Household Debt and Labor Market Fluctuations*

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Abstract

The co-movements of labor productivity with output, total hours, vacancies and unemployment have changed since the mid 1980s. This paper offers an explanation for the sharp break in the fluctuations of labor market variables based on endogenous labor supply decisions following the mortgage market deregulation. We set up a search model with efficient bargaining and financial frictions, in which impatient borrowers can take an amount of credit that cannot exceed a proportion of the expected value of their real estate holdings. When borrowers' equity requirements are low, the impact of a positive technology shock on the marginal utility of consumption is strengthened, which in turn results in lower hours per worker and higher wages in the bargaining process. This shift in labor supply discourages firms from opening vacancies, reducing the impact of the shock on employment. We simulate the effects of a continuous increase in both the loan-to-value ratio and the share of borrowers in total population. Our exercise shows that the response of labor market variables might have been substantially affected by the increase in household leverage in the US in the last twenty years.

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1. Introduction

Recent research has revealed significant changes in the co-movements and volatility of most labor market variables since the early eighties. In particular, Galí and Gambetti (2009) and Galí and van Rens (2010) highlight the following facts:

- The correlation of labor productivity with both output and labor input has experienced a sharp decline.

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- The volatility of hours, in relative terms, has risen.
- The volatility of real wages, relative to that of output, has increased.

Additionally, Barnichon (2009) emphasizes the following correlations:

- The correlation between labor productivity and unemployment has increased from negative to positive.
- The correlation between labor productivity and vacancies has shifted from positive to zero.

This empirical evidence poses a challenge for macroeconomic models that rely on structural stability to produce testable implications and policy recommendations. Do these variations stem from variations in the data generating process of exogenous shocks, or are they rather the consequence of the many changes that have taken place in most markets during the postwar era? Galí and van Rens (2010) provide an explanation of most of these changes on the basis of increased labor market flexibility in the US, that they parameterize as a reduction of hiring costs in a model with two labor inputs: hours and effort [1].

In this paper we turn our attention to another well documented structural change that has taken place over the last twenty years: the process of financial deepening favored by the worldwide reduction in interest rates and the numerous reforms in regulations. The effects of financial conditions on the real economy has attracted increasing attention since the works of Bernanke and Gertler (1995) and Kiyotaki and Moore (1997). Here, we focus on the reorganization of the housing finance system that took place in the early 1980s as a consequence of the Monetary Control Act of 1980 and the Garn-St. Germain Act of 1982. This change brought about a substantial reduction in the required home equity for indebted households, which was followed by a borrowing boom[2].

We develop a tractable search and matching model with efficient bargaining for wages and hours [3] with two types of households: patient and impatient. Due to the presence of underlying friction in the credit market, more impatient consumers are restricted in the amount they can borrow by the expected real value of their real estate. We follow a methodological strategy akin to that of Galí and van Rens (2010) and investigate how changes in some key parameters, such as the loan-to-value ratio and the proportion of borrowers in the economy, help make model predictions consistent with all the facts described above. We see our results as complementary to those of Galí and van Rens (2010), since the most likely explanation of these facts would involve a combination of both mech-

[1] Because of the features of their model, they cannot address issues regarding unemployment and vacancies.

[2] See Campbell and Hercowitz (2009).

[3] Dromel et al (2009) use an equilibrium matching model with exogenous wage and credit market imperfections to study the persitence of unemployment, but their modeling strategy is otherwise quite different to ours.

anisms: increased labor market flexibility and financial deepening.

Other authors have explored the role that financial reforms have in the business cycle. Campbell and Hercowitz (2005) explain the decline in the (aggregate) volatility of hours worked, output, household debt and durable goods purchases, as the effect of the reduction in equity requirements for borrowers; Iacoviello and Neri (2010) conclude that the effects of fluctuations in house prices on consumption have become more important after financial liberalization in the mortgage market; and Campbell and Hercowitz (2009) establish the effect of deregulation in the mortgage market on real interest rates and household welfare[4].

Our paper departs from previous research in different aspects. First, with respect to our focus, we aim to connect all the facts listed above to the changing volume of household indebtedness in the economy. As far as we are aware, this link has not been previously established in the literature. Second, while we allow for changes in the intensive margin of borrowing (loan-to-value), we also consider the extensive margin, defined as the number of borrowers over the total population. Third, by building our model on a search and matching framework, we are able to explore the connections of household indebtedness with variables such as unemployment and vacancies that are not present in frictionless labor markets.

The main result of the paper is that increasing household borrowing is sufficient to explain the observed changing pattern of second moments described above. This happens regardless of whether leverage is increased through changes in the intensive or extensive borrowing margin, although a high loan-to-value is required to match the evidence relative to some other moments. We also show that the explanation provided by Galí and van Rens (2010) for the vanishing procyclicality of labor productivity withstands the more complex structure of our model. In our set-up, enhanced labor market flexibility, in the form of diminishing costs of vacancy posting, also helps to explain other empirical features such as the increasing correlation between productivity and unemployment.

Although both types of institutional changes, in labor and financial markets, give rise to qualitatively similar results in terms of labor market statistics, the transmission mechanism is different. Raising labor market frictions affects employment, productivity and wages through the demand side of the labor market. Changes in labor market flexibility have a direct bearing on the extensive margin, making adjustments in the intensive margin less compelling. In our model, less onerous vacancy posting intensifies the (positive) response of the number of job openings to a positive technological innovation. This results in a stronger increase in employment, as well as in wages and output. The sharper

[4] Smith (2009) shows that the conclusions reached by Campbell and Hercowitz are robust to changes in the exact details of how housing, housing debt and mortgage financing are modeled.

increase in wages mutes the response of hours per person (intensive margin), so total labor input, and hence output, react less than employment, thus increasing the relative volatility of the latter. The intuition for the other results goes along the same lines.

When it comes to financial deepening, it is the interplay between consumption and labor supply decisions that shapes the response of total labor input. In a nutshell, the reduction in equity requirements eases borrowing constraints and facilitates access to consumption by impatient households after a technology shock. This drags down the marginal utility of consumption, which affects the bargaining process as a negative labor supply effect, reinforcing the fall in hours per worker and the upward pressure on wages. These less favorable outcomes of bargaining reduce the surplus of successful matches, thereby discouraging vacancy posting and augmenting the (negative) impact of the shock on employment. The larger the loan-to-value ratio, the more negative the response of total hours is, thus increasing its volatility relative to output and reducing its correlation with labor productivity.

Additionally, as borrowers face less borrowing restrictions, lenders find it optimal to increase the amount of loans by deviating resources away from consumption and investment. As a consequence, productive investment reacts less to the technology shock and capital becomes less volatile, contributing to a substantial reduction in the standard deviation of output for a sufficiently large number of borrowers.

The rest of the paper is organized as follows. Section 2 outlines the theoretical model. Section 3 contains the empirical facts as well as the calibration of the model. Section 4 presents the simulation exercises. Finally, section 5 offers the main conclusions.

2. Theoretical framework

We model a decentralized closed economy in which households and firms trade one final good and two production factors: productive capital and labor. While capital is exchanged in a perfectly competitive market, the labor market is non-Walrasian. Besides labor and capital, households own all the firms operating in the economy. Households rent capital and labor services to firms and receive income in the form of interest and wages. Firms post new vacancies every period, paying a fixed cost while the vacancy remains unfilled. The fact that trade in the labor market is resource and time-consuming generates a monopoly rent associated with each job match. It is assumed that workers and firms bargain over these monopoly rents in Nash fashion.

Each household is made up of working-age agents who may be either employed or unemployed. If unemployed, agents are actively searching for a job. Firms' investment in vacant posts is endogenously determined and so are job inflows. Finally, job destruction is considered exogenous.

As in Kiyotaki and Moore (1997) and Iacoviello (2005), there are two types of representative households, N_t^l of them are patient and N_t^b are impatient. All have access to the financial market and patient households are the owners of physical capital. Patient households are characterized by having a lower discount rate than impatient ones. This ensures that in the steady-state, and under fairly general conditions, patient households are net lenders while impatient households become net borrowers. Due to some underlying friction in the financial market, borrowers face a binding constraint in the amount of credit they can take that is given by the expected real value of their real estate holdings. Houses are assumed to be the only collateralizable asset. The size of the working-age population is given by $N_t = N_t^l + N_t^b$. Let $1 - \tau^b$ and τ^b denote the proportions of lenders and borrowers households in the working-age population; these shares are assumed to be constant over time, unless otherwise stated. For simplicity, we assume no growth in the working-age population.

Both types of households maximize intertemporal utility by selecting streams of consumption, leisure and housing services. Household members may be either employed or unemployed, but are able to fully insure each other against fluctuations in employment, as in Andolfatto (1996) or Merz (1995).

2.1 Patient households

Patient households discount the future less heavily than impatient ones. They face the following maximization program:

$$\max_{c_t^l, k_t^l, j_t^l, b_t^l, x_t^l} E_t \sum_{t=0}^{\infty} (\beta^l)^t \left[\begin{array}{c} \ln\left(c_t^l - h^l c_{t-1}^l\right) + \phi_x \ln\left(x_t^l\right) + n_{t-1}^l \phi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta} \\ +(1-n_{t-1}^l)\phi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} \end{array} \right] \tag{1}$$

subject to,

$$c_t^l + j_t^l \left(1 + \frac{\phi}{2}\left(\frac{j_t^l}{k_{t-1}^l}\right)\right) + q_t\left(x_t^l - x_{t-1}^l\right) - b_t^l = n_{t-1}^l w_t l_{1t} + r_{t-1} k_{t-1}^l - (1 + r_{t-1}^n)\frac{b_{t-1}^l}{\pi_t} - \zeta_t^l \tag{2}$$

$$k_t^l = j_t^l + (1-\delta) k_{t-1}^l \tag{3}$$

$$n_t^l = (1-\sigma) n_{t-1}^l + \rho_t^w (1 - n_{t-1}^l) \tag{4}$$

Lower case variables in the maximization problem above are normalized by the working-age population (N_t). Variables and parameters indexed by b and l respectively denote impatient and patient households. Non-indexed variables apply indistinctly to both types of households. Thus, c_t^l, x_t^l,n_{t-1}^l and $(1 - n_{t-1}^l)$ represent, consumption, housing holdings, the employment rate and the unemployment rate of patient households. There is risk-sharing at household level, so that consumption is the same regardless of employment status. The time endowment is normalized to one; l_{1t} and l_2 are hours worked per employee and hours devoted to job seeking by the unemployed. Note that while the household decides over l_{1t}, the time devoted to job searching (l_2) is assumed to be exogenous.

Regarding the parameters in the utility function of Ricardian households, $\beta^l \in (0, 1)$ is the time discount rate, whereas $-\frac{1}{\eta}$ measures the negative of the Frisch elasticity of labor supply. As consumption is subject to habits, the parameter h^l takes a positive value, ϕ_x is the housing weight in life-time utility. In general $\phi_1 \neq \phi_2$, i.e., the subjective value of leisure imputed by workers may vary with their employment status[5].

The flow of funds constraint (2) describes the various sources and uses of income. The term $w_t n_{t-1}^l l_{1t}$ captures net labor income earned by the fraction of employed workers, where w_t stands for hourly real wages. There are three assets in the economy. First, private productive capital (k_t^l), which is owned solely by patient households who get a total return of $r_{t-1}k_{t-1}^l$, where r_t represents the gross return on physical capital. Second, there are loans/debt in the economy. Thus, patient households lend in real terms $-b_t^l$ (or borrow b_t^l) and receive back $-(1 + r_{t-1}^n)b_{t-1}^l$, where r_{t-1}^n is the nominal interest rate on loans between $t - 1$ and t. Notice that in the budget constraint (2), the gross inflation rate between $t - 1$ and t (π_t) in the term $(1 + r_{t-1}^n)\frac{b_{t-1}^l}{\pi_t}$ reflects the assumption that debt contracts are set in nominal terms. Third, impatient households own a given amount of houses x_t^l out of a total fixed stock of real estate in the economy; the term $q_t\left(x_t^l - x_{t-1}^l\right)$ denotes housing investment by patient households, where q_t is the real housing price.

Consumption and investment are respectively given by c_t^l and $j_t^l\left(1 + \frac{\phi}{2}\left(\frac{j_t^l}{k_{t-1}}\right)\right)$, which includes investment installation costs. There are also adjustment costs stemming from changing the housing stock that we model as:

$$\zeta_t^l = \phi_h\left(\left(x_t^l - x_{t-1}^l\right)/x_{t-1}^l\right)^2 q_t x_{t-1}^l/2$$

The remaining constraints faced by patient households concern the laws of motion for capital and employment. Each period the capital stock k_{t-1}^l depreciates at the exogenous rate δ and is accumulated through investment, j_t^l. Thus, it evolves according to (3). Employment obeys the law of motion (4), where n_{t-1}^l and $(1 - n_{t-1}^l)$ respectively denote the

[5] Note, that there are two differences in the utility function with respect to a standard search model as in Andolfatto (1996); the presence of habits in consumption and the presence of housing services.

fraction of employed and unemployed patient workers in the economy at the beginning of period t. Each period, jobs are lost at the exogenous rate σ. Likewise, new employment opportunities come at the rate ρ_t^w, which represents the probability that one unemployed worker will find a job. Although the job-finding rate ρ_t^w is considered exogenous by individual workers, at the aggregate level it is endogenously determined according to the following Cobb-Douglas matching function[6]:

$$\rho_t^w(1-n_{t-1}) = \chi_1 v_t^{\chi_2}\left[(1-n_{t-1})\, l_2\right]^{1-\chi_2} \tag{5}$$

where v_t stands for the number of active vacancies during period t.

Given the recursive structure of the above problem, it may be equivalently rewritten in terms of a dynamic program. Thus, the value function $W(\Omega_t^l)$ satisfies the following Bellman equation:

$$W(\Omega_t^l) = \max_{c_t^l, k_t^l, j_t^l, b_t^l, x_t^l} \left\{ \begin{array}{c} \ln\left(c_t^l - h^l c_{t-1}^l\right) + \phi_x \ln\left(x_t^l\right) + n_{t-1}^l \phi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta} \\ +(1-n_{t-1}^l)\phi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} + \beta^l E_t W(\Omega_{t+1}^l) \end{array} \right\} \tag{6}$$

where maximization is subject to constraints (2), (3) and (4). The solution to the optimization program above generates the following first-order conditions for consumption, capital stock, investment, loans and housing demand:

$$\lambda_{1t}^l = \left(\frac{1}{c_t^l - h^l c_{t-1}^l} - \beta^l \frac{h^l}{c_{t+1}^l - h^l c_t^l}\right) \tag{7}$$

$$\frac{\lambda_{2t}^l}{\lambda_{1t}^l} = \beta^l E_t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l}\left\{ r_t + \frac{\phi}{2}\frac{j_{t+1}^{l2}}{k_t^{l2}} + \frac{\lambda_{2t+1}^l}{\lambda_{1t+1}^l}(1-\delta)\right\} \tag{8}$$

$$\lambda_{2t}^l = \lambda_{1t}^l\left[1 + \phi\left(\frac{j_t^l}{k_{t-1}^l}\right)\right] \tag{9}$$

$$1 = \beta^l E_t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l}\left\{\frac{r_t^n + 1}{\pi_{t+1}}\right\} \tag{10}$$

[6] This specification presumes that all workers are identical to the firm.

$$\lambda_{1t}^{l} q_t \left[1 + \phi_h \left(\frac{x_t^l}{x_{t-1}^l} - 1 \right) \right] = \frac{\phi_x}{x_t^l}$$
$$+ \beta^l E_t q_{t+1} \lambda_{1t+1}^l \left[1 + \frac{1}{2} \phi_h \left(\frac{x_{t+1}^l}{x_t^l} - 1 \right) \left(\frac{x_{t+1}^l}{x_t^l} + 1 \right) \right] \tag{11}$$

According to condition (7) the current marginal utility of consumption depends on both past and expected future consumption due to the presence of habits. Expression (8) ensures that the intertemporal reallocation of capital cannot improve the household's utility. Equation (9) states that investment is undertaken to the extent that the opportunity cost of a marginal increase in investment in terms of consumption is equal to its marginal expected contribution to the household's utility. First-order condition (10) means that variations across periods in the marginal utility of consumption are coherent with the discount rate and existing real interest rates. Finally, expression (11) determines the optimal path of housing purchases or housing demand.

Now it is convenient to derive the marginal value of employment for a worker ($\frac{\partial W_t^l}{\partial n_{t-1}^l} \equiv \lambda_{ht}^l$) which will play an important role in the bargaining process discussed below. This is given by,

$$\lambda_{ht}^l = \lambda_{1t}^l w_t l_{1t} + \left(\phi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta} - \phi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} \right) + (1 - \sigma - \rho_t^w) \beta^l E_t \frac{\partial W_{t+1}^l}{\partial n_t} \tag{12}$$

where λ_{ht}^l measures the marginal contribution of a newly created job to the household's utility. The first term on the right hand side captures the value of the cash-flow generated by the new job in t, i.e. the labor income measured according to its utility value in terms of consumption (λ_{1t}^l). The second term represents the net utility arising from the newly created job. Finally, the third term represents the "capital value" of an additional employed worker, given that this employment status will persist in the future, conditional to the probability that the new job will not be lost.

2.2 Impatient households

Impatient households discount the future more heavily than patient ones so their discount rate satisfies $\beta^b < \beta^l$. Since these households do not hold physical capital, they face the following maximization program,

$$\max_{c_t^b, b_t^b, x_t^b} E_t \sum_{t=0}^{\infty} (\beta^b)^t \left[\begin{array}{c} \ln \left(c_t^b - h^b c_{t-1}^b \right) + \phi_x \ln \left(x_t^b \right) + n_{t-1}^b \phi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta} \\ + (1 - n_{t-1}^b) \phi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} \end{array} \right] \tag{13}$$

subject to the flow of funds constraint, a borrowing constraint and the law of motion of employment, as reflected in

$$c_t^b + q_t\left(x_t^b - x_{t-1}^b\right) - b_t^b = n_{t-1}^b w_t l_{1t} - (1 + r_{t-1}^n) b_{t-1}^b / \pi_t - \zeta_t^b \tag{14}$$

$$b_t^b \leq m^b E_t\left(\frac{q_{t+1}\pi_{t+1}x_t^b}{1 + r_t^n}\right) \tag{15}$$

$$n_t^b = (1 - \sigma)n_{t-1}^b + \rho_t^w(1 - n_{t-1}^b) \tag{16}$$

where $\zeta_t^b = (\phi_h\left(\left(x_t^b - x_{t-1}^b\right)/x_{t-1}^b\right)^2 q_t x_{t-1}^b/2)$ denotes the housing adjustment cost. The parameter ϕ_x that accounts for the weight of housing in preferences is the same as for patient households. Notice that restrictions (14) and (16) are analogous to those for patient individuals (with the exception that impatient households do not accumulate physical capital). m^b in (15) is the loan-to-value ratio that determines the degree of pledgeability of housing holdings. As shown in Iacoviello (2005), without uncertainty the assumption $\beta^b < \beta^l$ guarantees that (15) holds with equality.

In the case of impatient households, the value function $W(\Omega_t^b)$ satisfies the following Bellman equation:

$$W(\Omega_t^b) = \max_{c_t^b, b_t^b, x_t^b}\left\{\begin{array}{c} \ln\left(c_t^b - h^b c_{t-1}^b\right) + \phi_x \ln\left(x_t^b\right) + n_{t-1}^b \phi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta} \\ +(1 - n_{t-1}^b)\phi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} + \beta^b E_t W(\Omega_{t+1}^b) \end{array}\right\} \tag{17}$$

The solution to the optimization program, subject to (14), (15) and (16), is characterized by the following first-order conditions:

$$\lambda_{1t}^b = \left(\frac{1}{c_t^b - h^b c_{t-1}^b} - \beta^b \frac{h^b}{c_{t+1}^b - h^b c_t^b}\right) \tag{18}$$

$$\lambda_{1t}^b = \beta^b E_t \lambda_{1t+1}^b \left(\frac{1 + r_t^n}{\pi_{t+1}}\right) + \mu_t^b\left(1 + r_t^n\right) \tag{19}$$

$$\lambda_{1t}^b q_t \left[1+\phi_h\left(\frac{x_t^b}{x_{t-1}^b}-1\right)\right]=\frac{\phi_x}{x_t^b}+\mu_t^b m^b q_{t+1}\pi_{t+1}$$
$$+\beta^b E_t q_{t+1}\lambda_{1t+1}^b\left[1+\frac{1}{2}\phi_h\left(\frac{x_{t+1}^b}{x_t^b}-1\right)\left(\frac{x_{t+1}^b}{x_t^b}+1\right)\right] \tag{20}$$

where μ_t^b is the Lagrange multiplier of the borrowing constraint, and the marginal value of employment for an impatient household worker ($\frac{\partial W_t^b}{\partial n_{t-1}^b} \equiv \lambda_{ht}^b$) is,

$$\lambda_{ht}^b=\lambda_{1t}^b w_t l_{1t}+\left(\phi_1\frac{(1-l_{1t})^{1-\eta}}{1-\eta}-\phi_2\frac{(1-l_2)^{1-\eta}}{1-\eta}\right)+(1-\sigma-\rho_t^w)\beta^b E_t\frac{\partial W_{t+1}^b}{\partial n_t} \tag{21}$$

which can be interpreted in the same way as that of patient households.

2.3 Aggregation

Aggregate consumption and employment are weighted averages of the corresponding variables for each household type,

$$c_t=\left(1-\tau^b\right)c_t^l+\tau^b c_t^b \tag{22}$$

$$n_t=\left(1-\tau^b\right)n_t^l+\tau^b n_t^b \tag{23}$$

$$\tau^b b_t^b+(1-\tau^b)b_t^l=0 \tag{24}$$

$$\tau^b x_t^b+(1-\tau^b)x_t^l=X \tag{25}$$

where τ^b represents the share of impatient households in the economy and X is the fixed stock of real estate in the economy. Aggregate capital and investment can be obtained as:

$$k_t=\left(1-\tau^b\right)k_t^l \tag{26}$$

$$j_t=\left(1-\tau^b\right)j_t^l \tag{27}$$

In addition, as we will explain below, we consider an aggregator (trade union) that pools the surpluses from employment, in terms of consumption, of both types of households and uses this aggregate in the negotiation of hours and wages:

$$\lambda_{ht} = \left(1-\tau^b\right)\frac{\lambda_{ht}^l}{\lambda_{1t}^l} + \tau^b\frac{\lambda_{ht}^b}{\lambda_{1t}^b} \tag{28}$$

2.4 Factor demands

Factor demands are obtained by solving the profit maximization problem faced by each competitive producer:

$$\max_{k_t, v_t} E_t \sum_{t=0}^{\infty} (\beta^l)^t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} \left(y_t - r_{t-1}k_{t-1} - w_t n_{t-1} l_{1t} - \kappa_v v_t\right) \tag{29}$$

subject to

$$y_t = z_t k_{t-1}^{1-\alpha} (n_{t-1} l_{1t})^{\alpha} \tag{30}$$

$$n_t = (1-\sigma)n_{t-1} + \rho_t^f v_t \tag{31}$$

where, in accordance with the ownership structure of the economy, future profits are discounted at the patient household's relevant rate $\left((\beta^l)^t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l}\right)$. Producers use two inputs, capital and labor and all workers are perfect substitutes in production irrespective of their financial position.[7] Technological possibilities are given by a standard Cobb-Douglas constant-returns-to-scale production function, where z_t stands for a technology shock $\ln z_t = (1-\rho_z)\ln A + \rho_z \ln z_{t-1} + \varepsilon_t$, A represents the long-run level of total factor productivity and $\varepsilon_t \sim N(0, \sigma_z)$. ρ_t^f is the probability that a vacancy will be filled in any given period t. The probability of filling a vacancy, ρ_t^f, is exogenous from the firm's perspective; however, the aggregate rate is endogenously determined by the following condition

$$\rho_t^w(1-n_{t-1}) = \rho_t^f v_t = \chi_1 v_t^{\chi_2}\left[(1-n_{t-1})\, l_2\right]^{1-\chi_2} \tag{32}$$

which involves the Cobb-Douglas matching function

[7] Iacoviello and Neri (2010) assume complementarity across the labor skills of the two groups. As the authors recognize 'the formulation in which hours are substitutes is perhaps more natural, but analytically less tractable: while it implies equal wages across agents, it also implies that hours worked by one group will affect total wage income received by the other group, thus creating a complex interplay between borrowing constraints and labor supply decisions of both groups' *[sic]*

We can express the maximum expected value of the firm at t Ω_t^f as a function $V(\Omega_t^f)$ that satisfies the following Bellman equation:

$$V(\Omega_t^f) = \max_{k_t, v_t} \left\{ y_t - r_{t-1}k_{t-1} - w_t n_{t-1} l_{1t} - \kappa_v v_t + \beta^l E_t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} V(\Omega_{t+1}^f) \right\} \tag{33}$$

The solution to the optimization program above generates the following first-order conditions for private capital and the number of vacancies

$$r_t = (1-\alpha)\frac{y_{t+1}}{k_t} \tag{34}$$

$$\frac{\kappa_v}{\rho_t^f} = \beta^l E_t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} \frac{\partial V_{t+1}}{\partial n_t} \tag{35}$$

where the demand for capital is determined by (34) and is positively related to the marginal productivity of capital $(1-\alpha)\frac{y_{t+1}}{k_t}$, which in equilibrium must be equal to the gross return on productive capital. Expression (35) reflects that firms choose the number of vacancies in such a way that the marginal posting cost per vacancy, κ_v, is equal to the expected present value of holding it, $\beta^l E_t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} \rho_t^f \frac{\partial V_{t+1}}{\partial n_{t+1}}$.

Using the Bellman equation the marginal value of an additional employment in t for a firm ($\lambda_{ft} \equiv \frac{\partial V_t}{\partial n_{t-1}}$) is,

$$\lambda_{ft} = \alpha \frac{y_t}{n_{t-1}} - w_t l_{1t} + (1-\sigma)\beta^l E_t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} \frac{\partial V_{t+1}}{\partial n_t} \tag{36}$$

where the marginal contribution of a new job to profits equals the marginal product net of the wage rate, plus the capital value of the new job in t, adjusted by the probability that the job will continue in the future. Now using (36) one period ahead, we can rewrite condition (35) as:

$$\frac{\kappa_v}{\rho_t^f} = \beta^l E_t \left[\frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} \left(\alpha \frac{y_{t+1}}{n_t} - w_{t+1} l_{1t+1} + (1-\sigma) \frac{\kappa_v}{\rho_{t+1}^f} \right) \right] \tag{37}$$

2.5 Trade in the labor market: the labor contract

The key departure of search models from the competitive paradigm is that trade in the labor market is subject to transaction costs. Each period, unemployed workers engage in search activities in order to find a job. The existence of costly searches in the labor market implies that there are simultaneous flows into and out of the state of employment, so an increase (reduction) in the stock of unemployment results from the predominance of job losses (creation) over job creation (losses). Stable unemployment occurs whenever inflows and outflows cancel out one another, i.e.,

$$\rho_t^f v_t = \rho_t^w (1 - n_{t-1}) = \chi_1 v_t^{\chi_2} \left[(1 - n_{t-1}) \, l_2 \right]^{1-\chi_2} = \sigma n_{t-1} \tag{38}$$

Because it takes time (for households) and real resources (for firms) to make profitable contacts, some pure economic rent emerges with each new job, which is equal to the sum of the expected transaction (search) costs the firm and the worker will further incur if they refuse to match. The emergence of such rent gives rise to a bilateral monopoly framework.

Once a representative job-seeking worker and vacancy-offering firm match, they negotiate a labor contract in hours and wages. Although patient and impatient households have a different reservation wage, they delegate the bargain process with firms to a trade union. This trade union maximizes the aggregate marginal value of employment for workers (28) and distributes employment according to their shares in the working-age population. The implication of this assumption is that all workers receive the same wage, work the same number of hours and have the same unemployment rates. Thus, following standard practice, the Nash bargain process maximizes the weighted product of the parties' surpluses from employment.

$$\max_{w_t, l_{1t}} \left(\left(1 - \tau^b\right) \frac{\lambda_{ht}^l}{\lambda_{1t}^l} + \tau^b \frac{\lambda_{ht}^b}{\lambda_{1t}^b} \right)^{\psi^w} \left(\lambda_{ft}\right)^{1-\psi^w} = \max_{w_t, l_{1t}} \left(\lambda_{ht}\right)^{\psi^w} \left(\lambda_{ft}\right)^{1-\psi^w} \tag{39}$$

where $\psi^w \in [0, 1]$ reflects the workers' bargaining power. The first term in brackets represents the worker surplus (as a weighted average of borrower and lender worker surpluses), while the second is the firm surplus. More specifically, $\lambda_{ht}^l / \lambda_{1t}^l$ and $\lambda_{ht}^b / \lambda_{1t}^b$ respectively denote the premium (in terms of consumption) of employment over unemployment for a patient and an impatient worker. Notice that both premia are weighted in (39) according to the share of borrowers in the population (τ^b). The solution of the Nash maximization problem gives the optimal real wage and hours worked[8]:

$$w_t l_{1t} = \psi^w \left(\alpha \frac{y_t}{n_{t-1}} + \frac{\kappa_v v_t}{(1-n_{t-1})} \right) \tag{40}$$
$$+(1-\psi^w)\left(\frac{(1-\tau^b)}{\lambda^l_{1t}} + \frac{\tau^b}{\lambda^b_{1t}} \right)\left(\phi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} - \phi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta} \right)$$
$$+(1-\psi^w)(1-\sigma-\rho^w_t)\tau^b E_t \frac{\lambda^b_{ht+1}}{\lambda^b_{1t+1}} \left(\beta^l \frac{\lambda^l_{1t+1}}{\lambda^l_{1t}} - \beta^b \frac{\lambda^b_{1t+1}}{\lambda^b_{1t}} \right)$$

$$\alpha \frac{y_t}{n_{t-1} l_{1,t}} = \left[\frac{1-\tau^b}{\lambda^l_{1t}} + \frac{\tau^b}{\lambda^b_{1t}} \right] \phi_1 (1-l_{1t})^{-\eta} \tag{41}$$

Putting the last term on the right hand side aside, the wage prevailing in the search equilibrium is a weighted average of the highest feasible wage (i.e., the marginal productivity of labor plus hiring costs per unemployed worker) and the outside option (i.e., the reservation wage as given by the difference between the utility of leisure of an unemployed person and an employed worker). This reservation wage is, in turn, a weighted average of the lowest acceptable wage of both types of workers. The third term on the right hand side of (40) is part of the reservation wage and can be interpreted as an inequality term in utility. The economic intuition is as follows: impatient consumers are constrained by their collateral requirements, so that they are not allowed to use their entire wealth to smooth consumption over time. However, they can take advantage of the fact that a match today continues with some probability $(1-\sigma)$ in the future, yielding a labor income that in turn will be used to consume tomorrow. Therefore, they use the margin that hour and wage negotiations provide them to improve their lifetime utility by narrowing the gap in utility with respect to patient consumers.

2.6 Interest rate rule and the accounting identity

We assume the existence of a central bank in our economy that follows a Taylor's interest rate rule,

$$1 + r^n_t = \left(1 + r^n_{t-1}\right)^{r_R} \left((\pi_{t-1})^{1+r_\pi} \left(\frac{y_{t-1}}{\overline{y}} \right)^{r_y} \overline{rr} \right)^{1-r_R} \tag{42}$$

where $\overline{y}$ and $\overline{rr}$ are steady-state levels of output and the real interest rate, respectively. The parameter r_R captures the extent of interest rate inertia, and r_π and r_y represent the

[8] Boscá, Doménech and Ferri (2011) derive similar equations in a search model with *Ricardian* and *rule-of-thumb* consumers.

weights given by the central bank to inflation and output objectives.

Finally, to close the model, output is defined as the sum of demand components:

$$y_t = c_t + j_t \left(1 + \frac{\phi}{2}\left(\frac{j_t}{k_{t-1}}\right)\right) + \kappa_v v_t \tag{43}$$

3. Evidence and calibration

3.1 Stylized facts

Although the US cyclical features we document here are already known[9], we summarize our own empirical estimates for the relevant second moments in Table 1. Data come from different sources (see Table A1 in the Appendix). All series have been HP filtered (with a smoothing parameter of 1600) to obtain their trend and cyclical components. In addition to the complete period 1964:1-2008:3[10], we split the sample in two, taking the year 1982 as a breaking point, in order to capture the important reorganization of the housing finance system that was brought about by the Monetary Control Act of 1980 (President Carter) and the Garn-St. Germain Act of 1982 (President Reagan). This new system, along with the progressive deepening in the financial market, triggered a substantial increase in indebtedness that is the key ingredient of the simulations below and one possible explanation for the changes observed in Table 1. We can list these empirical facts, comparing the pre and post 1982 samples as follows:

1. The volatility of hours, relative to that of output, has risen.
2. The volatility of real wages, relative to that of output, has increased.
3. The positive correlation of labor productivity with output has vanished.
4. The correlation of labor productivity with labor input (total hours) has experienced a sharp decline, changing from positive to negative.
5. The correlation between labor productivity and unemployment has increased from negative to positive.
6. The correlation between labor productivity and vacancies has shifted from positive to non significantly distinct to zero.

Figures 1 and 2 offer an illustration of these facts by confronting the evolution of the

[9] Galí and Gambetti (2009) and Barnichon (2009) document the changing pattern across time of relative volatilities and correlations of labor market variables. Many other authors, for example Cheron and Langot (2004), Shimer (2005) or Ravn and Simonelli (2008), have also documented labor market data moments without distinguishing across subsamples.

[10] Data for vacancies end in 2006:3.

TABLE 1 — STYLIZED FACTS

	Periods		
Moments	64-08	64-82	83-08
$\sigma(y)$	1.54	1.93	1.17
$\sigma(l_{1t}n_t)/\sigma(y)$	1.12	1.04	1.26
$\sigma(w_t)/\sigma(y)$	0.61	0.42	0.88
$corr(\frac{y_t}{l_{1t}n_t}, y_t)$	0.44	0.67	-0.02
$corr(\frac{y_t}{l_{1t}n_t}, l_{1t}n_t)$	0.00	0.30	-0.48
$corr(\frac{y_t}{l_{1t}n_t}, u_t)$	-0.06	-0.33	0.44
$corr(\frac{y_t}{l_{1t}n_t}, v_t)$	0.22	0.46	-0.20

cyclical component of the variables implied over time.

3.2 Model parameterization

The calibration strategy follows three steps. First, some model parameters have been set to some consensus values drawn from related papers in the literature. Second, some other parameters have been obtained from the steady-state relationships in the model. Finally, the values of parameters m^b and τ^b are chosen to target the time increase in the degree of indebtedness of the economy.

Parameters from previous studies

Iacoviello (2005) provides values for the subjective intertemporal discount rate of patient households, $\beta^l = 0.99$, the subjective discount rate of impatient households, $\beta^b = 0.95$, the depreciation rate of physical capital, $\delta = 0.03$, and the adjustment cost for housing capital $\phi_h = 0.0$. We take the Cobb-Douglas parameter $\alpha = 0.7$ from Campbell and Hercowitz (2005 and 2009). With respect to labor market parameters, and following Andolfatto (1996) and Cheron and Langot (2004), we set the exogenous transition rate from employment to unemployment, $\sigma = 0.15$, and the elasticity of matchings to vacant posts, $\chi_2 = 0.6$. From these authors we also pick up some average steady-state values, as the probability of a vacant position becoming a productive job, which is assumed to be $\overline{\rho}^f = 0.9$, is consistent with a vacancy being opened 45 days on average. The long-run employment ratio and the fraction of time spent working are computed to be $\overline{n} = 0.57$ and $\overline{l_1} = 1/3$, and the fraction of time households spend searching is half the time spent working, $l_2 = 1/6$. Also, we assume that equilibrium unemployment is socially-efficient (see Hosios, 1990) and, as such $\psi^w = 0.4$ is equal to $1 - \chi_2$. For the intertemporal labor elasticity of substitution, η, we rely on Andolfatto (1996) and consider $\eta = 2$ implying that average individual labor

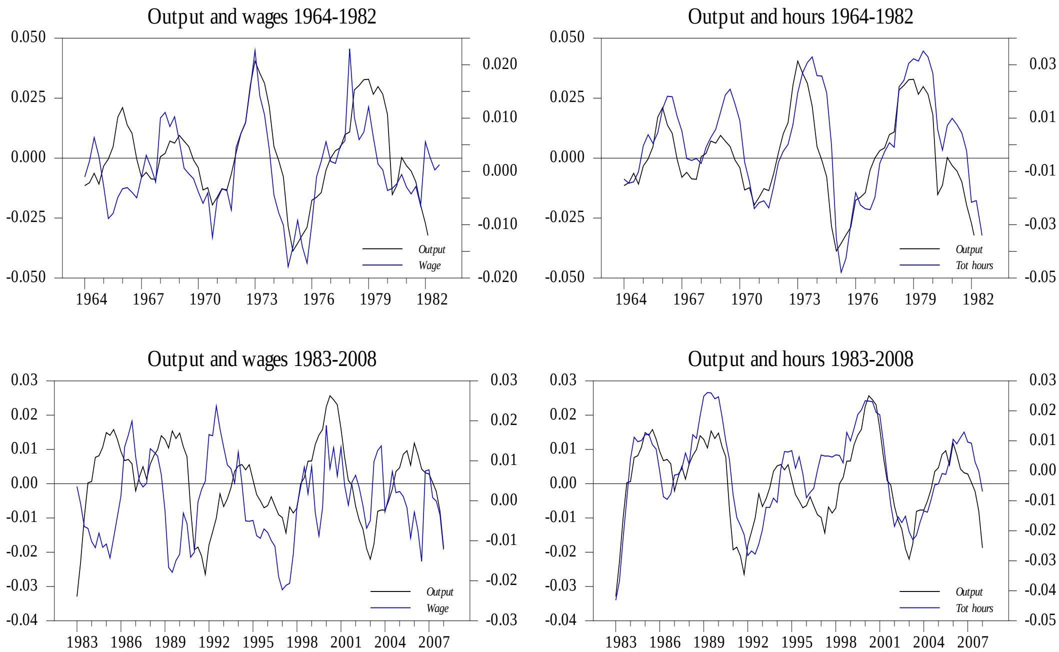

Figure 1: *Cyclical components of output, wages and total hours.*

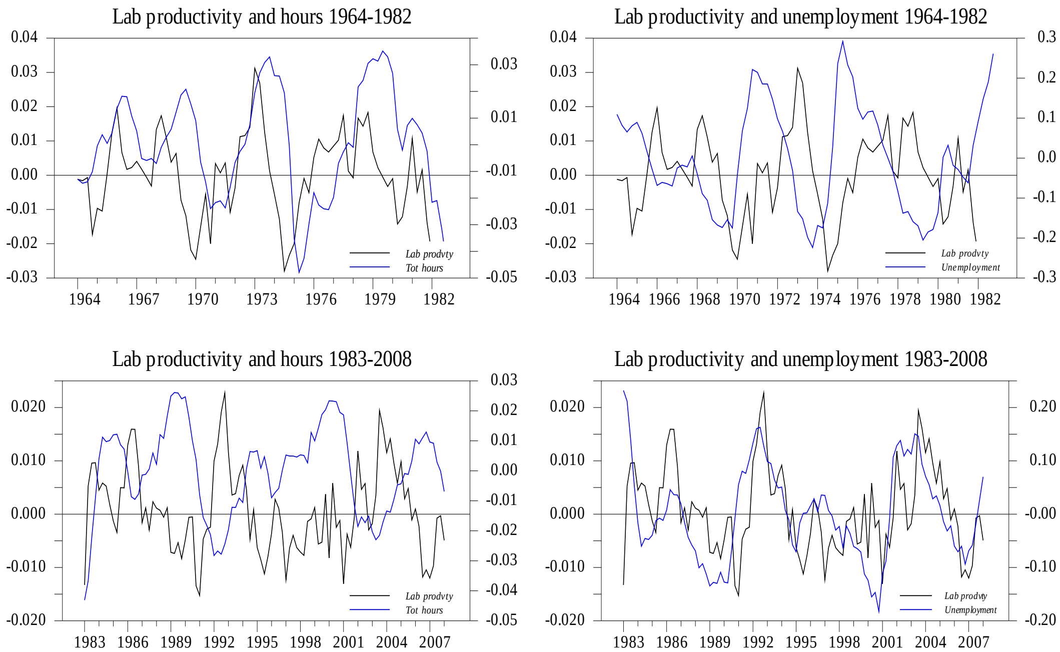

Figure 2: *Cyclical components of productivity, unemployment and total hours.*

supply elasticity is equal to 1. The adjustment costs parameter, $\phi = 5.95$, is taken from QUEST II (see Roeger and in't Veld, 1997), which considers the same function as ours for capital installation costs. The external habits parameters in consumption, $h^l = h^b = 0.7$, are between the low (*0.36*) and high (*0.81*) values estimated by Liu *et al.* (2009) and in the upper bound of a 95 probability interval for impatient household habits estimated by Iacoviello and Neri (2010).

Calibrated parameters from steady-state relationships

We normalize both steady-state output ($\overline{y}$) and real housing prices ($\overline{q}$) to one. From (38) we obtain the long-run value for vacancies $\overline{v} = \sigma\overline{n}/\overline{\rho}^f$. Then, we calibrate the ratio of recruiting expenditures to output ($\kappa_v\overline{v}/\overline{y}$) to represent 0.5 percentage points of output, as in Cheron and Langot (2004), to obtain a value of $\kappa_v = 0.053$. In order to obtain A, we first use (3) and (9) to ascertain the steady-state value of Tobin's q ($\frac{\overline{\lambda}_2^l}{\overline{\lambda}_1^l}$). Hence, we gain the return on capital ($\overline{r}$) using (8) and this allows us to compute the steady-state value for the capital stock ($\overline{k}$) from (34). Therefore the long-run value of total factor productivity, $A = 1.801$, is calibrated from the production function (30). The steady-state value of matching flows in the economy equals the flow of jobs that are lost ($\sigma\overline{n}$) and we use the equality ($\sigma\overline{n} = \chi_1\overline{v}^{\chi_2}\left[(1-\overline{n})\,l_2\right]^{1-\chi_2}$) to solve for the scale parameter of the matching function, $\chi_1 = 1.007$.

Using equation (37), we can solve for the steady-state value of wages ($\overline{w}$). The steady-state value of the nominal interest rate, $\overline{r}^n$, is related to the intertemporal discount rate of lenders through equation (10). Let γ_l be the ratio of assets of patient households in the steady state to total output ($\overline{b}^l = \gamma_l\overline{y}$). From equation (24) we obtain $\overline{b}^b$ conditional to the value of γ_l. Next, we can compute the steady-state level of consumption of borrowers, $\overline{c}^b$, from the budget restriction (14) and the consumption level of lenders, $\overline{c}^l$, from the aggregation equation (22). Our next step consists of calibrating steady-state levels of the marginal utilities of consumption of both types of consumers, $\overline{\lambda}_1^l$ and $\overline{\lambda}_1^b$, from their respective first-order conditions in equations (7) and (18). We can now obtain the steady-state holdings of housing of these types of agents, $\overline{x}^b$, from the borrowing restriction of impatient households (equation (15)). The long-run equilibrium value for the multiplier of the impatient household borrowing constraint, $\overline{\mu}^b$, can now be computed directly from the first-order condition (19). This makes it possible to compute the parameter that accounts for the housing weight in preferences, ϕ_x, from the last first-order condition of borrowers' optimization program (equation (20)). The value of the parameter ϕ_x enables us to compute the steady-state holdings of housing for lenders, $\overline{x}^l$, from the first order condition (11), and the fixed stock of real estate in the economy, X, from the aggregation rule (25).

TABLE 2 — PARAMETER VALUES

β^l	0.99	η	2.00
β^b	0.95	$h^l = h^b$	0.70
α	0.70	ϕ	5.95
δ	0.03	τ^b	0.36
κ_v	0.053	ϕ_h	0.00
σ	0.15	m^b	0.775
χ_1	1.007	ϕ_x	0.088
χ_2	0.60	r_R	0.73
ψ^w	0.40	r_π	0.27
l_2	1/6	r_y	0.0
ϕ_1	2.22	ϕ_2	1.42

Notice that the value of ϕ_x and X is going to depend on the value we assign to the ratio of assets of patient households in the steady state to total output, γ_l. In order to produce a sensible calibration of this parameter and the steady-state level of the variables, we follow Iacoviello (2005) and choose a value for γ_l, such that the total stock of housing over yearly output is 140 per cent. The resulting value for ϕ_x is 0.097.

As regards preference parameters in the household utility function, $\phi_1 = 2.221$ is calculated from the steady-state version of expression (41). A system of three equations implying the steady state of expressions (12) (21) and (40) is solved for ϕ_2, $\overline{\lambda}_h^b$ and $\overline{\lambda}_h^l$. The resulting value for ϕ_2 is 1.420. Therefore, the calibrated values for ϕ_1 and ϕ_2 are similar to those in Andolfatto (1996) and other related research in the literature. Such values imply that the imputed value for leisure by an employed worker is situated well above the imputed value for leisure by an unemployed worker.

Shocks and policy rule parameters

The parameters $r_R = 0.73$ and $r_\pi = 0.27$ in the interest rate rule are taken from Iacoviello (2005). For the parameter measuring interest rate reaction to output, r_y, we choose a value of 0. Regarding the productivity shock, we have chosen a high value for the autocorrelation parameter for technology shocks ($\rho_z = 0.95$) as in Campbell and Hercowitz (2005) and Cheron and Langot (2004), whereas the standard deviation of the shock σ_z has been calibrated so that the standard deviation of output matches its actual value in the 1964:1-1982:4 subsample.

Loan to value ratios and share of borrowers

We use two adjusting parameters, the loan-to-value ratio and the share of borrowers, to

TABLE 3 — STEADY STATE

Search model with borrowing constraints and housing					
c_t	0.77	n_t	0.57	b_t^b	2.15
c_t^l	0.83	n_t^l	0.57	r_t^n	0.01
c_t^b	0.67	n_t^b	0.57	q_t	1.00
j_t	0.20	r_t	0.04	x_t^l	7.19
j_t^l	0.32	v_t	0.095	x_t^b	2.80
k_t	6.78	w_t	3.66	X	5.61
k_t^l	10.59	y_t	1.00		
l_{1t}	0.33	b_t^l	-1.21		

characterize the evolution of household leverage over time. In particular, we will allow m^b to change between 0.775 and 0.95. In the same vein, we will allow the fraction of impatient consumers in the economy to vary between 0.36 and 0.56, which we conjecture to be sensible bounds for the share of highly leveraged people in the US economy over the period.

Our baseline calibration is $m^b = 0.775$ and $\tau^b = 0.36$ and we normalize steady state output and housing prices to one. This calibration is assumed to represent a low indebtedness regime during the first period. Then, we relax the restrictions to obtain credit in the economy either by allowing m^b or τ^b to increase. The rest of parameters characterizing the different equations and shocks of the model are kept constant. Thus, all the results discussed below are only conditional to the values for m^b or τ^b.

A summary of the parameters of the model and the steady-state values of the endogenous variables implied by the model solution for the baseline calibration are given in Tables 2 and 3.

4. Simulation results

4.1 Borrowing restrictions

Our aim here is to show that mortgage market deregulation, and the consequent increase in private leverage, may be behind the changes observed in the dynamic pattern of labor market variables at the cycle frequency. With that purpose, we carry out a numerical exercise that shows how the model is able to qualitatively generate the kind of changes that the empirical second moments discussed above have undergone across the two samples. First, we will use the initial impacts recovered from the impulse-response functions generated by the model, as a mean to illustrate the mechanism that causes our results, to offer afterwards the predicted pattern in the variation of the second moments.

Impact functions

In Figures 3 and 4 we depict the impact response to a one-percentage point transitory increase in total factor productivity. We do it for a set of variables as a function of the share of borrowers in the economy (first column) and of the loan-to-value ratio (second column). These figures illustrate to what extent the variation in the degree of private borrowing at both the extensive and intensive margins can affect the dynamics of the real economy after a technology shock. To check the sensitivity of our results, we display the plots in the first column for two levels of the loan-to-value ratio: $m^b = 0.775$ and $m^b = 0.925$[11]. In the same way, in the second column, we graph the results for two values concerning the share of borrowers: $\tau^b = 0.36$ and $\tau^b = 0.56$.

The marginal utility of consumption is a key variable that determines the outcome of the bargaining process. Changes in the weighted average of (the inverse of) that variable, $\left[\frac{1-\tau^b}{\lambda^l_{1t}} + \frac{\tau^b}{\lambda^b_{1t}}\right]$, can be thought of as shocks to the labor supply. Given that consumption decisions and trade in the labor market are closely entwined in our model, we first focus on Figure 3, concerning how consumption reacts to the shock. The reduction in equity requirements for borrowers that we find as we move rightward along the loan-to-value axis in the second column, relaxes the borrowing constraint, conditional to a positive shock. This is reflected in the figure by the response of the Lagrange multiplier associated to the borrowing constraint, μ^b_t. This response is negative and falls further as the loan-to-value ratio increases. Therefore, after a positive technology shock, consumption of impatient households, c^b_t, increases by more the higher the loan-to-value ratio. The stronger increase in borrower consumption drags down the marginal utility of consumption (λ^b_{1t}), as depicted in the figure.[12] The increase in the demand for loans triggers a response from lenders who find it optimal to channel resources from consumption and investment towards purchasing private bonds. As a result, lenders' consumption increases by less the lower the equity requirements for borrowing are, moderating to some extent the reduction of their marginal utility of consumption (λ^l_{1t}). Importantly, the reaction to a positive tech-

[11] Coinciding with the ones set by Iacovello and Neri (2010) for the periods before and after the year 1982, respectively.

[12] Habits at this step play a role. Habits in consumption, sure enough, act as an amplifier in the translation of the impact of consumption to the marginal utility of consumption. This can be seen in a log-linearized version (in deviations from the steady state) of the expression (18)

$$\widehat{\lambda}^b_{1t} = \frac{1}{(1-\beta h^b)(1-h^b)}\left[\beta h^b\left(\widehat{c}^b_{t+1} - h^b \widehat{c}^b_t\right) - \left(\widehat{c}^b_t - h^b \widehat{c}^b_{t-1}\right)\right]$$

It is easy to recognize that as the degree of habits in consumption increases (as h tends to 1), the impact on $\widehat{\lambda}_{1t}$ also increases for a given $\widehat{c}_t$.

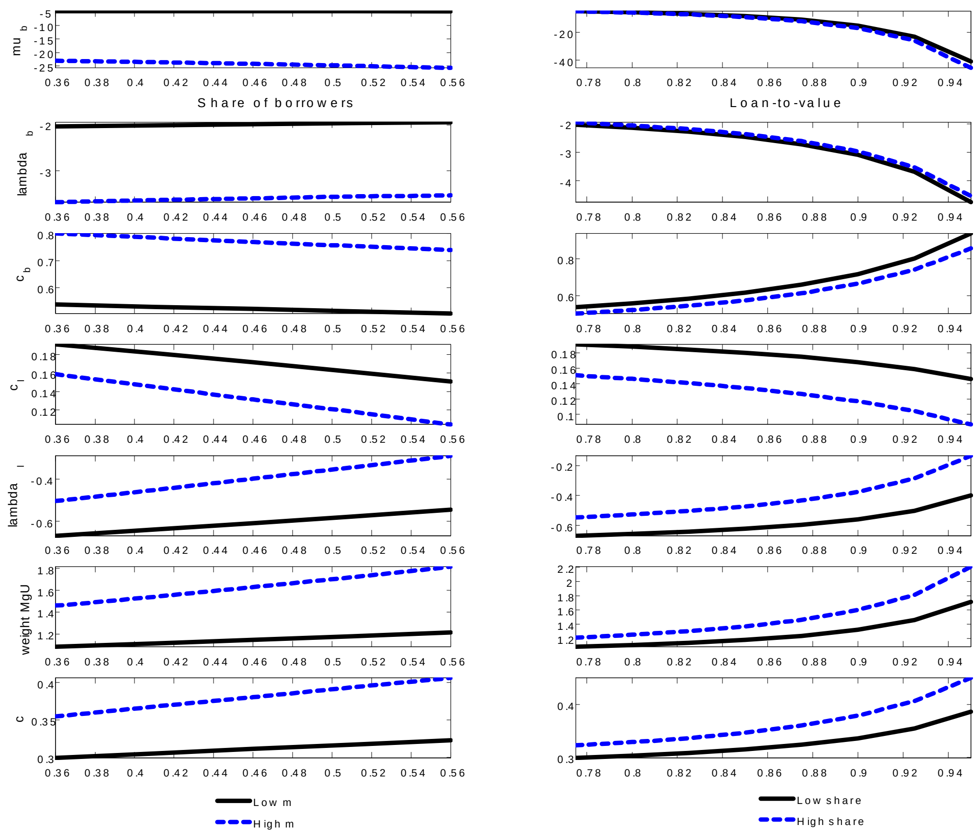

Figure 3: *Initial impacts to a technology shock: consumption decisions*

nology shock of the marginal utility of consumption of heavily leveraged and constrained consumers is much stronger than that of lenders, as the shock not only increases their current income, but also the value of their collateral (due to both the increase in the relative price of houses and the fall in real interest rates) making their access to credit easier. This means that the response of the weighted average of the inverse marginal utilities of consumption of both types of households in the economy is dominated by the response of λ_{1t}^b and increases with m^b.

The patterns for the initial impacts that we find on the left hand side of the Figure 3, corresponding to a variation in the share of borrowers, seem to indicate that while the effect on lenders' consumption tends to be reinforced by the number of borrowers, the opposite is also true, albeit to a limited extent, for the case of borrowers. This fact is a consequence of both a second-round effect driven by the behavior of labor income (see explanation below), and also a scale effect that influences the per capita consumption of both types of households.

The reaction of the labor market variables (Figure 4) can be better understood using the expression 40, for the negotiated wage, and the equation 41, for hours:

$$
\begin{aligned}
w_t l_{1t} = \psi^w \left(\alpha \frac{y_t}{n_{t-1}} + \frac{\kappa_v v_t}{(1-n_{t-1})} \right) \\
+(1-\psi^w) \left(\frac{(1-\tau^b)}{\lambda_{1t}^l} + \frac{\tau^b}{\lambda_{1t}^b} \right) \left(\phi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} - \phi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta} \right) \\
+(1-\psi^w)(1-\sigma-\rho_t^w)\tau^b E_t \frac{\lambda_{ht+1}^b}{\lambda_{1t+1}^b} \left(\beta^l \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} - \beta^b \frac{\lambda_{1t+1}^b}{\lambda_{1t}^b} \right)
\end{aligned}
$$

$$
\frac{\alpha}{\phi_1} \frac{y_t}{n_{t-1} l_{1,t}} (1-l_{1t})^\eta = \left[\frac{1-\tau^b}{\lambda_{1t}^l} + \frac{\tau^b}{\lambda_{1t}^b} \right]
$$

After a positive technology shock, $\left[\frac{1-\tau^b}{\lambda_{1t}^l} + \frac{\tau^b}{\lambda_{1t}^b} \right]$ increases with m^b, which in turn pushes the (optimally chosen) level of working hours down in equation (41)[13], and increases both the reservation wage and the real market wage in equation (40). A rise in the share of impatient households, τ^b, strengthens this mechanism and, therefore, augmenting the number of borrowers for a constant loan-to-value ratio provokes a similar reaction from the labor market variables.

13 Notice that this fall in hours worked following a technology shock is obtained without relying on price stickiness as is common in the literature.

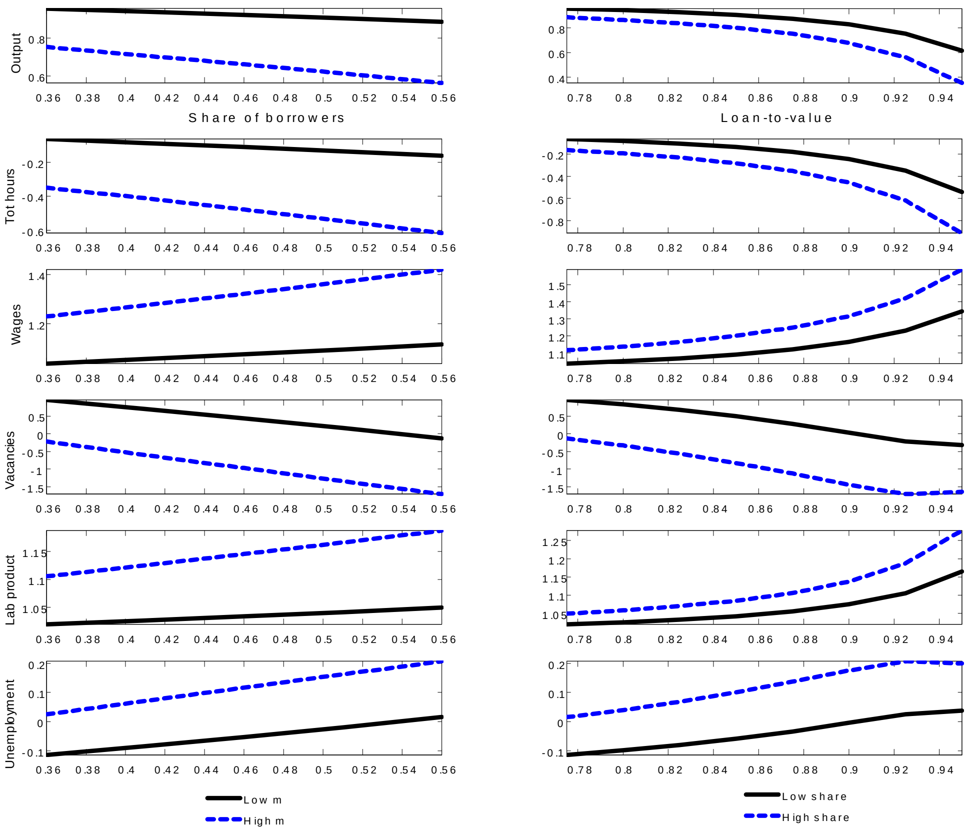

Figure 4: *Initial impacts to a technology shock: labor market*

Finally, less hours and higher market wages act as a disincentive to post vacancies, thus reducing matching activity in the labor market. As a result, the effect on employment scales down, along with that on capital and output, augmenting unemployment and dampening the positive output effect of the shock itself. Because the impact on total hours declines faster than that on output as the amount of leverage increases, the total impact on labor productivity $\frac{y_t}{n_{t-1}l_{1,t}}$ increases.

Second moments

Having offered a picture of the initial impacts, we now turn our attention to the pattern for second moments as a function of the level of private borrowing. Let us recall that the standard deviation of the shock, σ_z, has been calibrated so that the standard deviation of output in the model matches its actual value in the sample period prior to 1982:4. We will assume that the autocorrelation and standard deviation of the shocks remain constant right across the simulations. Thus, the empirical exercise we carry out below is conditional only to the change in either the parameter m^b capturing the loan-to-value ratio, or the number of borrowers, τ^b.

In Figure 5 we represent the predictions the model makes for the correlation of labor productivity with output and total hours, as well as the standard deviations (relative to output) of total hours and wages. According to the stylized facts unveiled from the data, these correlations have declined over time, whereas relative volatilities have increased. These shifts appear clearly in the simulations in Figure 5, as a result of increasing private borrowing in the economy, both at the extensive margin (increase in the number of borrowers) and intensive margin (increase of the loan-to-value ratio). The explanation of the behavior concerning the relative standard deviations is quite straightforward looking at the impact functions in the previous subsection. As borrowing increases, the positive impact of a technology shock on wages increases and, at the same time, there is a more intense decline in hours worked. Thus, the relative volatility of both wages and also total labor input increases in a way that is consistent with the time pattern of these moments.

The intuition behind the two correlations is less straightforward. As impatient consumers face less borrowing restrictions, lenders find it optimal to increase the amount of loans by reducing their consumption and investment. As a consequence, productive investment and the capital stock become less volatile, lowering the standard deviation of output. The different behavior of the labor input and capital, as indebtedness increases, reduces the co-movement of hours with capital and makes labor productivity less corre-

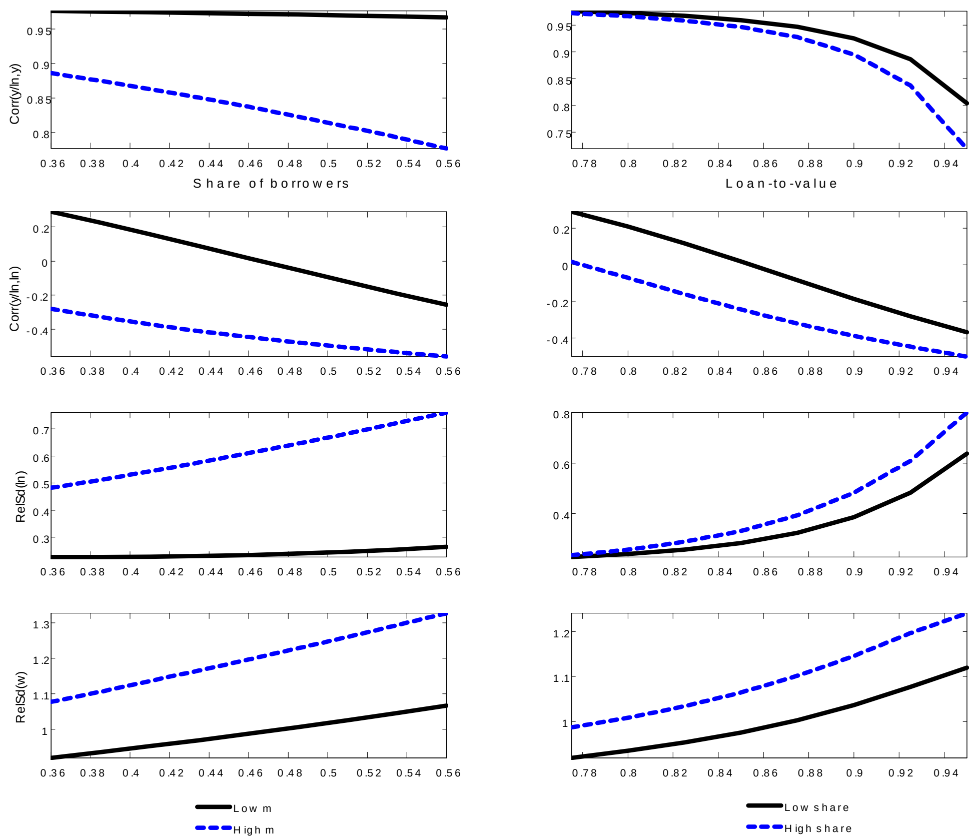

Figure 5: *Second moments as a function of private indebtedness: labor productivity, hours and wages*

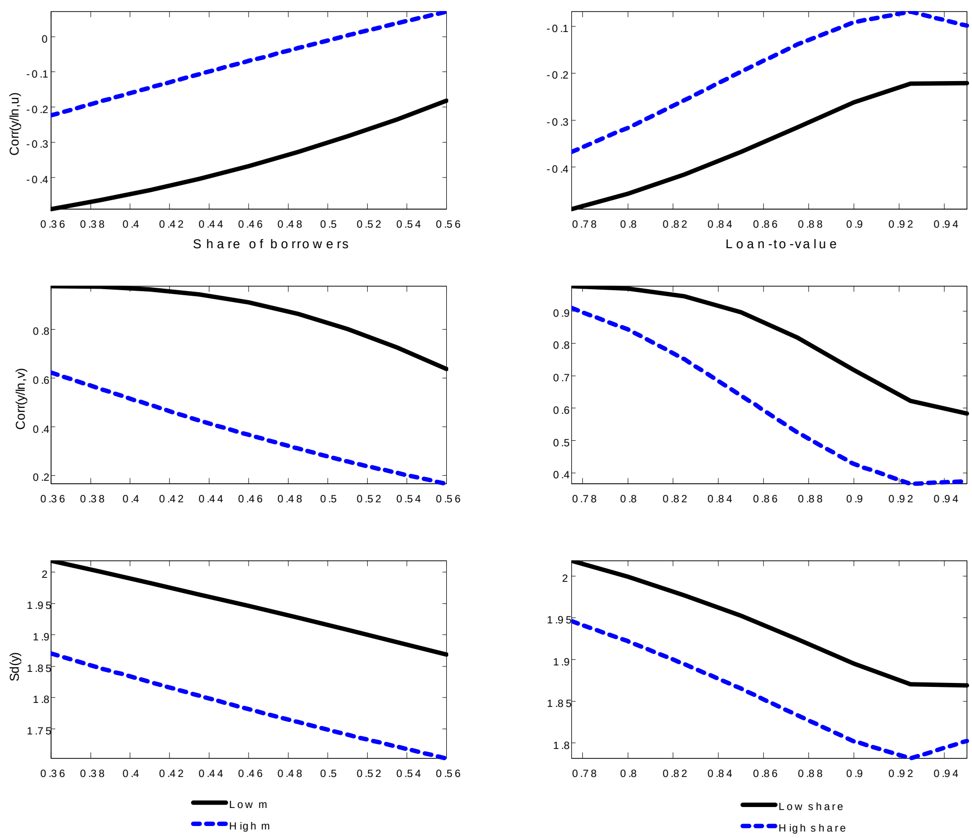

Figure 6: *Second moments as a function of private indebtedness: labor productivity, unemployment and vacancies*

lated with total hours and output.[14]

The model also explains the increase observed in the correlation between labor productivity and unemployment and the fall in the correlation of productivity with vacancies (Barnichon, 2009) (see Figure 6). Again, the explanation behind these results lies in the different behavior of unemployment and vacancies along the changes in the parameters we are considering. While the technology shock generates a response of unemployment that increases with the degree of leverage in the economy, the opposite is true for the case of vacancies.

4.2 Labor market frictions

As said in the introduction, we do not interpret our results as opposite to those in Galí and van Rens (2010) based on changes in labor market regulations. In fact our model encompasses both explanations, since the introduction of financial frictions does not alter the effect of relaxing labor market constraints. Our model replicates some of the results concerning the second moments discussed above, as resulting from a steady reduction in the cost of posting new vacancies. The range for this parameter in Figure 7 lies between a 0 and a 3 per cent of output, with the low bound 0 being close to the frictionless scenario in the labor market. As in Galí and van Rens (2010), we take the labor input to be represented only by employment and, therefore, we change the definition of labor productivity. As the results in Figure 7 show, the expected decrease in the correlations between productivity and output and productivity and employment are captured to some extent by a reduction in this friction. Interestingly, this exercise also captures the increase in correlation between productivity and unemployment and the increasing relative deviation of employment, although it fails to replicate the change in the relative volatility of wages.[15]

The interpretation of the mechanism is akin to Galí and van Rens (2010) and, contrary to what happens when we relax borrowing constraints, it falls on the demand side of the labor market. When labor market frictions are high, firms adjust the intensive margin (in our case, hours per worker) to a positive technology shock. The reduction in labor market frictions allows firms to adjust the extensive margin more easily, thus increasing the relative volatility of employment. In our model, this substitution between the intensive and the extensive margin is of sufficient magnitude, providing borrower indebtedness is high enough, as to trigger a significant response from the intensive margin (hours per worker) to the shock.

14 When considering these correlations, it is useful to bear in mind the log-linearized version of the production function we are using in our model $\widehat{y}_t = \alpha(\widehat{n}_t + \widehat{l}_t) + (1-\alpha)\widehat{k}_t + \varepsilon_t$ which can be directly transformed into labor productivity as $\widehat{y}_t - (\widehat{n}_t + \widehat{l}_t) = (\alpha - 1)(\widehat{n}_t + \widehat{l}_t) + (1-\alpha)\widehat{k}_t + \epsilon_t$.

15 This is also the case in Galí and van Rens (2010) for their flexible wage model.

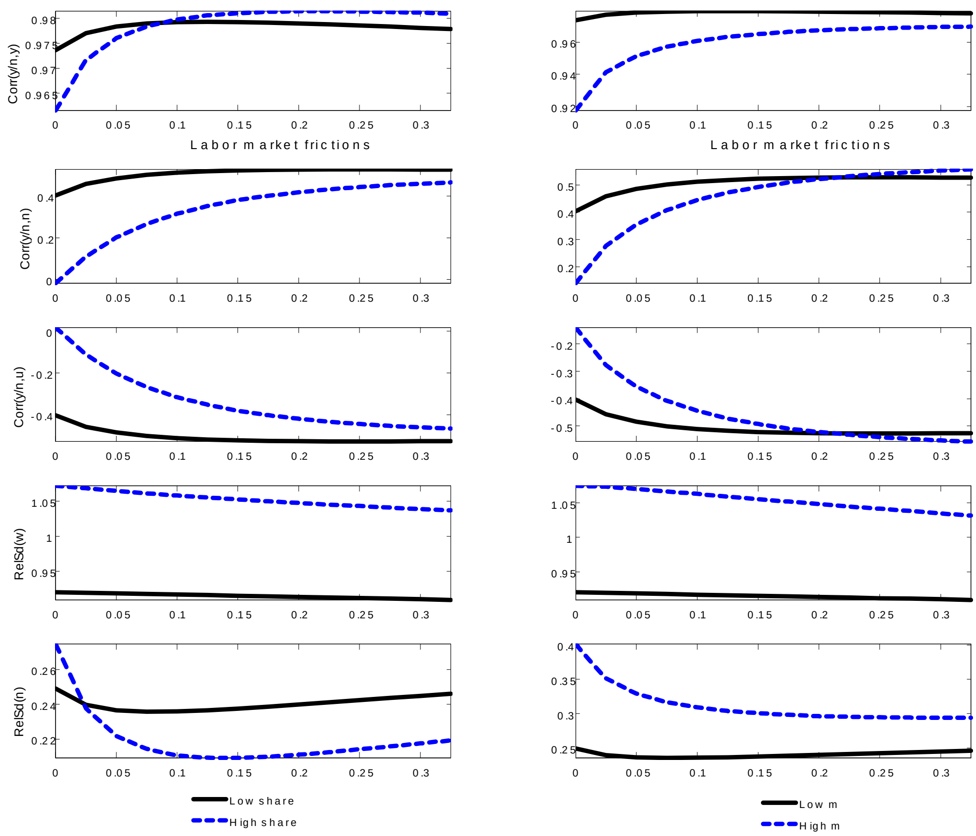

Figure 7: *Simulated second moments for variations in labor market frictions: labor input is employment.*

5. Conclusions

The dynamics of business cycle fluctuations have undergone a substantial transformation over the last two decades. The labor market has not been exempt from these changes; in fact, recent empirical research has uncovered a clear pattern as regards the evolution of volatilities and cross correlations of the most important labor market variables, such as employment, wages, labor productivity, unemployment and vacancies. The most natural explanation of this evidence can be found in the profound impact that labor market deregulation, since the early eighties, may have had on the dynamics of these variables. This is indeed what Galí and van Rens (2010) achieve on the basis of a reduction in hiring costs and which we replicate in this paper as a consequence of a fall in vacancy posting costs. The labor demand channel is the key in this explanation: labor market deregulation cheapens the adjustment through the extensive margin (employment), the volatility of which increases, while that of the intensive margin (effort in Galí and van Rens, 2010, and hours per worker in our paper) falls.

In this paper we show that these and other labor market facts can be also thought of as the outcome of the continuous process of financial deepening, as represented by the increase in household indebtedness that has occurred since the early eighties. To that end we set up a DSGE model with flexible prices, in which the presence of financially constrained consumers is intertwined with the process of vacancy creation, to deliver a powerful transmission mechanism of technology shocks. Leveraging in our model is parameterized as an increase in the loan-to-value ratio for constrained borrowers, or as an increase in the number of borrowers in the economy. The way financial factors affect labor market outcomes is a bit more cumbersome, since it primarily entails not a labor demand but rather a labor supply effect, in which both the extensive and intensive margins respond in the same way. When borrowers have easier access to credit, their consumption reacts more strongly and so their relative bargaining power vis-a-vis the firm increases. Thus, higher access to credit reduces working hours and increases wages, which in turn discourages firms from posting vacancies. This heightened response of total labor input to the technology shock is the pivotal element in explaining the observed time pattern in volatilities and correlations in the data.

References

Andolfatto, D. (1996): “Business Cycles and Labor-Market Search”. *American Economic Review*, 86 (1), 112-32, March.

Barnichon, R. (2009): ˇProductivity, Aggregate Demand and Unemployment Fluctuationsı. Finance and Economics Discussion Series (FEDS). Federal Reserve Board, Washington, D.C. Staff Working Paper 2008-47.

Bernanke, B. and M. Gertler (1995): "Inside the Black Box: The Credit Channel of Monetary Policy Transmission", *Journal of Economic Perspectives*, Vol. 9(4), 27-48, Fall.

Boscá, J.E., R. Doménech and J. Ferri (2011): "Search, Nash Bargaining and Rule of Thumb Consumers," *European Economic Review*, forthcoming.

Campbell, J. R. and Z. Hercowitz (2005): "The Role of Collateralized Household Debt in Macroeconomic Stabilization". NBER Working Papers N^o 11330.

Campbell, J. R. and Z. Hercowitz (2009): "Welfare Implications of the Transition to High Household Debt," *Journal of Monetary Economics*, 56(1): 1-16.

Chéron, A. and F. Langot (2004): "Labor Market Search and Real Business Cycles: Reconciling Nash Bargaining with the Real Wage Dynamics". *Review of Economic Dynamics*, 7, 476-493.

Dromel, N., E. Kolakez, and E. Lehmann (2009): "Credit Constraints and the Persistence of Unemployment," IZA Discussion Papers 4501, Institute for the Study of Labor (IZA).

Galí, J. and L. Gambetti (2009): ˇOn the Sources of the Great Moderationı. *American Economic Journal: Macroeconomics*. Vol. 1(1), 26-57.

Galí, J. and van Rens, T. (2010): "The Vanishing Procyclicality of Labor Productivity," IZA Discussion Papers 5099, Institute for the Study of Labor (IZA).

Hosios, A. J. (1990): “On the Efficiency of Matching and related Models of Search Unemployment”. *Review of Economic Studies*, 57, 279-98.

Iacoviello, M. (2005): "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle". *American Economic Review*, 95 (3), 739-764.

Iacoviello, M. and S. Neri (2010): "Housing Market Spillovers: Evidence from an Estimated DSGE Model,ı *American Economic Journal: Macroeconomics*, Vol. 2(2), 125-64.

Kiyotaki, N. and J. Moore (1997): "Credit Cycles". *Journal of Political Economy*, 105(2), 211-248.

Liu, Z., P. Wang and T. Zha (2009): "Do Credit Constraints Amplify Macroeconomic Fluctuations?. Federal Reserve Bank of San Francisco. Working Paper Series, N. 28.

Merz, M. (1995): “Search in the Labor Market and the Real Business Cycle”. *Journal of Monetary Economics*, 36, 269-300.

Ravn, M. O. and S. Simonelli (2008): "Labor Market Dynamics and the Business Cycle: Structural Evidence for the United States," *Scandinavian Journal of Economics*, vol. 109(4), 743-777.

Roeger, W. and J. in’t Veld (1997): "QUEST II: A Multi Country Business Cycle and Growth Model". European Economy - Economic Papers, 123.

Shimer, R. (2005): ˇThe Cyclical Behavior of Equilibrium Unemployment and Vacanciesı. *American Economic Review*, 95 (March), 25-49.

Smith, A. A. (2009): "Comment on: Welfare Implications of the Transition to High Household Debt, by Campbell and Hercowitz". *Journal of Monetary Economics*, 56(2009), 17-19.

Appendix 1: Data Sources

TABLE A1 - DATA

Variable	Data	Source
Total Hours	Nonfarm Business Sector: Hours of All Persons	FRED
Labor productivity	Nonfarm Business Sector: Output Per Hour of All Persons	FRED
Wages	Nonfarm Business Sector: Real Compensation Per Hour	FRED
Vacancies	Help wanted index	Conference Board
Unemployment rate	Monthly Civilian Unemployment Rate	BLS