CIRJE-F-371

The Effects of the Loss of Skill on Unemployment Fluctuations

Julen Esteban-Pretel
University of Tokyo

September 2005; Revised in November 2007

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November 8, 2007

Abstract

This paper studies the effects of the loss of skill on the persistence of unemployment and other macroeconomic variables. It combines a Real Business Cycle model with a search and matching labor market to explain how the loss of skill of workers and the subsequent decrease in their probability of finding new jobs creates more persistent business cycles. Using numerical simulations, the paper shows that the introduction of this mechanism improves the performance of the model and is able to replicate cross-country differences in unemployment and output persistence.

Keywords: Business Cycles, Search and Matching, Unemployment Persistence, Loss of Skill

JEL Classification: E32, J41, J31

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*I would like to acknowledge the support and guidance of Mark Gertler and Ricardo Lagos. I am also grateful to Gianluca Violante, Elisa Faraglia, Luca Flabbi, Antonella Trigari and the attendants to the seminars at New York University, University ot Tokyo, Bank of England and Bank of Japan. Financial support was provided by the Center for International Research on the Japanese Economy at the University of Tokyo. All errors are mine.

†Department of Economics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. *E-mail:* julen@e.u-tokyo.ac.jp

1 Introduction

Macroeconomic variables, especially unemployment, show high persistence in their cyclical components. Analyzing quarterly data from 1981 to 2004, we can observe that for the U.S. economy, the serial correlation between unemployment rates one quarter apart is 91 percent, and 26 percent with one year difference. In Europe, these numbers are bigger, and an economy like that of Span shows even more persistence, with 90 percent autocorrelation for one quarter difference and 45 percent when the distance is one year. These facts raise the question of the determinants of such high persistence and its differences across countries.

This paper argues that a factor which affects the persistence of the business cycle, in particular the persistence of unemployment, is the loss of skill of workers who have been unemployed for an extended period of time. It has been well documented that the probability of finding a job decreases with the duration of unemployment, and that the longer the spell of unemployment, the higher the possibility of deterioration of the human capital of the worker[1]. Hence, we build a model, calibrate it, and perform simulations to understand how numerically important is the loss of skill of workers to explain the persistence of unemployment and other macroeconomic variables.

The model incorporates a search and matching labor market into a Real Business Cycle (RBC) model. It assumes infinitely lived risk-averse agents who decide how to best allocate their wealth

[1] Bover, Arellano and Bentolila (2002) show that for the Spanish economy, the probability of finding a job decreases steadily with the duration of unemployment and is reduced by half for individuals who have been out of work for over a year. Jackman and Layard (1991) find that the exit rate from unemployment decreases when there is a higher proportion of the long-term unemployed. They also note the relationship between the duration of unemployment and the possibility of atrophy of the skills of the worker.

between consumption and savings. They also supply labor to firms which produce a homogenous good. It uses a simple version of the RBC model which abstracts from capital accumulation or any type of rigidity or inefficiency except for the search and matching friction in the labor market[2]. This market is modeled in the style of Mortensen and Pissarides (1994), where job destruction is endogenous, although we also assume that matches can be exogenously destroyed, as in den Haan, Ramey and Watson (2000). We assume a single type of firm, which hires either low or high skilled workers. Both types of workers are equally productive, although low skilled workers must undergo training in their first period of work, whereas high skilled workers do not. The cost of training makes low skilled workers less attractive to firms since it reduces their profits. This in turn implies that low skilled workers find jobs with a lower probability than the high skilled. This probability is endogenous in the model and depends on the cost of training. The loss of skill occurs over time and is modeled as a random process, transferring workers from the high to the low skilled unemployment pool. The longer a worker is unemployed, the more likely it is that he loses the skill.

This paper finds that introducing the loss of skill mechanism in this framework increases the persistence of unemployment and other variables with respect to the model with one skill, and makes the model closer to the data in terms of the autocorrelations of variables. This model can also replicate the differences in persistence in unemployment across countries. This is shown by calibrating and simulating the model to the extreme cases of Spain and the U.S. We find that the loss of skill mechanism is more important for explaining macroeconomic fluctuations for economies with a high unemployment and high proportion of long-term unemployment, such as Spain, than

[2] The theoretical structure of the model is kept to the minimum to isolate the effects of the loss of skill from other mechanisms which affect unemployment and output fluctuations.

for economies with the opposite labor market features, such as the U.S. We also show that the model with loss of skill is able to partially address the critiques of Shimer (2005) and Hall (2005) to the search and matching models. We find that for the Spanish calibration, the model with skill deterioration generates higher volatilities in unemployment, vacancies and market tightness than the model with one skill. However, there is still a gap between theory and data, and the loss of skill mechanism does not improve the performance of the model in this respect for the U.S. economy [3].

The intuition for the increase in persistence is as follows. When the economy suffers a negative shock, employment drops and unemployment increases. Given the matching friction in the economy, unemployed workers cannot return to work instantaneously. Both the reduction in vacancies, due to the reduction in profits, and the increase in unemployment, decrease the probability of unemployed individuals finding jobs, lengthening their unemployment spell. The increase in the duration of unemployment raises the chances of workers losing their skill, which eventually leads to an increase in low skilled unemployment. Both the increase in unemployment and the increase in the proportion of the low skilled, who have even lower probability of finding jobs, raises the average duration of unemployment in the economy and the persistence of unemployment and other macroeconomic variables. This intuition also helps explain the ability of the model to replicate the higher persistence in unemployment observed in countries which have a higher unemployment rate and higher proportion of long-term unemployment. The increase in volatility in the two skill model for economies where the loss of skill is important is due to the fact in the model with skill loss, the proportion of low-skilled workers increases in recessions and decreases in expansions, making

[3] Sala and Silva (2005) study a version of the search and matching model which addresses specifically the Shimer-Hall critique for both the U.S. and Spanish economies.

total unemployment more responsive to shocks and also generating higher fluctuations in vacancies, since the low skilled pool is less attractive to firms.

The loss of skill of unemployed workers has been previously used in the literature to explain the differences between unemployment levels in the U.S. and Europe. Ljungqvist and Sargent (2004) and den Haan, Haefke and Ramey (2005) use this mechanism to analyze the rise of unemployment in Europe in the eighties, although they reach different conclusions[4]. The former argues that differences in institutions and labor market characteristics, such as unemployment benefits, help explain how an increase in the rate of loss of skill of workers raises unemployment in economies like those of Europe, but it does not have such a big impact in an economy with the features of the U.S. On the other hand, the latter show that the results shown in Ljungqvist and Sargent (2004) depend critically on the assumption that only workers who have been fired, and not those who quit, lose their skill. However, neither of the two studies analyzes the cyclical behavior of unemployment and other macroeconomic variables.

Pissarides (1992) shows that the temporary effects of employment shocks last longer when unemployed workers lose their skill over time. His analysis is purely qualitative, but the mechanism which creates the more persistent dynamics is similar to the one in this paper. When workers lose their skill they become less attractive to potential employers and few firms enter the market, making the labor market thinner and lowering the probability of finding work for every type of worker. Another paper which studies the consequences of the loss of skill on the dynamics of unemployment is Eriksson (2006). He uses a one-sided-search model and shows simulations of the

[4] Another important related paper which uses a search and matching model with multiple skills to perform steady state analysis is Albrecht and Vroman (2002).

effects of technology shocks on unemployment for a German calibration of the model. However, no results on persistence or volatility moments of the variables are shown. In this paper we try to quantify the mechanism studied by Pissarides (1992) and show that this more persistent effect of shocks can be extended to other macroeconomic variables. To do so, it is necessary to work with a more complete model, one which includes production, consumption and the other elements that the business cycle models take into consideration.

Other papers have addressed macroeconomic fluctuations within a framework which combines a business cycle model with a search and matching labor market. Merz (1995) and Andolfatto (1996) are the best known references. However, these two papers, although performing well in other aspects, are not able to replicate the persistence in unemployment and output observed in the data, except by assuming very low re-employment rates[5]. Pries (2004) challenges these previous studies by developing a model which generates higher persistence on labor market variables by assuming not low hiring rates but high firing rates for newly formed matches. However, since no simulation moments are shown by Pries, it is not possible to understand the quantitative importance of his mechanism. Our paper uses a different explanation for the high persistence of unemployment and claims what the previous literature lacks is the additional effect that the loss of skill has on the persistence of labor market and other macroeconomic variables.

The remainder of the paper is organized as follows: section 2 presents the model, explaining

[5]As shown by Cole and Rogerson (1999), in order to replicate certain business cycles facts, low job finding rates need to be assumed. These low re-employment rates are only consistent with the data if workers loosely attached to the labor force, which are low intensity searchers, are counted as unemployed. This is one of the assumptions made by Andolfatto (1996), who calibrates the model to a 40 percent unemployment rate.

the problem of the household and the problem of the firm and the worker. Section 3 explains the calibration of the parameters. Section 4 presents the results of the paper and Section 5 summarizes the main conclusions.

2 The Model

This is a discrete time model with two types of agents, workers/consumers and firms. The problem of these agents is presented below.

2.1 The Problem of the Household

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

$$u(C_t) - h(L_t) = \log C_t - a_n \frac{1}{1+\gamma_n} L_t^{1+\gamma_n} \tag{1}$$

where C_t is the level of consumption and L_t the hours worked in period t. $\gamma_n > 0$ and $a_n > 0$.

In order to avoid the heterogeneity problem resulting from the employment status of the agent, we follow the standard in the literature and assume that all of the individuals belong to a big family where earnings are pooled together as an insurance mechanism. The family also enforces that those members matched with firms perform the work. Firms are assumed to be owned by this large household and all their profits rebated to it. The household decides the level of consumption and savings in order to maximize its life time utility.

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

$$E_t \left\{ \sum_{i=0}^{\infty} \beta^i \left[u\left(C_{t+i}\right) - H_{t+i} \right] \right\} \tag{2}$$

subject to

$$\begin{aligned} C_{t+i} &= \Pi_{t+i} + \left(1 - n_{t+i}\right) b + W_{t+i} - t_t^w n_{lt} - \frac{1}{1 + r_{t+i}} B_{t+i} + B_{t+i-1} \\ \text{for } i &= \{0, ..., \infty\}, \end{aligned} \tag{3}$$

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. Hours of work do not appear explicitly, since they are not chosen by the household, but by decentralized bargaining between each firm and worker. Π_t is the profits rebated by the firms; n_t is the number of employed workers; b is home production of those individuals who are not working; W_t is sum of all the wages paid to the workers; $t_t^w n_{lt}$ is the share of all the training costs which is paid by the workers; B_t is the number of real bonds purchased, and r_t the real interest rate in the economy.

This problem yields the following optimal conditions:

Consumption Euler equation, which shows how in equilibrium the individual is indifferent between saving or consuming one more unit,

$$C_t^{-1} = \beta E_t \left\{ \left(1 + r_t\right) C_{t+1}^{-1} \right\}. \tag{4}$$

Budget constraint, in which bonds do not appear since in equilibrium their demand is equal to zero,

$$C_t = \Pi_t + \left(1 - n_t\right) b + W_t - t_t^w n_{lt}. \tag{5}$$

2.2 Labor Market

In the labor market workers and firms engage in employment relationships, which 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, occurs with probability λ for the high skilled unemployed workers who are not matched with a firm.

Firms can hire either type of unemployed worker. Both types are equally productive, although the low skilled needs 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

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

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

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 aggregate technology level is $A_t = A^{(1-\rho_A)} A_{t-1}^{\rho_A} e^{\epsilon_t}$, where A is the steady state level of technology and ϵ_t is an i.i.d. aggregate technology shock. The costs of production for the firm are the wages paid to the worker, the cost of training if the worker is low skilled 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 and independent and identically distributed across firms and time, with distribution function $F : [0, \infty] \rightarrow [0, 1]$. 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 which dissolves the match is denoted by $\bar{\eta}_t$ and can be different for firms which hire high or low skilled workers, since the latter have to pay the extra cost of training. Newly formed matches need to draw an intermediate input cost, and hence may never start production if the cost is high enough, but for simplicity it is assumed that they cannot be destroyed by exogenous forces.

The timing of the model is as follows: at the beginning of every period, a proportion ρ_x of firms who have been producing during the previous period are destroyed for exogenous reasons. The remaining matched firms draw an intermediate input cost. This new cost and the current level of technology determine the new threshold of endogenous destruction $\bar{\eta}_{it}$ for $i \in \{l, h\}$ and establishes total destruction. After destruction takes place, the levels of employment, high, and low skilled unemployment are determined. At that point, the household decides the level of consumption and savings, and through bargaining with the firm, wages and hours of work are chosen. Once these decisions are made, production starts at firms, and vacancies and unemployed workers try to meet. High skilled workers who are not matched with firms can suffer the loss of skill, after which they become low skilled and have to wait until the following period to search again.

2.3 The problem of the firm and the worker

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 matches with a worker of type $i \in \{l, h\}$ with probability $q_{it} = \frac{m(\theta_t)}{\theta_t}\frac{u_{it}}{u_t}$. 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 worker of type i; otherwise it remains 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 a worker of type i. Hence, the value of a vacancy is[6]

$$(6) \qquad V_t = -k + E_t\beta_t \left[q_{lt} \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} J_{lt+1}(\eta_{t+1})\, dF(\eta_{t+1}) + \right.$$

$$\left. + q_{ht} \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}(\eta_{t+1})\, dF(\eta_{t+1}) + \left(1 - q_{lt}F(\bar{\eta}_{lt+1}) - q_{ht}F(\bar{\eta}_{ht+1})\right) V_{t+1} \right]$$

where $\beta_t = \beta \frac{C_t}{C_{t+1}}$ 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.

The value for the firm with a high skilled worker is

$$(7) \qquad J_{ht}(\eta_t) = A_t L_t^{\alpha_y} - \eta_t - w_{ht}(\eta_t) L_t + E_t\beta_t (1 - \rho_x) \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}(\eta_{t+1})\, dF(\eta_{t+1}) .$$

The interpretation of the previous equation is as follows: during the current period, given the firm's idiosyncratic cost of intermediate inputs, η_t, the firm produces output and pays wages and

[6] Note that the threshold for the intermediate input cost which makes the low skilled match unproductive is different from that for the high skilled match. During the first period of the match, the low skilled unemployed needs to be trained and that cost lowers the acceptable intermediate input cost.

the cost of these inputs. In the following period, if it is not exogenously destroyed and the idiosyncratic intermediate input cost is below the threshold, the match is still productive with a value of $J_{ht+1}\left(\eta_{t+1}\right)$, otherwise the match is destroyed and it becomes a vacancy, which has value zero.

A firm which hires a low skilled worker has a similar present value. This differs only in the fact that the firm 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.

$$J_{lt}\left(\eta_t\right) = A_t L_t^{\alpha_y} - \eta_t - t_t^f - w_{lt}\left(\eta_t\right) L_t + E_t \beta_t \left(1-\rho_x\right) \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1}\left(\eta_{t+1}\right) dF\left(\eta_{t+1}\right). \tag{8}$$

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

$$\Pi_t = n_{ht}\left(A_t L_t^{\alpha_y} - \tilde{\eta}_{ht} - \tilde{w}_{ht} L_t\right) + n_{lt}\left(A_t L_t^{\alpha_y} - \tilde{\eta}_{lt} - \tilde{w}_{lt} L_t - t_t^f\right) - k v_t \tag{9}$$

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.

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

A high skilled unemployed worker obtains flow utility b from being unemployed. If it matches with a firm, which happens with probability $p_t = m\left(\theta_t\right)$, and the intermediate input cost for the firm is below the threshold, $\bar{\eta}_{ht+1}$, he becomes a productive worker the following period. If the search process is not successful, he may lose the skill, an 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 remains a high skilled unemployed. Hence, the value of being high skilled unemployed at period t is:

(10)

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

Similarly, a low skilled unemployed worker receives flow utility from home production. He can meet a firm, and begins producing the following period if the idiosyncratic shock to the firm is favorable. Otherwise, he remains a low skilled unemployed.

$$U_{lt} = b + E_t\beta_t \left[p_t \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} N_{lt+1}\left(\eta_{t+1}\right) dF\left(\eta_{t+1}\right) + \left(1 - p_t F\left(\bar{\eta}_{lt+1}\right)\right) U_{lt+1} \right]. \tag{11}$$

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 it is.

$$\begin{aligned} N_{ht}\left(\eta_t\right) &= w_{ht}\left(\eta_t\right) L_t - \frac{h\left(L_t\right)}{u'\left(C_t\right)} + \\ & E_t\beta_t \left[\left(1-\rho_x\right) \left(\int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} N_{ht+1}\left(\eta_{t+1}\right) dF\left(\eta_{t+1}\right) + \left(1 - F\left(\bar{\eta}_{ht+1}\right)\right) U_{ht+1} \right) + \rho_x U_{ht+1} \right]. \end{aligned} \tag{12}$$

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

$$\begin{aligned} N_{lt}\left(\eta_t\right) &= w_{lt}\left(\eta_t\right) L_t - \frac{h\left(L_t\right)}{u'\left(C_t\right)} - t_t^w + \\ & E_t\beta_t \left[\left(1-\rho_x\right) \left(\int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} N_{ht+1}\left(\eta_{t+1}\right) dF\left(\eta_{t+1}\right) + \left(1 - F\left(\bar{\eta}_{ht+1}\right)\right) U_{ht+1} \right) + \rho_x U_{ht+1} \right]. \end{aligned} \tag{13}$$

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 $S_{it}(\eta_t) = J_{it}(\eta_t) + N_{it}(\eta_t) - U_{it}$ for $i \in \{h, l\}$. The sharing rule for the surplus is obtained optimally as the Nash solution to a bargaining problem. Such a solution implies that both parties obtain a constant fraction of the surplus equal to their bargaining power. If β_w is 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 (7) to (13), the surplus in terms of units of consumption for a high and low skilled match can be expressed as:

$$\begin{aligned} S_{ht}(\eta_t) &= A_t L_t^{\alpha_y} - \eta_t - \frac{h(L_t)}{u'(C_t)} - b + E_t\beta_t(1 - \rho_x - p_t\beta_w) \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} S_{ht+1}(\eta_{t+1})\, dF(\eta_{t+1}) + \\ & \quad E_t\beta_t\left(1 - p_t F(\bar{\eta}_{ht+1})\right)\lambda(U_{ht+1} - U_{lt+1}) \end{aligned} \tag{14}$$

$$\begin{aligned} S_{lt}(\eta_t) &= A_t L_t^{\alpha_y} - \eta_t - t_t - \frac{h(L_t)}{u'(C_t)} - b + E_t\beta_t(1 - \rho_x) \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} S_{ht+1}(\eta_{t+1})\, dF(\eta_{t+1}) - \\ & \quad E_t\beta_t p_t\beta_w \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} S_{lt+1}(\eta_{t+1})\, dF(\eta_{t+1}) - E_t\beta_t(U_{ht+1} - U_{lt+1}). \end{aligned} \tag{15}$$

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:

$$\begin{aligned} w_{ht}(\eta_t) L_t &= \beta_w \left[A_t L_t^{\alpha_y} - \eta_t + E_t\beta_t p_t \int_{\eta_{\min}}^{\bar{\eta}_{ht+1}} J_{ht+1} dF(\eta_{t+1}) \right] \\ & \quad (1 - \beta_w)\left[\frac{h(L_t)}{u'(C_t)} + b - E_t\beta_t\left(1 - p_t F(\bar{\eta}_{ht+1})\right)\lambda(U_{ht+1} - U_{lt+1}) \right] \end{aligned} \tag{16}$$

$$w_{lt}(\eta_t) L_t \quad = \quad \beta_w \left[A_t L_t^{\alpha_y} - \eta_t + E_t \beta_t p_t \int_{\eta_{\min}}^{\bar{\eta}_{lt+1}} J_{lt+1} dF(\eta_{t+1}) \right] + (1-\beta_w) \left[\frac{h(L_t)}{u'(C_t)} + b - E_t \beta_t (U_{ht+1} - U_{lt+1}) \right]. \tag{17}$$

The worker is compensated for a proportion β_w of the production of the firm net of the 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, the high skilled worker avoids the risk of becoming low skilled. The low skilled worker also benefits from being hired, since he gets trained and his value of unemployment increases once the match is destroyed.

Total wages paid in the economy can be defined as

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

The number of hours worked at every employment relationship is chosen to maximize the surplus. 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:

$$\frac{h'(L_t)}{u'(C_t)} = \alpha_y A_t L_t^{\alpha_y - 1}.$$

Plugging the functional forms of $h(\cdot)$ and $u(\cdot)$, from equation (1) we obtain:

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

The optimal amount of hours supplied by the work depends positively on the technology level and negatively on the level of consumption, due to the decreasing marginal utility of consumption. Note, however, that it does not depend on the cost of intermediate inputs of the firm or the skill of the worker, which is a consequence of the additive nature of that cost and the assumption that both types of workers are equally productive.

An employment relationship is terminated endogenously 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 agree to dissolve the match and search for better options. Using equations (14) and (15) and equating them to zero, we can obtain the expressions for the low and high skill thresholds.

Given the timing explained earlier, the flows in and out of the different states for the workers are:

$$u_{ht} = \left(1 - p_{t-1} F\left(\bar{\eta}_{ht}\right)\right)(1-\lambda)\, u_{ht-1} + \left(\rho_x + (1-\rho_x)\left(1 - F\left(\bar{\eta}_{ht}\right)\right)\right) n_{ht-1} + (1-\rho_x)\left(1 - F\left(\bar{\eta}_{ht}\right)\right) n_{lt-1} \tag{20}$$

$$u_{lt} = \left(1 - q^w_{t-1} F\left(\bar{\eta}_{lt}\right)\right) u_{lt-1} + \rho_x n_{lt-1} + \left(1 - p_{t-1} F\left(\bar{\eta}_{ht}\right)\right) \lambda u_{ht-1} \tag{21}$$

$$n_{ht} = (1-\rho_x)\, F\left(\bar{\eta}_{ht}\right) n_{ht-1} + (1-\rho_x)\, F\left(\bar{\eta}_{ht}\right) n_{lt-1} + p_{t-1} F\left(\bar{\eta}_{ht}\right) u_{ht-1} \tag{22}$$

$$n_{lt} = p_{t-1} F\left(\bar{\eta}_{lt}\right) u_{lt-1} \tag{23}$$

$$1 = u_{lt} + u_{ht} + n_{lt} + n_{ht}. \tag{24}$$

This economy can be supported as a recursive competitive equilibrium.

3 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 benchmark calibration is done for the Spanish economy, since the model is more relevant for economies such as that one, where both the unemployment rate and the proportion of long-term unemployment are high. However, the calibration strategy is the same for the U.S. economy, and a short description of the parameters used for the U.S. simulations can be found in Table A1 in the Appendix.

The length of a period is one month. The discount factor of the economy is $\beta = 0.997$, which implies a quarterly real interest rate of 1 percent.

The labor share in the production function, α_y, is set to 0.66, as is standard in the literature. 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 steady state level of technology, A, is normalize to 1.

The flow value of leisure, or home production, b, is assumed to be 40 percent of firm's production, as in Shimer (2005). Setting b to this low value, compared to that preferred by Hagedorn and Manovskii (2007), allows the results to be easily comparable with those found by Shimer (2005). b is set to 0.19.

Following Mortensen and Pissarides (1994), the bargaining power of the worker, β_w, is set 0.5.

The parameter in the utility function γ_n is set to 1, which implies quadratic disutility from labor supply. a_n is calibrated using the optimal labor supply, equation (19), and the steady state level of hours, technology and consumption, and set to $a_n = 8.7$.

The matching function is assumed to be constant returns to scale, and takes the form $m(u_t, v_t) = \mu u_t^{\alpha} v_t^{1-\alpha}$. The idiosyncratic shock to the firm is assumed to be distributed as an exponential,

$\eta \sim \frac{1}{\varphi} e^{-\frac{\eta}{\varphi}}$. Following Mortensen and Pissarides (1994) we set $\alpha = 0.5$. To derive the values for the scaling parameter in the matching function, μ, the parameter characterizing the exponential distribution, φ, the cost of posting a vacancy, k, and the probability of skill loss, λ, we use the steady state equations of the model and impose the following empirical facts. The unemployment rate is 0.17, which corresponds to the average between 1981q1 and 2004q4. Disaggregated data by length of the unemployment spell is only available for the sample period 1987q2 to 2004q4. According to this data, the proportion of unemployed workers which have been without a job for more than 12 months is 0.5, hence we set the proportion of low skilled unemployed to 0.5 of total unemployment. The monthly probability of leaving unemployment is 0.13, as in Sala and Silva (2005). Following Shimer (2005) we normalize the market tightness, θ, to 1, since this simply rescales μ and k without affecting the probability for a worker to find a job in the model. The implied values for the parameters are $\mu = 0.17, \varphi = 0.12$, $k = 0.021$ and $\lambda = 0.1$. This last parameter implies that the probability at the beginning of the period of losing the skill is 0.086, or equivalently, the average unemployed high skilled worker takes 12 months to lose the skill. Setting λ in this way justifies the association of long-term unemployment in the data with low-skilled unemployment in the model.

Given the steady state unemployment rates and the probabilities of leaving unemployment and losing the skill, the steady state separation rate is 0.026. Given the lack of better empirical estimates, we assume that the exogenous separations are 68 percent of total separations, as estimated by Davis, Haltiwanger and Schuh (1996) for the U.S. economy. Hence, $\rho_x = 0.018$.

Bover, Arellano and 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 by half for workers who have been unemployed for a whole year. Therefore, 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, we impose that the probability of a successful match for a low skilled worker is half of that for a high skilled, and set the training cost to $t = 0.89$ to match this fact.

Technology follows a first order autoregressive process, $A_t = A^{(1-\rho_A)} A_{t-1}^{\rho_A} e^{\epsilon_t}$, where $\epsilon_t \sim N\left(0, \sigma_\epsilon^2\right)$. We set $\rho_A = 0.983$, and $\sigma_\epsilon^2 = 0.04$ so that the simulations match the empirical first order autocorrelation and volatility of productivity in Spain from 1981q1 to 2004q1, which are 0.74 and 0.01 respectively.

Table 1 shows the values of all the parameters in the model.

Table 1

4 Results

Now that the model and calibration have been explained, it is possible to quantify how much extra persistence is generated by the inclusion of skill loss in the model. In the introduction of the paper, we noted the high persistence of unemployment over the business cycle and its different behavior in the U.S. and Europe, specially with the extreme case of Spain. Here we present more concrete empirical evidence on these facts and we show how this model can partially explain them through the introduction of the loss of skill of workers and the subsequent costly training.

Given the recent criticisms by Shimer (2005) and Hall (2005) of the ability of the search and matching models to replicate the volatility of vacancies and unemployment over the business cycle, we also provide some results on how the model performs in this dimension.

We start by presenting the impulse responses of the main variables of the model to a negative technology shock, which allows us to understand the intuition behind the higher persistence generated by the model. We then show the simulation autocorrelation results, and finally we show the volatility results to study the Shimer-Hall critique in this context.

The results shown in Tables 2 through 5 are obtained by simulating the economy for 288 months[7] and 100 repetitions. We then calculate quarterly averages of the variables and obtain the statistics of interest. Finally, we calculate averages and standard deviations of the statistics for the 100 replications. The impulse responses in Figure 1 and A1 are also quarterly averages of the monthly responses simulated with the model.

4.1 One vs. Two Skills

Figure 1 shows the response, in percent deviations from the steady state, of the main variables of the model to a one time 1 percent negative technology shock when the model is calibrated to Spanish data. The solid line corresponds to the response of the model with one skill and the bulleted line to the model with two skills.

Comparing the responses of the two models, we can clearly observe that the model with skill depreciation generates a more pronounced and persistent response for all the variables except for job destruction. Total unemployment, the main variable of interest in this paper, increases in both models after the negative shock, but increases by more, peaks later, and takes longer to return to the

[7]The model is simulated for 488 months and the initial 200 observations of each repetition are dropped.

steady state for the model with two skills. The reason for the higher and more persistent response can be understood by considering the other variables. On impact, the technology shock decreases job creation and increases job destruction. Both effects make high and low skilled unemployment increase, which raises total unemployment. With higher unemployment, the probability of finding a job decreases for all workers, and hence increases the average duration of unemployment. The extra effect in the model with skill deterioration comes from the fact that with time, some of the high skilled unemployed workers lose their skill and enter the low skilled unemployment pool. In this latter state, workers have even a lower probability of finding work, which further decreases the average probability of finding a job, making unemployment very persistent. We can observe from the impulse response functions that high skilled unemployment peaks after two quarters and later even drops below the steady state. This fact, which is consistent with den Haan et al. (2005), is caused by the reaction of high skilled workers, who in the face of the negative shock are not as willing to quit their jobs for fear of losing the skill while unemployed. This reaction of high skilled workers makes the job destruction rate also drop below the steady state level. The response of low skilled unemployment is higher in magnitude and much more sluggish, peaking after eight quarters and showing a slower return to the steady state. The more persistent response of low skilled unemployment is explained by the low probability of finding work and the slow entry of high skilled workers into this pool. Since low skilled unemployment constitutes half of the steady state unemployment for the Spanish economy, the strong and persistent response of unskilled unemployment is the driving force behind the higher persistence of total unemployment in the model with two skills compared with the model with one skill.

The response of vacancies to the technology shock is also different for the two models. In both cases, vacancies decrease following the shock, but the response of the two skill model is more pronounced and persistent. The stronger and more sluggish response of vacancies in the model with two skills is driven by the fact that, after the shock low skilled unemployment increases substantially and takes very long to converge back to the steady state. The higher proportion of low skilled in the pool of unemployed workers decreases the willingness of firms to post vacancies, since those workers need to be trained and offer lower profits in the short run.

The response of the other main variables of the model is as follows. Employment decreases after the shock, mirroring the increase in unemployment since there are no inactive workers in the economy. Hours of work decrease on impact and go temporarily above the steady state to later slowly return to the long run levels. Initially, the reduction in the technology level of the economy decreases the marginal product of labor, and given the disutility suffered by the worker from supplying labor, it makes leisure more attractive and reduces the number of hours of work. The temporary increase in hours above the steady state is due to the fact that the optimal supply of hours is a function of the utility obtained through the extra consumption derived from working extra hours. Given the properties of the utility function, the drop in consumption following the negative technology shock, places the agent in a region of the utility function where an increase in consumption produces a bigger increase in utility. This effect dominates the negative impact on the supply of hours due to the reduction in technology and temporarily increases the supply of hours.

The decrease in technology, employment, and hours reduce output and consequently consumption. Slowly, these two variables return to the steady state as the direct effects of the shock and their indirect consequences through the sluggish movements in the labor market disappear.

Figure 1

4.2 Cross Country Analysis

The previous section showed how the model proposed in this paper generates a more sluggish unemployment response to a shock, compared to a model which does not take into account the loss of skill of unemployed workers, when the model is calibrated to the Spanish economy. This section analyzes the ability of the model to explain cross country differences in the persistence of the business cycle, specifically in the persistence of unemployment and output. The benchmark simulations are performed by calibrating the model to an extreme case, the Spanish economy, which is characterized by a high level of unemployment and an elevated proportion of long term unemployment. Thereafter, the other extreme is taken and the model is put to test by analyzing its ability to explain the persistence of the cyclical unemployment in the U.S. economy, where this level is low, as is the fraction of long term unemployment.

The case for the Spanish economy is shown in Table 2. We can see how the model which takes into account the loss of skill of workers is able to create more persistence on unemployment and the same amount of persistence on output. For the sample period of 1981q1 to 2004q4, the Spanish economy shows a first order autocorrelation of 0.90 and fourth order autocorrelation of 0.45. The model presented in this paper delivers autocorrelations of higher magnitude and closer to the ones in the data than the model with one skill. Another level in which the model is successful is in being able to generate higher persistence for the low skilled unemployed compared to the high skilled.

This is something we observe in the data if we identify short term unemployment with high skilled unemployment in the model[8]. The model with two skills also delivers more persistence in output compared with the one skill model, although it is not as close to the data as for unemployment.

Table 2

Table 3 shows the results of the simulations for the U.S. economy. U.S. unemployment is less persistent than that of Spain in the data. The first order autocorrelation is very similar in both countries, being 0.91 for the U.S., but the fourth order autocorrelation is 0.26 for the U.S. versus 0.45 in Spain. Calibrating the model to U.S. empirical evidence[9], we observe that both models generate this lower persistence observed in the U.S., but again the model with skill deterioration generates more persistence. The gap between the two models is smaller for the U.S. than for Spain, however. This is due to the lower proportion of low skilled unemployed in total unemployment[10], which implies that the behavior of total unemployment is mostly driven by the behavior of high skilled unemployment. The difference between the two models is almost non-existent when looking

[8] This identification is appropiate for the Spanish economy calibration, since the rate of skill loss, λ, implies that on average workers take one year to lose the skill. One year is also the length of time a worker must be out of work to be considered long-term unemployed in the data. The association of low skilled and long-term unemployed cannot be done for the U.S., due to the lack of quarterly data on the number of workers unemployed for longer than one year.

[9] See the Appendix for details on the U.S. calibration.

[10] In order to be able to make a clean comparison between the results for Spain and the U.S., we set the rate of skill loss, λ, to the same level in both economies, 0.1. For the U.S., this implies a fraction of low skilled unemployment of 0.12, which is not far from the average proportion of workers who were unemployed for more than 1 year, 0.09, between 1987 and 2004 according to yearly data from the OECD.

at persistence of output. We can also observe this smaller difference between the two models by looking at the impulse responses in Figure A1 of the Appendix.

Table 3

In summary, these results show the ability of the model to not only create higher persistence in unemployment and output than a model which does not consider the loss of skill, but also to reproduce the differences in unemployment persistence in economies as different as Spain and the U.S. We now test the model in a different dimension.

4.3 Shimer-Hall Critique

Shimer (2005) shows that the standard Mortensen-Pissarides search and matching model fails to generate sufficient volatility in vacancies and unemployment compared to the data[11]. Although the objective of this paper is not to solve this puzzle, it is interesting to investigate the performance of the two skill specification in this dimension. Tables 4 and 5 show the standard deviation and autorcorrelations of vacancies, unemployment, and market tightness for the Spanish and U.S. simulations respectively. Looking at Table 4, we observe that for the Spanish calibration, the model with skill loss is able to generate higher volatility and persistence in unemployment and vacancies, which in turn generates higher volatility in the market tightness. The reason for the higher volatility and persistence of these variables is that in the model with skill loss, the proportion of low-skilled workers increases in recessions and decreases in expansions, making total unemployment

[11] Different solutions to this puzzle have been proposed in recent years. A short and incomplete list of some of these papers include Hagedorn and Manovskii (2007), Krause and Lubick (2007), Gertler and Trigari (2006), Andres, Domenech and Ferri (2006) and Sala and Silva (2005). This last paper deals specifically with the Spanish economy.

more responsive to shocks and also generating higher fluctuations in vacancies. That is, compared with the model with no skill loss, in the model with two skill, vacancies posted increase further over the steady state value in good times driven by the lower proportion of workers who require training, and in bad times they decrease further below the steady state value for the opposite reason. Hence fluctuations in unemployment, vacancies, and market tightness are amplified by the existence of skill deterioration. However, despite the improvement brought by the introduction of skill loss in the model, this mechanism by itself is not sufficient to bridge the gap between the volatilities in the model and the data. Specifically, the volatility of vacancies is still lower than in the data and so is that of market tightness.

Table 5 shows the results for the U.S. and corroborates some of the findings stated earlier. We can see that for an economy like that of the U.S., with low unemployment and a low proportion of long-term unemployed, the impact of loss of skill on the variability and persistence of unemployment, vacancies, and market tightness is minimal.

Hence, although the loss of skill mechanism is not intended to explain the Shimer-Hall critique to the search and matching models, it does help to bring the model closer to the data in this respect for economies with high unemployment and high proportion of long-term unemployment.

Table 4

Table 5

5 Conclusions

This paper studies the quantitative effects of the introduction of the loss of skill as a mechanism to increase the ability of business cycle models to explain the cyclical persistence of unemployment and other macro variables.

The model presented here combines a real business cycle model with a search and matching labor market, which has the additional characteristic that workers can lose their skill if they are unemployed for an extended period of time. These workers need to be retrained in order to be productive, and this costly training has an effect on their chances of finding work. When a negative shock hits the economy, raising unemployment and decreasing the overall probability of becoming employed, the loss of skill of workers who are unemployed for a long period of time further decreases the average possibility of returning to work, and raises the overall duration of unemployment. This mechanism makes unemployment more persistent than in a model which ignores it.

The simulations of the paper show quantitatively that the introduction of the loss of skill mechanism helps the model become closer to the data in terms of the persistence of unemployment and output. First, unemployment persistence, measured through its serial correlations, is increased, and that of output is drawn close to the data by the introduction of the loss of skill mechanism. Second, the model is able to replicate the different cyclical persistence of unemployment across countries, and we show that the loss of skill mechanism is more important for economies with high unemployment and a high proportion of long-term unemployment, such as Spain, than for economies such as the U.S. with low unemployment and a low incidence of long-term unemployment, where workers are not unemployed long enough for this mechanism to have a substantial effect. Finally, we also show that for the economies similar to that of Spain, the model with skill deterioration is capable of partially addressing the Shimer-Hall critique, by generating higher fluctuations in unemployment, vacancies, and market tightness.

6 Appendix

Parametrization of the Model for the U.S. Economy. The calibration for the U.S. economy is done following the same procedure as in the Spanish calibration, but targeting the following empirical facts obtained by using U.S. data from 1981q1 to 2004q4: 6 percent unemployment rate; 0.35 job finding rate[12]; productivity autocorrelation and standard deviation of 0.76 and 0.01, respectively. The rest is the same as in the benchmark calibration. Note that the probability of skill loss, λ, is set to the same value as in the Spanish calibration (0.1), which allows us to perform a clean comparison between the results of the model for Spain and the U.S. The calibrated parameters are shown in Table A1. The impulse responses of the main variables to a negative technology shock are shown in Figure A1.

Table A1

Figure A1

[12] The job finding rate is calculated using the methodology described in Shimer (2005).

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Table 1: Parameters of the Model - Spanish Calibration

Exogenous parameters						
	$\beta = 0.997$	$\Upsilon_n = 1$	$A = 1$	$\alpha_y = 0.66$	$\beta_w = 0.5$	$\alpha = 0.5$
Endogenous parameters						
	$\lambda = 0.1$	$t = 0.89$	$k = 0.021$	$b = 0.19$	$a_n = 8.7$	$\mu = 0.17$
	$\rho_x = 0.018$	$\varphi = 0.12$	$\rho_A = 0.98$	$\sigma_\varepsilon = 0.004$		

Table 2: Serial Correlations of Unemployment and Output - Spain

Variable	corr(X_t,X_{t-1})	corr(X_t,X_{t-2})	corr(X_t,X_{t-3})	corr(X_t,X_{t-4})
Total Unemployment				
Data [a]	*0.90*	*0.77*	*0.61*	*0.45*
Model with 1 Skill	0.88	0.65	0.40	0.17
	(0.03)	(0.08)	(0.11)	(0.14)
Model with 2 Skills	0.90	0.71	0.49	0.28
	(0.03)	(0.07)	(0.11)	(0.13)
Low Skilled Unemployment				
Data [b]	*0.89*	*0.76*	*0.61*	*0.47*
Model with 2 Skills	0.91	0.74	0.53	0.31
	(0.03)	(0.06)	(0.10)	(0.13)
High Skilled Unemployment				
Data [c]	*0.80*	*0.62*	*0.42*	*0.24*
Model with 2 Skills	0.79	0.44	0.15	-0.06
	(0.05)	(0.11)	(0.13)	(0.13)
Output				
Data [a]	*0.93*	*0.83*	*0.70*	*0.57*
Model with 1 Skill	0.83	0.58	0.34	0.13
	(0.04)	(0.09)	(0.12)	(0.14)
Model with 2 Skills	0.85	0.64	0.42	0.21
	(0.04)	(0.08)	(0.12)	(0.14)

Notes: Data source: Labor Force Survey (*Encuesta de Poblacion Activa*) for unemployment variables and Quarterly National Accounts (*Contabilidad Trimestral de España*) for output. All data is seasonally adjusted, taken logs and detrended using HP filter with smoothing parameter of 1600. Standard errors are shown in parenthesis.

a. Total unemployment rate and Real GDP. Sample: 1981q1-2004q4.

b. Unemployed who have been out of work for more than 12 months. Sample: 1987q2-2004q4.

c. Unemployed who have been out of work for less than 12 months. Sample: 1987q2-2004q4.

Table 3: Serial Correlations of Unemployment and Output - U.S.

Variable	corr(X_t,X_{t-1})	corr(X_t,X_{t-2})	corr(X_t,X_{t-3})	corr(X_t,X_{t-4})
Total Unemployment				
Data	*0.91*	*0.74*	*0.51*	*0.26*
Model with 1 Skill	0.81	0.52	0.26	0.06
	(0.05)	(0.10)	(0.13)	(0.14)
Model with 2 Skills	0.86	0.62	0.37	0.15
	(0.03)	(0.08)	(0.12)	(0.14)
Output				
Data	*0.88*	*0.68*	*0.43*	*0.17*
Model with 1 Skill	0.76	0.46	0.23	0.05
	(0.06)	(0.11)	(0.13)	(0.13)
Model with 2 Skills	0.75	0.46	0.23	0.06
	(0.07)	(0.12)	(0.13)	(0.13)

Notes: Data source: Bureau of Labor Statistics for unemployment and NIPA for output. Sample: 1981q1-2004q4. All data is seasonally adjusted, taken logs and detrended using HP filter with smoothing parameter of 1600. Standard errors are shown in parenthesis.

Table 4: Serial Correlations and Volatilities of Labor Market Variables - Spain

Variable	Std	corr(X_t,X_{t-1})	corr(X_t,X_{t-2})	corr(X_t,X_{t-3})	corr(X_t,X_{t-4})
Vacancies					
Data	*0.20*	*0.75*	*0.46*	*0.22*	*0.03*
Model with 1 Skill	0.04	0.51	0.12	-0.06	-0.16
	(0.00)	(0.09)	(0.12)	(0.11)	(0.10)
Model with 2 Skills	0.06	0.72	0.51	0.36	0.21
	(0.01)	(0.09)	(0.12)	(0.13)	(0.13)
Unemployment					
Data	*0.07*	*0.90*	*0.77*	*0.61*	*0.45*
Model with 1 Skill	0.04	0.88	0.65	0.40	0.17
	(0.01)	(0.03)	(0.08)	(0.11)	(0.14)
Model with 2 Skills	0.09	0.90	0.71	0.49	0.28
	(0.02)	(0.03)	(0.07)	(0.11)	(0.13)
Market Tightness					
Data	*0.23*	*0.78*	*0.52*	*0.31*	*0.12*
Model with 1 Skill	0.06	0.71	0.41	0.19	0.03
	(0.01)	(0.07)	(0.12)	(0.13)	(0.13)
Model with 2 Skills	0.14	0.87	0.69	0.49	0.29
	(0.03)	(0.04)	(0.08)	(0.11)	(0.13)

Notes: Data source: Labor Force Survey (*Encuesta de Poblacion Activa*) for unemployment and OECD Main Economic Indicators for vacancies. Sample: 1981q1-2004q4. Market tightness is calculated as the ratio of vacancies and unemployment. All data is seasonally adjusted, taken logs and detrended using HP filter with smoothing parameter of 1600. Standard errors are shown in parenthesis.

Table 5: Serial Correlations and Volatilities of Labor Market Variables - U.S.

Variable	Std	corr(X_t,X_{t-1})	corr(X_t,X_{t-2})	corr(X_t,X_{t-3})	corr(X_t,X_{t-4})
Vacancies					
Data	*0.12*	*0.91*	*0.74*	*0.50*	*0.24*
Model with 1 Skill	0.02	0.24	-0.07	-0.11	-0.11
	(0.00)	(0.10)	(0.11)	(0.10)	(0.10)
Model with 2 Skills	0.02	0.79	0.60	0.39	0.19
	(0.00)	(0.07)	(0.09)	(0.11)	(0.13)
Unemployment					
Data	*0.09*	*0.91*	*0.74*	*0.51*	*0.26*
Model with 1 Skill	0.06	0.81	0.52	0.26	0.06
	(0.01)	(0.05)	(0.10)	(0.13)	(0.14)
Model with 2 Skills	0.06	0.86	0.62	0.37	0.15
	(0.01)	(0.03)	(0.08)	(0.12)	(0.14)
Market Tightness					
Data	*0.20*	*0.74*	*0.51*	*0.20*	*-0.06*
Model with 1 Skill	0.06	0.73	0.43	0.21	0.04
	(0.01)	(0.07)	(0.12)	(0.13)	(0.13)
Model with 2 Skills	0.08	0.86	0.64	0.39	0.17
	(0.02)	(0.03)	(0.08)	(0.11)	(0.14)

Notes: Data source: Bureau of Labor Statistics for unemployemt and Shimer (2005) for vacancies (for additional details, see Shimer (2005) and http://home.uchicago.edu/~shimer/data/flows). Sample: 1981q1-2004q4. All data is seasonally adjusted, taken logs and detrended using HP filter with smoothing parameter of 1600. Standard errors are shown in parenthesis.

Table A1: Parameters of the Model - U.S. Calibration

Exogenous parameters					
	β = 0.997	$\Upsilon_n = 1$	A = 1	$\alpha_y = 0.66$	$\beta_w = 0.5$
	α = 0.5	$\lambda = 0.1$			
Endogenous parameters					
	$t = 1.97$	$k = 0.076$	$b = 0.19$	$a_n = 8.13$	$\mu = 0.44$
	$\rho_x = 0.017$	$\varphi = 0.11$	$\rho_A = 0.98$	$\sigma_\varepsilon = 0.0057$	

Figure 1: Impulse Responses to a 1% Negative Technology Shock in a Model with 1 and 2 Skills, Spanish Calibration.

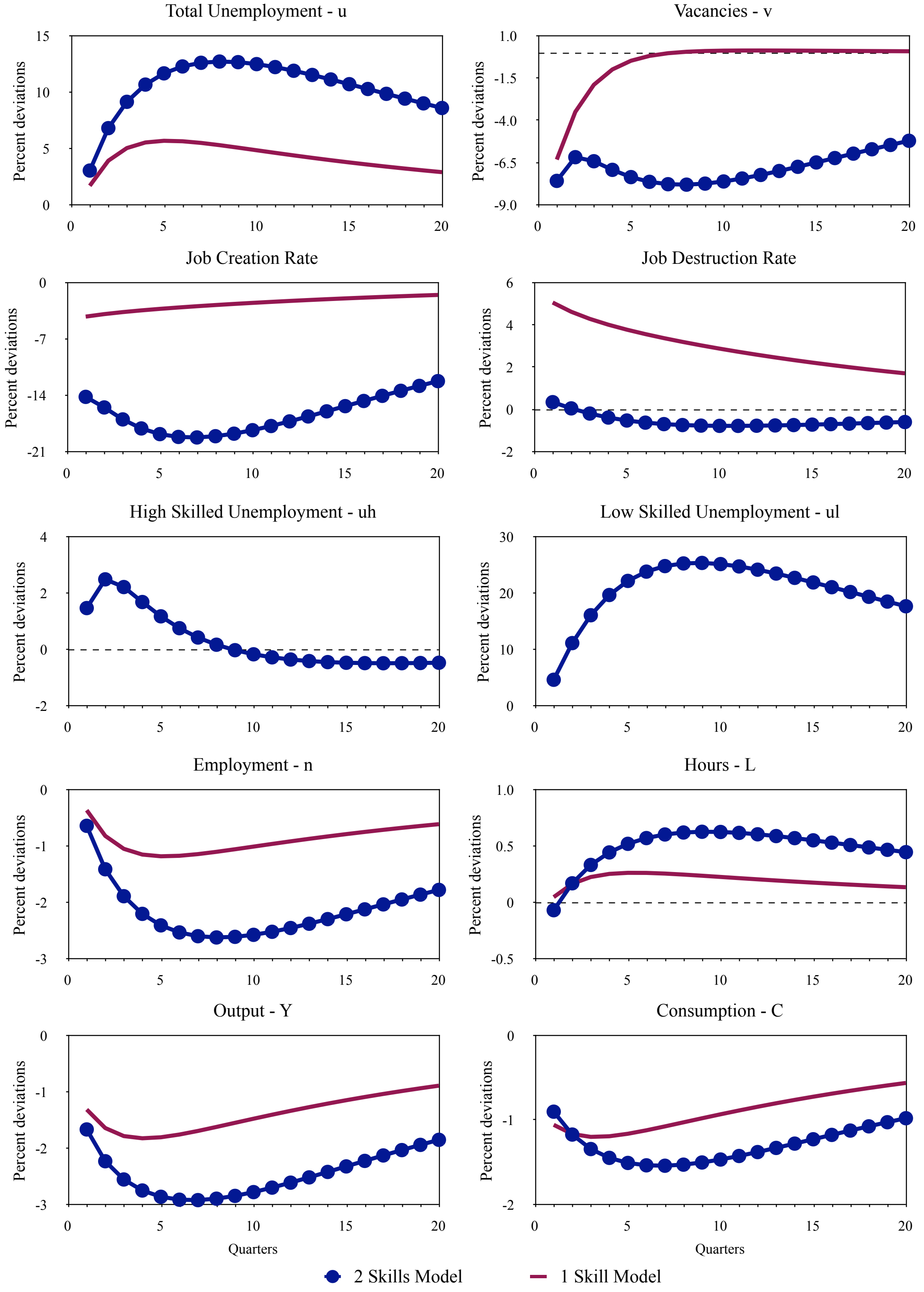

Figure A1: Impulse Responses to a 1% Negative Technology Shock in a Model with 1 and 2 Skills, U.S. Calibration.