of $J_{ht+1}(\eta_{t+1})$. Otherwise the match is destroyed and it becomes a vacancy, which has value zero.

A similar expression holds in the case of employing a low-skilled worker [5], except for the fact that we need to account for the share of the training cost to the firm, t_t^f.

$$
J_{lt}(\eta_t) = x_t A_t L_t^{\alpha_y} - \eta_t - t_t^f - w_{lt}(\eta_t) L_t + E_{t-1}\beta_t (1 - \rho_x) \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}).
\tag{10}
$$

---

[5]Note that since training only takes one period, the continuation value is the same as that of the firm hiring a high-skilled worker.

Given the previous expressions, we can define the total amount of flow profits made by intermediate goods firms as

$$\Pi_t^f \equiv n_{ht} \left(x_t A_t L_t^{\alpha_y} - \tilde{\eta}_{ht} - \tilde{w}_{ht} L_t \right) + n_{lt} \left(A_t L_t^{\alpha_y} - \tilde{\eta}_{lt} - \tilde{w}_{lt} L_t - t_t^f \right) - k v_t \qquad (11)$$

where $\tilde{\eta}_{it}$ and $\tilde{w}_{it} L_t$ are respectively the average intermediate input cost and wage paid to a worker in a productive employment relationship of skill i in period t.

Value of Unemployment

A high-skilled unemployed worker obtains flow utility b while not working. If he matches with a firm, which happens with probability $q_t^w = m(\theta_t)$, and the intermediate input cost for the firm is below the threshold, $\bar{\eta}_{ht+1}$, he becomes a productive worker in the following period. If the search process is not successful, he may lose the skill with probability λ, becoming low-skilled unemployed. If he does not enter into an employment relationship with a firm and does not lose the skill, he remains as high-skilled unemployed. Hence:

$$U_{ht} = b + E_{t-1}\beta_t \left[q_t^w \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} N_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}) + (1 - q_t^w F(\bar{\eta}_{ht+1})) (\lambda U_{lt+1} + (1-\lambda) U_{ht+1}) \right].$$
$$(12)$$

Analogously, the present value for a low-skilled unemployed worker is:

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

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 of 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 employment is exogenously or endogenously destroyed.

$$N_{ht}(\eta_t) = w_{ht}(\eta_t) L_t - \frac{h(L_t)}{\phi_t} \qquad (14)$$
$$+ E_{t-1}\beta_t \left[(1 - \rho_x) \left(\int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} N_{ht+1}(\eta_{t+1}) \, dF(\eta_{t+1}) + (1 - F(\bar{\eta}_{ht+1})) U_{ht+1} \right) + \rho_x U_{ht+1} \right].$$

Similarly, the present value for a low-skilled employed worker is:

$$
N_{lt}(\eta_t) = w_{lt}(\eta_t) L_t - \frac{h(L_t)}{\phi_t} - t_t^w \tag{15}
$$

$$
+ E_{t-1}\beta_t \left[(1-\rho_x) \left(\int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} N_{ht+1}(\eta_{t+1}) dF(\eta_{t+1}) + (1-F(\bar{\eta}_{ht+1})) U_{ht+1} \right) + \rho_x U_{lt+1} \right].
$$

Surplus, wages, hours and worker flows

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. The expression for the surplus is $S_{it}(\eta_t) = J_{it}(\eta_t) + N_{it}(\eta_t) - U_{it}$ with $i = \{l, h\}$. The sharing rule for the surplus is obtained as the Nash solution to a bargaining problem, which results in a constant fraction for each party. Let β_w be the bargaining 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), we can obtain the surplus in terms of units of consumption for both high and low-skilled matches.

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

$$
w_{ht}(\eta_t) L_t = \beta_w \left[x_t A_t L_t^{\alpha_y} - \eta_t + \beta_t q_t^w E_t \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1} dF(\eta_{t+1}) \right] \tag{16}
$$

$$
+ (1-\beta_w) \left[\frac{h(L_t)}{u'(C_t)} + b - \beta_t (1 - q_t^w F(\bar{\eta}_{ht+1})) \lambda E_t (U_{ht+1} - U_{lt+1}) \right],
$$

$$
w_{lt}(\eta_t) L_t = \beta_w \left[x_t A_t L_t^{\alpha_y} - \eta_t + \beta_t q_t^w E_t \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} J_{lt+1} dF(\eta_{t+1}) \right] \tag{17}
$$

$$
+ (1-\beta_w) \left[\frac{h(L_t)}{u'(C_t)} + b - \beta_t E_t (1-\rho_x) (U_{ht+1} - U_{lt+1}) \right].
$$

The worker is compensated for a proportion 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

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for a fraction $(1 - \beta_w)$ of the disutility from supplying labor, and for the foregone home production. The wages also take into account the cost associated with the risk to the high-skilled unemployed worker of becoming low-skilled. The total wages paid to the workers are defined as

$$W_t \equiv n_{ht}\tilde{w}_{ht}L_t + n_{lt}\tilde{w}_{lt}L_t. \tag{18}$$

The number of hours worked in every employment relationship is chosen to maximize the surplus of the match. This is optimal for the firm and the worker since both the surplus and the wages depend on L. The optimal number of hours is given by the following expression:

$$L_t = \left(\frac{x_t \alpha_y A \phi_t}{a_n} \right)^{\frac{1}{1 + \gamma_n - \alpha_y}}. \tag{19}$$

The optimal amount of hours supplied by the worker depends positively on the technology level and negatively on the level of consumption, due to the decreasing marginal utility of consumption. Because of the additive nature of the idiosyncratic cost, and the fact that both types of workers are assumed to be equally productive, the optimal choice of hours does not depend on the cost of intermediate inputs of the firm or the skill of the worker.

An employment relationship is terminated endogenously when the idiosyncratic intermediate input cost of the firm is so high that it drives the surplus to zero. $\bar{\eta}_{ht}$ is such that $S_{ht}(\bar{\eta}_{ht}) = 0$. $\bar{\eta}_{lt}$ is defined in the same way.

Given the timing and the decision rules of the agents, the evolution of the different employment and unemployment pools is determined by the following equations:

$$u_{ht} = \left(1 - q_{t-1}^w F(\bar{\eta}_{ht})\right)(1 - \lambda)u_{ht-1} + \left(\rho_x + (1 - \rho_x)(1 - F(\bar{\eta}_{ht}))\right)n_{ht-1} \tag{20}$$
$$+ (1 - \rho_x)(1 - F(\bar{\eta}_{ht}))n_{lt-1},$$
$$u_{lt} = \left(1 - q_{t-1}^w F(\bar{\eta}_{lt})\right)u_{lt-1} + \rho_x n_{lt-1} + \left(1 - q_{t-1}^w F(\bar{\eta}_{ht})\right)\lambda u_{ht-1}, \tag{21}$$
$$n_{ht} = (1 - \rho_x)F(\bar{\eta}_{ht})n_{ht-1} + (1 - \rho_x)F(\bar{\eta}_{ht})n_{lt-1} + q_{t-1}^w F(\bar{\eta}_{ht})u_{ht-1}, \tag{22}$$
$$n_{lt} = q_{t-1}^w F(\bar{\eta}_{lt})u_{lt-1}, \tag{23}$$
$$1 = u_{lt} + u_{ht} + n_{lt} + n_{ht}. \tag{24}$$

3.3 Retailers

There is a continuum of retail firms which operate in monopolistic competition. They buy intermediate goods, transform them one for one into retail goods and then sell them to the consumers.

Define the quantity of retail good j sold as Y_{jt} and let P_{jt} be its price. The final good purchased by the consumer, Y_t, is

$$Y_t = \left[\int_0^1 Y_{jt}^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{25}$$

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

The demand for retail good i and the aggregate price at time t are:

$$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} Y_t, \tag{26}$$

$$P_t = \left[\int_0^1 P_{jt}^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}. \tag{27}$$

The previous expressions allow us to write the total profits made by the retailers as

$$\Pi_{t+i}^r = \int_0^1 \left(\frac{P_{jt}}{P_t} - x_t \right) Y_{jt} dj.$$

Following Calvo (1983), we assume that in every period, a fraction $(1 - \varphi)$ of retailers can change their prices. Hence, the aggregate price can be expressed as

$$P_t = \left[\varphi P_{t-1}^{1-\varepsilon} + (1 - \varphi) \tilde{P}_t^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}, \tag{28}$$

where $\tilde{P}_t$ is the average price set by the firms that can change prices. At the individual level, retailers who can re-optimize choose their prices by solving the following problem:

$$\max_{P_{jt}} E_{t-1} \sum_{i=0}^{\infty} \varphi^i \beta_{t+i} \left[\frac{P_{jt}}{P_{t+i}} - x_{t+i} \right] Y_{jt,t+i},$$

which yields the following optimal condition:

$$\tilde{P}_{jt} = \mu_\varepsilon E_{t-1} \sum_{i=0}^{\infty} \varpi_{jt,t+i} x_{t+i}^n. \tag{29}$$

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

$$\varpi_{jt,t+i} = \frac{\varphi^i \beta_{t+i} R_{jt,t+i}}{E_{t-1} \sum_{k=0}^{\infty} \varphi^k \beta_{t+k} R_{jt,t+k}}, \tag{30}$$

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where $R_{jt,t+s}$ denotes the expected revenues of firm j at time $t + s$. In equilibrium all optimizing firms choose the same price, $\tilde{P}_t$:

$$\tilde{P}_t = \mu_\varepsilon E_{t-1} \sum_{i=0}^{\infty} \frac{\varphi^i \beta_{t+i} R_{t,t+i}}{E_{t-1} \sum_{k=0}^{\infty} \varphi^k \beta_{t+k} R_{t,t+k}} x^n_{t+i}.$$

After performing a first-order Taylor approximation around a zero-inflation steady state, the retailer side of the economy can be summarized in the following well-known aggregate supply equation:

$$E_{t-1}\hat{\pi}_t = \varphi_x \hat{x}_t + \beta E_{t-1}\hat{\pi}_{t+1}, \tag{31}$$

where $\hat{\pi}_t = \log P_{t+1} - \log P_t$ and $\hat{x}_t = \log x_t - \log x$, $\varphi_x = \frac{(1-\varphi)(1-\varphi\beta)}{\varphi}$ and x is the steady state value of the price of the intermediate goods. This equation, which is standard in business cycle models with monopolistic competition and staggered prices in the style of Calvo (1983), states that current inflation is a positive function of the prices of intermediate inputs and future inflation.

3.4 Monetary authority

The monetary authority sets the nominal interest rate in the economy following a Taylor rule. Nominal interest rates are subject to monetary policy shocks, $\epsilon_t^m \sim iid\,(0, \sigma_\epsilon)$. Let $\gamma_\pi \geq 1$ and $\gamma_y \geq 0$ represent the weights of the Central Bank on inflation and output gap when setting the monetary policy, then

$$r_t^n = \varphi_r \left(r_{t-1}^n\right)^{\rho_m} E_t \left(\frac{P_{t+1}}{P_t}\right)^{\gamma_\pi(1-\rho_m)} \left(\frac{Y_t}{Y}\right)^{\gamma_y(1-\rho_m)} e^{\epsilon_t^m}. \tag{32}$$

3.5 Equilibrium

This economy can be supported as a recursive competitive equilibrium.

4 Parametrization

In this section, we present the procedure followed to parametrize the model. The values for a subset of the parameters are chosen following other studies, and what has become standard in the literature. The values for the other parameters are calibrated to match the empirical evidence from the Spanish economy for the long run values of the variables in the model, which would correspond to the steady state.

The length of a period is one quarter. The discount factor of the economy is $\beta = 0.99$, which using the Euler equation (5) implies a quarterly real interest rate of 2 percent in the steady state. The production function is assumed to be constant returns to scale, so $\alpha_y = 1$. The results of the simulations are robust to changes in this parameter. Setting it equal to 0.66, as in a standard production function with capital, does not alter the results presented in the next section. The steady state labor supply is assumed to be $L = 1/3$, which implies that on average, 8 hours per working day are devoted to work. The level of technology, A, is normalized to 1.

The flow value of unemployment or home production, b, has been a subject of debate in recent years. Shimer (2005) sets its value such that the ratio of home production to the surplus flow (critical to make wages more or less responsive to productivity shocks, which in his model coincides with the productivity of the firm), $\frac{z}{p}$ in his model, is 0.4. More recently, Hagedorn and Manovskii (2008) set its value such that the ratio $\frac{z}{p}$ is 0.955. In our model, we choose b so that the ratio of home production to the surplus flow is 60%, which is between the numbers in the previous two papers, and set it to $b = 0.033$. Changing this parameter within reasonable bounds does not alter the main conclusions of the paper. Following Mortensen and Pissarides (1994), the bargaining power of the worker is set to $\beta_w = 0.5$.

The parameters in the utility function are $\gamma_c = 1$ and $\gamma_n = 1$, which imply log-utility in consumption and quadratic disutility from labor supply. We follow Walsh (2005) and Trigari (2009) and set the habit persistence parameter, e, to 0.55. a_n is calibrated using the optimal labor supply, equation (19), and the steady state levels of hours, technology, and consumption. We set to $a_n = 14.1$.

The matching function is assumed to be constant returns to scale and to take the following functional form, $m(u_t, v_t) = \mu u_t^{\alpha_m} v_t^{1-\alpha_m}$. Following Mortensen and Pissarides (1994) we set $\alpha_m = 0.5$. The probability of leaving unemployment in Spain is set to 0.3, following Bover et al. (2002). After Shimer (2005) we set the market tightness of the economy, θ, to unity. Changing this value does not affect the results, since it only rescales the parameter μ in the matching function without any effect in the results, as Shimer (2005) explains. Using OECD quarterly data from 1982:1 to 2005:4 [6], the unemployment rate is set to 0.15. In our sample of Spanish data, the proportion of unemployment lasting longer than 12 months is 0.55, hence we set the proportion of the low-skilled unemployed to 0.55 of total unemployment. Using these two probabilities and the steady state flow equations from the model, we obtain a steady state value for λ of 0.42, which implies that the probability at the beginning of the period of loss of skill is 0.25, or that on average a high-skilled

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[6]OECD International Statistics Yearbook.

unemployed worker takes one year to lose the skill. This average duration of skill deterioration allows us to make the comparison between the low-skilled unemployed workers in the model and the long-term unemployed in the data. Given the steady state unemployment rates and the probabilities of leaving unemployment and losing the skill, the destruction rate in the steady state is 0.053. For lack of better estimates, we assume that the exogenous destruction is 68 percent of total destruction, which is the same proportion which is used for U.S. calibrations, and has been estimated by Davis, Haltiwanger and Schuh (1996). Hence, $\rho_x = 0.036$. The scaling parameter in the matching function is calibrated using the equilibrium flow equations, and set to $\mu = 0.42$.

Bover et al. (2002) calculate the probability of exiting unemployment as a function of unemployment duration. They estimate that for the Spanish economy, this probability is reduced by half for workers who have been unemployed for a whole year. Since the matching probability is the same for both types of workers, and the difference in the probability of transition from unemployment to employment for low-skilled workers is marked by the training cost, we set this cost to $t = 0.57$ so that the probability of a successful match for a low-skilled worker is half of that for a high-skilled one.

Following Gali and Gertler (1999) we set the probability of changing prices for the retailers, φ, to 0.85. We set the steady state mark-up of the intermediate goods firms to $\mu_\varepsilon = 1.1$, which implies an elasticity of substitution between intermediate goods of $\varepsilon = 11$, as in Walsh (2005) and Trigari (2009).

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 follow the estimates of Favero and Marcellino (2001) for their benchmark specification of the Taylor rule for Spain, and we set $\rho_m = 0.912$, $\gamma_\pi = 1.5$, $\gamma_y = 1.74$. $\varphi_r = 0.19$ is chosen such that the nominal interest rate in the steady state is equal to the real rate.

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 obtained along with all of the remaining steady state variables of the economy through the steady state equilibrium of the model. We set $\psi = 0.0997$.

Table 1 summarizes the main parameters of the model.

<div align="center">Table 1</div>

5   Results

We provide two kinds of results. First, we compare the impulse responses of our two-skills model with the empirical responses shown in Section 2. At the same time, we compare our specification against a model with only one skill in order to understand where a model with loss of skill signifies an improvement over a model with a less heterogeneous labor market. Second, we test how robust the results are to changes in the probability of losing the skill, λ, in the habit persistence parameter, e, and in the rate of autocorrelation of the monetary policy instrument, ρ_m.[7]

Figures 3 and 5 show the results of our two specifications of the VAR against the responses to a 100 basis points increase in the annualized interest rate for the model with two skills and the model with only one skill. The dashed line and the light solid line represent the responses of the model with one and two skills, respectively, to the monetary shock. The dark solid line is the response in the data, and the dotted lines are the 95 percent confidence intervals.

All of the variables respond to the monetary shock showing the expected pattern: output, inflation, and hours decrease, and unemployment increases. The intuition is as follows. After an increase in the nominal interest rate, consumers face a higher trade-off between present and future consumption due to the increased returns on savings. Some current consumption is delayed to the future, which creates a drop in demand. Due to price rigidities, retailers cannot fully adjust their prices and instead reduce production to meet the decreased demand. The drop in final output reduces the demand by retailers of intermediate goods. Lower demand for intermediate goods produces a drop in the profits of those types of firms, which reduces the desirability of labor market matches. This drives a decrease in the creation of jobs and an increase in their destruction, since now some of the previous matches are not profitable. Lower creation and higher destruction reduce the employment level and increase unemployment. The higher unemployment level, together with the reduced profits for the firms, decrease the probability that unemployed workers match with firms. Over time, some of the high-skilled workers see their skills deteriorate and they become low-skilled, a state in which they have an even lower probability of finding work. The lower re-employment chances of low-skilled workers, together with the higher fraction of those types of workers in the unemployment pool, reduces the average job-finding rate in the economy. This, in turn, produces the more persistent response of unemployment and other variables. While the increase in unemployment occurs slowly, hours worked sharply decrease during the period after the shock due to the lack of frictions when adjusting the intensive labor margin. At the same time, some of the effects of the

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[7]The model has been solved and simulated using Dynare, version 3.05. (http://www.cepremap.cnrs.fr/dynare)

initial shock are undone by the monetary authority. The use of the Taylor rule allows the monetary authority to reduce the gap in output and the inflation generated by the increase in the interest rates.

Looking at Figure 3, we can see that in general, the model is able to replicate the behavior observed in the data for the main variables analyzed, and that all of the responses are significant, staying within the 95 percent confidence intervals, except for hours. The model tracks the response of output well. Output peaks in the second period and dies out in the same quarter in which the empirical response crosses the zero axes. Inflation in the model is as responsive as in the data but it converges back to the steady state faster, although it is always within the 95 percent confidence intervals [8].

If we compare the simulations for the two different models, the one-skill and the two-skills models, we observe that the latter delivers a more pronounced and persistent response of unemployment, and is a better match to the data. The two-skills model also produces an almost identical response for the interest rate and is a good fit for output and inflation.

Figure 3

The most interesting part of the result is the response of unemployment, where the model with two skills is able to generate a bigger and more persistent response than the model with one skill. Figure 4, which plots the responses of total, high and low-skilled unemployment after the monetary shock together, provides more insight into the response of unemployment. High-skilled unemployment peaks before low-skilled and goes below the steady state after 5 quarters. The low increase and eventual decrease in high-skilled unemployment is consistent with the arguments expressed in den Haan et al. (2005). High-skilled workers realize that if they become unemployed, they face the possibility of skill loss and a subsequent decrease in their probability of re-employment. Hence, following a negative monetary shock, high-skilled workers are less willing to terminate their jobs. The flow of high-skilled workers into unemployment is therefore not as big as it would be if there were no loss of skill. Moreover, with time some of the high-skilled unemployed workers lose their skill, and this further reduces the pool of the high-skilled unemployed. Low-skilled unemployment has a more pronounced and sluggish response to the negative monetary shock. It peaks after 5 quarters and returns to the steady state more slowly. This more responsive and persistent behavior

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[8]One way that has been suggested in the literature to generate a more persistent response of inflation, i.e. Walsh (2005), is to assume that a fraction of the firms which are allowed to change prices are backward-looking and update their prices using a rule of thumb according to the last period's inflation.

of low-skilled unemployment drives the better fit of the two-skills model compared to the model with one skill.

Figure 4

The model, however, does not fully match the timing of the response of unemployment. Even though the loss of skill mechanism is able to generate a more sluggish response on unemployment, it cannot replicate the very delayed peak observed in the data. The VAR analysis shows that unemployment peaks after 7 quarters, whereas the model response peaks after 4. The reason for this early peak in the model lies in the nature of the search and matching model, where shocks have an immediate effect on unemployment. Following a negative shock, destruction increases and creation drops, generating a very quick increase in unemployment. Since the focus of theis paper is in analyzing the effect of the loss of skill following a monetary shock, we have abstracted from features of the model such as firing restrictions, which could bring a more delayed response for unemployment. We can see that this early response of the model is also observed when looking at the response of high and low-skilled unemployment in Figure 5. Both variables peak several quarters before the data, although the magnitude of the response of low-skilled unemployment in the data is well matched by the model. High-skilled unemployment in the model also peaks early and is of insufficient magnitude.

The behavior of hours worked is not completely satisfactory. In both the one and two-skills models, hours react too strongly to the monetary policy shock, decreasing more than in the data. However, the responses of the model are outside the confidence bands only for the first two quarters.

Figure 5

5.1   Robustness

We now show the robustness of the results to changes in the probability of losing the skill, λ, in the habit persistence parameter, e, and in the rate of autocorrelation of the monetary policy instrument, ρ_m. We see that the improved performance of the model with skill loss is maintained even when we reduce the values assigned to these parameters in the benchmark calibration.

The rate of loss of skill is calibrated endogenously to match the steady state levels and flows of the labor market to the long-run labor market data. For this reason, changing the rate of loss of skill implies having to adjust another flow within the model in order to still match the employment and unemployment levels from the data. To this end, we adjust the rate at which the low-skilled

workers regain their skill after being hired. Until this point we have assumed that this skill upgrade is done in just one period, but decreasing the flow from high to low-skilled unemployment requires decreasing the flow from low to high-skilled employment. Hence, we re-derive the model for the case when the skill upgrade occurs only with certain probability, and we calibrate the model again to match the data [9].

Figure 6 shows the responses of output, total, high, and low-skilled unemployment for the model with one skill and the model with two skills with $\lambda = 0.42$, $\lambda = 0.27$ and $\lambda = 0.16$. The three different values of the rate of loss of skill correspond respectively to the benchmark calibration presented above, and to two calibrations where the skill upgrade occurs with probability 0.5 and 0.25. Also note that these three cases imply ex-ante probabilities of losing the skill of 0.25, 0.16 and 0.1 respectively. We can observe in Figure 6 that the model with two skills still delivers a higher and more sluggish response of unemployment than the model with one skill, even when we assume that the rate of loss of skill is lower than the one presented in Figures 3 to 5. The response of output does not change substantially as we decrease λ. However, as expected, the change in the rate of skill loss does affect the response of high and low-skilled unemployment. On the one hand, when λ decreases, high-skilled unemployment takes longer to peak and to decrease below the steady state. This confirms the intuition given above: high-skilled workers are less reluctant to terminate their jobs if the threat of skill loss is lower. On the other hand, it is also natural that as we decrease λ, low-skilled unemployment peaks earlier and returns more quickly to the steady state, since there is a lower flow from the high-skilled unemployment pool.

Figure 6

Trigari (2006) shows that the habit persistence parameter has a big role in determining the persistence of the response of inflation. We perform a similar experiment in our model showing the responses of the two main variables of interest, output and unemployment, when we assume that there are no consumption habits ($e = 0$). Figure 7 shows that consumption habits are not crucial in delivering the main result of our model. The response of unemployment remains high and persistent in both models. As expected, and similarly to Trigari (2006), the response of output is bigger when we set $e = 0$. Without consumption habits, consumption and output decrease sharply due to the decrease in demand, and the model no longer delivers a humped shape for output. As in the previous literature, we justify the introduction of consumption habits in order to match the delayed

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[9]The derivation of the model with a different time upgrade of skill is available from the authors upon request.

and persistent drop in output and consumption, although as we have shown, habit persistence is not essential to the results concerning the comparison of the one and two-skills models.

Figure 7

Finally, following Walsh (2005), we change the persistence of the monetary policy instrument in order to assess the importance of this parameter in the performance of the model. Figure 8 shows the behavior of unemployment and output when we assume that the monetary policy instrument has no autoregressive term ($\rho_m = 0$). It is clear from the graph that the extra persistence of the response of unemployment in the two-skills model is not driven by the persistence of the interest rate. However, as already noted by Walsh (2005), the magnitude of the responses of output and unemployment become very small without the persistence of the monetary shock. Hence, although the magnitude of the response depends crucially on the persistence of the shock, the higher persistence of the model with skill deterioration does not.

Figure 8

6 Conclusion

This paper develops a new Keynesian 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. The 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 to the latter when unemployed for an extended period of time.

The paper shows that the loss of skill mechanism helps explain the magnitude and persistence in the response of unemployment and other real and nominal variables to a monetary policy shock in economies which suffer from high unemployment and high long-term unemployment. Economies such as those of the European countries are perfect candidates to test our theory, and we thus estimate a VAR for a representative case of the European unemployment problem, Spain. We follow the approach of Christiano et al. (2000) and compare the responses of the simulations of our model with the ones of the data. Analyzing the results, we see that the model with loss of skill is able to generate a higher and more persistent response of unemployment following a monetary shock than a model which does not include this mechanism, even for different values of the rate of loss of skill, habit persistence in consumption, and persistence of the monetary policy instrument. The

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two-skills model also performs well when trying to match the magnitude and the persistence of the responses of output and inflation to a monetary shock. The model, however, is not able generate as much persistence in unemployment as that shown by the data, even with the inclusion of the loss of skill. Extensions in the labor market modeling in the line of firing restrictions or other rigidities which are found in the European labor markets would help to close this gap with the data.

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

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Table 1: Parameters of the Model

Exogenous Parameters			
$\beta = 0.99$	$\gamma_c = 1$	$e = 0.55$	$\gamma_n = 1$
$\alpha_y = 1$	$A = 1$	$\beta_w = 0.5$	$\alpha_m = 0.5$
$\rho_x = 0.36$	$\varepsilon = 0.2$	$\varphi = 0.85$	
$\rho_m = 0.97$	$\gamma_\pi = 1.02$	$\gamma_y = 1.4$	
Calibrated Parameters			
$\lambda = 0.42$	$t = 0.57$	$k = 0.036$	$b = 0.033$
$a_n = 14.05$	$\mu = 0.45$	$\psi = 0.099$	$\varphi_r = 0.053$

Figure 1: Impulse Responses of Output, Inflation, Unemployment and Interest rates of the Spanish Economy to 100 basis points positive shock to the interest rate

Output

Inflation

Unemployment

Hours
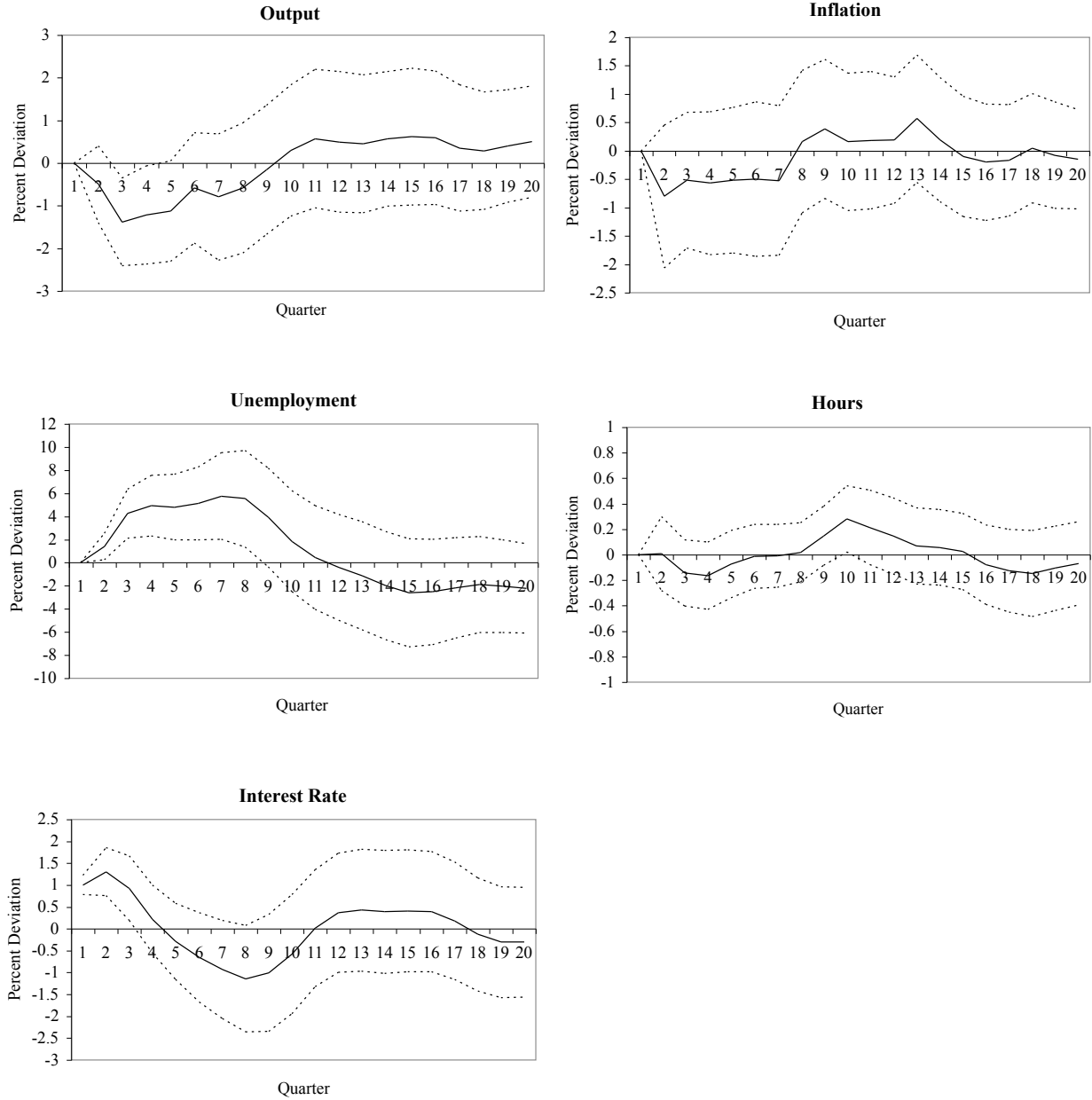
Interest Rate

Figure 2: Impulse Responses of Short-term and Long-term Unemployment of the Spanish Economy to 100 basis points positive shock to the interest rate
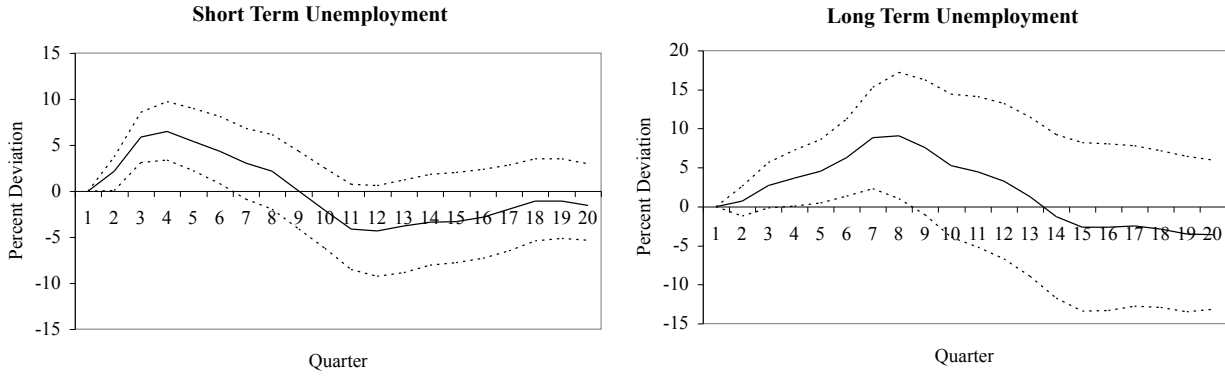
Short Term Unemployment

Long Term Unemployment

Figure 3: Impulse Responses of Output, Inflation, Unemployment and Interest rates of the Spanish Economy and of the Model to 100 basis points positive shock to the interest rate
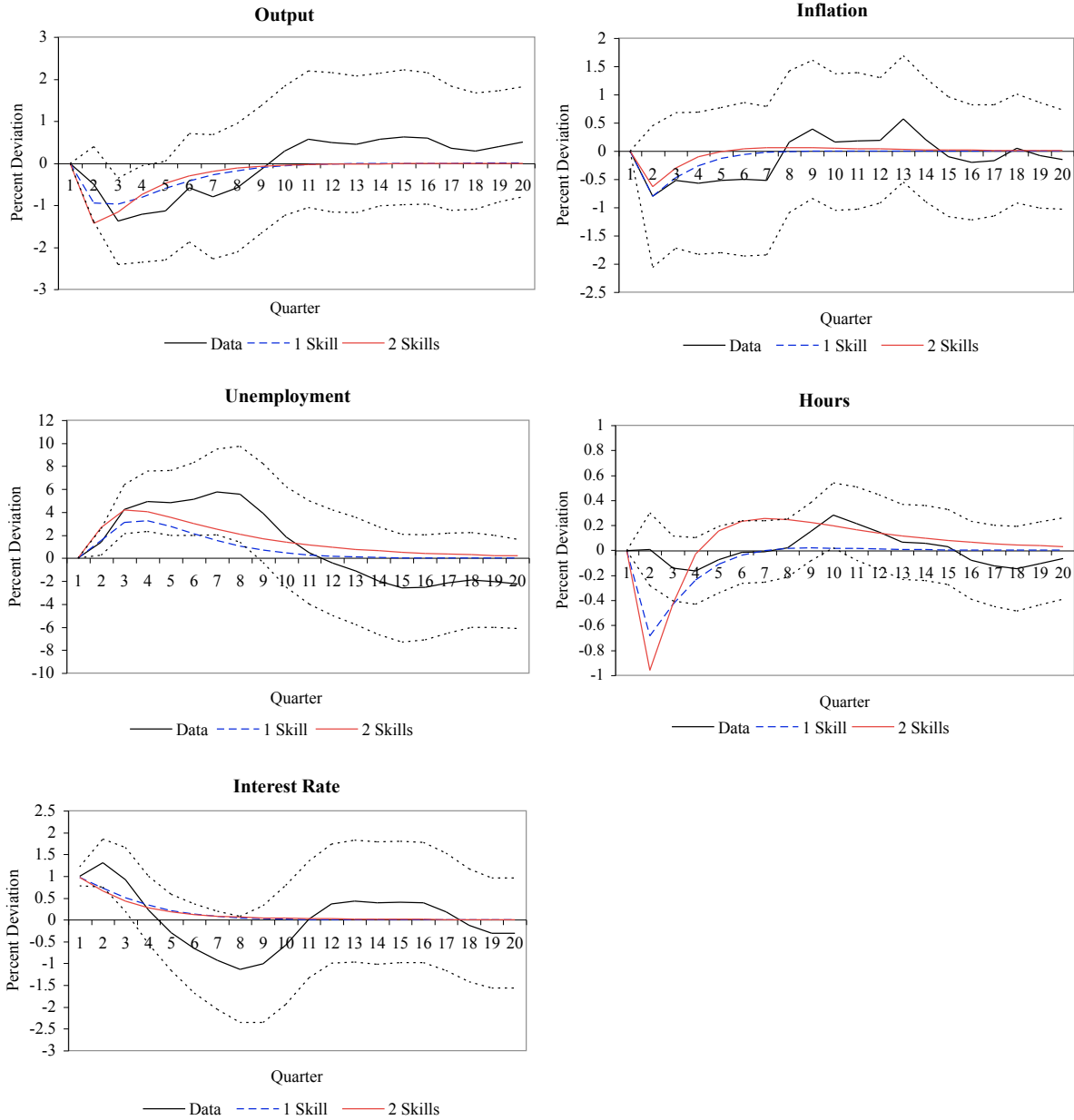

Output

Inflation

Unemployment

Hours

Interest Rate

Figure 4: Impulse Responses of Total, High and Low-Skilled Unemployment of the Model to 100 basis points positive shock to the interest rate
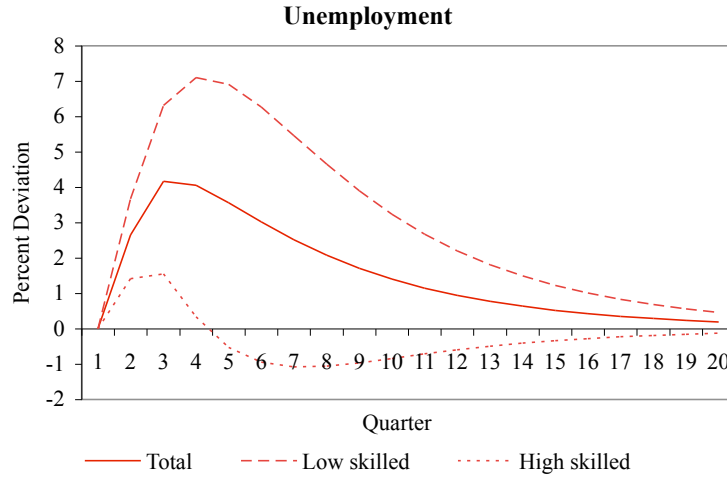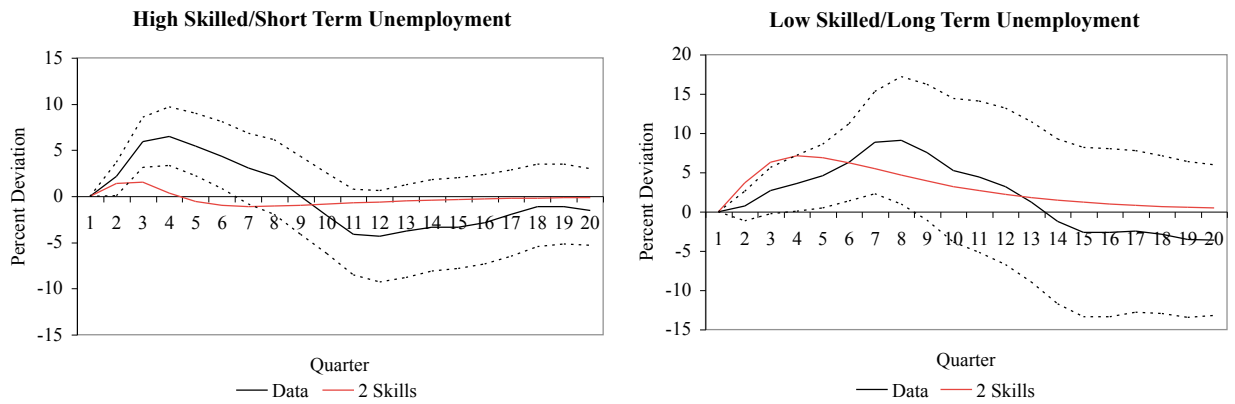
Unemployment

Figure 5: Impulse Responses of High and Low-Skilled Unemployment of the Model to 100 basis points positive shock to the interest rate

High Skilled/Short Term Unemployment   **Low Skilled/Long Term Unemployment**

Figure 6: Impulse Responses of Output, Total, High and Low-Skilled Unemployment of the Model to 100 basis points positive shock to the interest rate for different values of the Loss of the Skill Rate
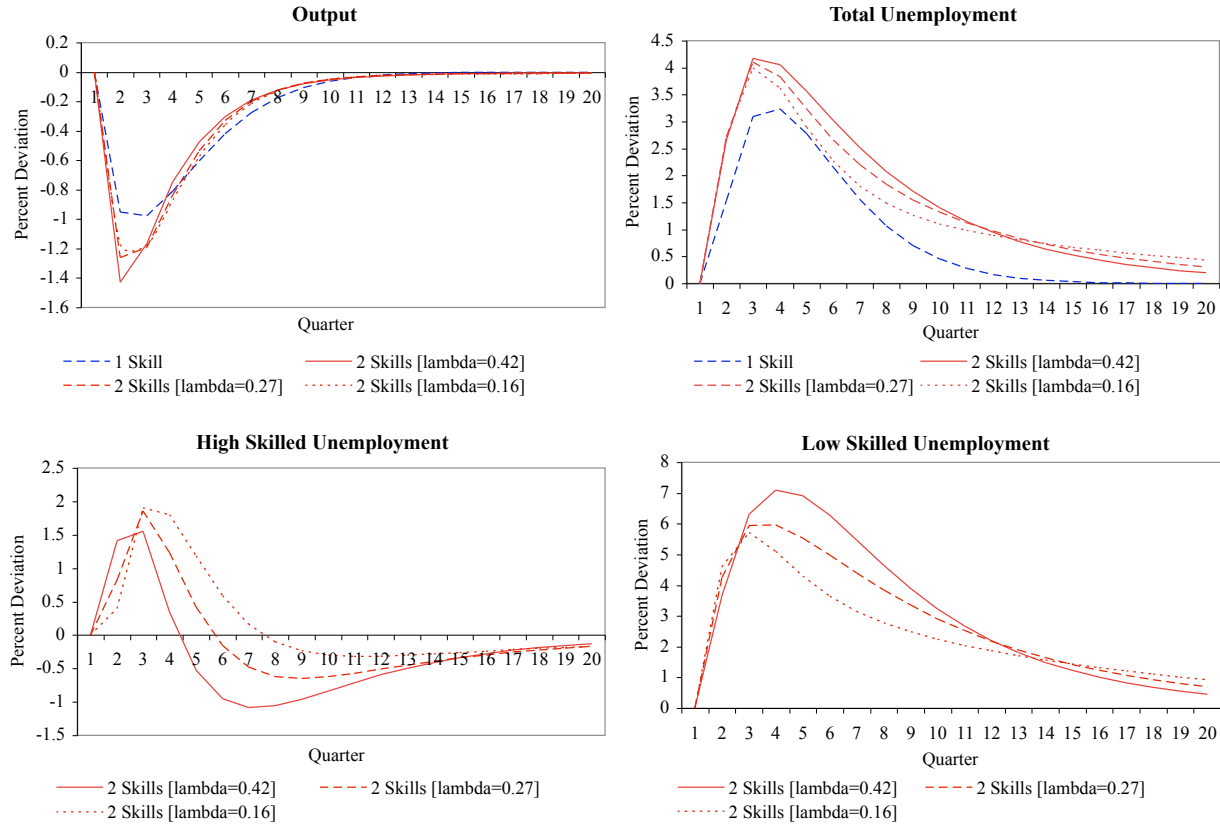
Figure 7: Impulse Responses of Output and Total Unemployment of the Model to 100 basis points positive shock to the interest rate with no habit persitence in consumption ($e = 0$).
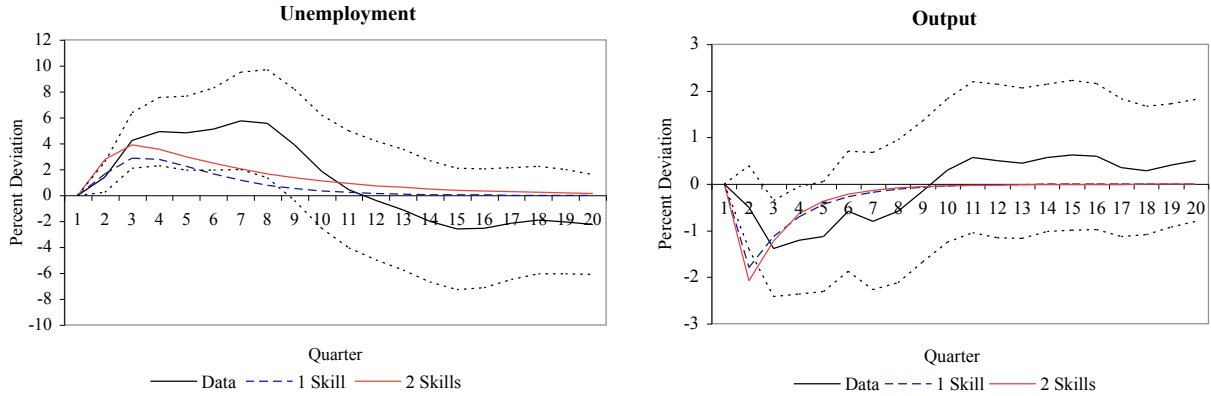
Unemployment

Output

Figure 8: Impulse Responses of Output and Total Unemployment of the Model to 100 basis points positive shock to the interest rate with no autocorrelation in the interest rate ($\rho_m = 0$).

Unemployment

Output