# Household Leverage and Fiscal Multipliers*

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**Abstract**

We study the size of fiscal multipliers in response to a government spending shock under different household leverage conditions in a general equilibrium setting with search and matching frictions. We allow for different levels of household indebtedness by changing the intensive margin of borrowing (loan-to-value ratio), as well as the extensive margin, defined as the number of borrowers over total population. The interaction between the consumption decisions of agents with limited access to credit and the process of wage bargaining and vacancy posting delivers two main results: (a) higher initial leverage makes it more likely to find output multipliers higher than one; and (b) a positive government expenditure shock always produces a positive multiplier for vacancies and employment. The latter result is in sharp contrast with models in which some households do not have access to the financial market (RoT consumers), in which the implied labor market responses to fiscal shocks are inconsistent with the empirical evidence. We also find that the impact on GDP of consolidations is lower when consumers have a more limited capacity to borrow, and that increasing government spending in an episode of intense private deleveraging can still generate positive and significant effects on consumption and output, although the fiscal output (employment) multiplier decreases (increases) with the intensity of the credit crunch. In the model with indebted impatient households we also observe that output (employment) multipliers decrease (increase) markedly with the degree of shock persistence and increase with the degree of price stickiness.

*Keywords*: fiscal multipliers, private leverage, labour market search.
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## 1. Introduction

The current economic crisis has aroused a renewed interest in fiscal policy as a stabilization tool. For many years the predominant view of pundits in the field, as represented by

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the so-called Jackson Hole consensus (see Bean et al, 2010), held that discretionary fiscal stimuli had an effect on output and employment ranging from weakly positive to negative. The only relevant use for this instrument should then be confined to the role of automatic stabilizers. This view changed rapidly during the early days of the financial turmoil when most academics and policy makers called for strong spending hikes and/or tax cuts to keep the world economy from plunging into an even deeper recession. Two years later many countries started to undo such fiscal actions, fearing the reaction of financial markets to the rapid surge of public debt all over the developed world. The discussion on the output and employment effects of government spending stimuli -and the likely reaction of the different economies to their withdrawal- has been central to the political and academic debate over the last two years.[1] This discussion has been going on for a long time now on a broader scale, accumulating a substantial amount of international empirical evidence in favor of each of the different views. This is reflected, for instance, in the IMF World Economic Outlook (2010) and the results in Alesina and Ardagna (2010). While the IMF report finds that discretionary cuts in public spending or tax hikes are contractionary with a moderate but significant effect on output and employment, Alesina and Ardagna (2010) argue that fiscal contractions might even be expansionary under fairly general conditions, and specially so in periods of fiscal stress and high public debt levels.

The positive effects of fiscal impulses that many authors find in empirical research are difficult to accommodate in general equilibrium macroeconomic models, especially with standard preferences and forward looking Ricardian consumers. Galí, López-Salido and Vallés (2007) obtained fiscal multipliers consistent with the empirical evidence assuming that a significant proportion of the population does not have access to this intertemporal substitution. These households do not participate in the financial market and their consumption is simply equal to their disposable income. But the fact is that most agents actually participate in the financial market either as lenders or borrowers. Debt is the key feature of the current financial crisis that has taken most firms and households highly leveraged with mortgages and other loans, after many years of financial deepening linked to the growing demand for housing. This is likely to affect their labor market choices, as well as their consumption behavior, since these agents' consumption is not only related to their labor income, but also to their net worth and hence to the evolution of inflation, interest rates, total debt and asset prices.

Some recent papers have pointed out the linkage between the presence of strongly debt-constrained agents and the delivery of economic activity in the present slump. For instance, Eggertsson and Krugman (2010) argue that under a credit crunch the economy is

[1] See Romer and Bernstein (2009), Cogan, Cwik, Taylor and Wieland (2010) and Uhlig (2010), among others, regarding the expected impact of the US fiscal packages.

likely to fall into the liquidity trap and that more public debt can be an appropriate solution to a private debt-induced slump. In a fully specified dynamic model, Hall (2011) studies the response of output and unemployment when the economy is hit by three adverse forces related to the stock of housing, the number of liquidity constrained households and the degree of financial frictions. Furthermore, Mian and Sufi (2010) exploit county-level data for the US and find clear correlation between the growth of household leverage from 2002 to 2006 and the fall in house prices and the rise in unemployment after the crisis. Glick and Lansing (2010) also find that the countries that experienced the largest declines in household consumption, once house prices started falling after the financial crisis, were those that prior to 2007 suffered the highest increases in house prices and household leverage.

In this paper we analyze the incidence of household leverage in the response of consumption, (un)employment and output to discretionary fiscal measures within a DSGE framework, an issue that has received scant attention to date[2]. We study the size of fiscal multipliers paying special attention to the main determinants of consumption, labor income and net worth, and to that end we augment the canonical neo-Keynesian model in two directions. Since the dynamics of labor market variables is essential in the transmission of fiscal impulses, we allow for two-sided market power, wage bargaining and matching frictions in the vein of Andolfatto's (1996) model. We also include financial frictions drawing on Iacoviello (2005). All agents in the economy participate in the financial market, but due to differences in their subjective valuation of the future, the most impatient of them borrow from the patient ones. Since differences in discount factors are deterministic, the amount of borrowing is limited by the value of the collateral given by the expected value of the household's housing holding. Hence, even constrained consumers leave some room for intertemporal substitution, such that a modified version of the Euler condition on consumption still prevails.[3].

The main results of the paper can be summarized as follows. First, under a fairly standard characterization, the model delivers impulse response fiscal multipliers in line with the empirical literature. In particular, while we obtain positive multipliers, the consumption response is positive but lower than that predicted by the standard model with rule-of-thumb (RoT) consumers. Second, our model predicts that vacancies and employ-

[2] A non-exhaustive list of exceptions includes Callegari (2007), Roeger and int Veld (2009), Eggertsonn and Krugman (2010) and Guerrieri and Lorenzoni (2011). Other approaches connect fiscal policy and financial frictions through the effect on the financial premium paid by firms (see Fernández-Villaverde, 2010 and Carrillo and Poilly, 2011).

[3] In previous papers (Andrés and Arce, 2010, Andrés, Boscá and Ferri, 2011 and Boscá, Doménech and Ferri, 2011), we have looked at some of the mechanisms involved in our model. Here we extend this line of research by analyzing the interaction between the consumption decisions of agents with limited access to credit and the process of wage bargaining and vacancy posting.

ment will grow after a fiscal expansion, as observed in the data, while the RoT model predicts the opposite. In the RoT model, the increase in wages is so strong that firms are less inclined to post more vacancies and exploit the intensive margin by increasing hours and reducing employment. Third, the greater the borrowing capacity (as measured by a higher loan-to-value ratio), the stronger the impact multiplier of fiscal policy. Impatient households borrow to the limit of their constraint, thus increasing their consumption substantially when the loan-to-value ratio is high, contributing to a higher aggregate multiplier. Notice that this result can be read in two ways regarding the current policy debate. With high leverage, multipliers are expected to be large because constrained consumers find it easy to borrow, but fiscal expansions lose strength after a credit crunch. Thus, pre-crisis multipliers might not be a good indicator of the likely impact of fiscal policy after the deterioration in the conditions under which households have access to credit.

The rest of the paper is organized as follows. In section 2 we review the empirical literature; section 3 summarizes the model; section 4 deals with calibration, while section 5 presents the main simulation results. Section 6 concludes.

## 2. Review of the empirical literature

In this section we present a non-exhaustive review of the main results in the literature regarding the impact of fiscal policies on the following variables: output, consumption, (un)employment and vacancies. Investment and real wages play an important role in the transmission of fiscal shocks, but their response is less controversial and can be easily reproduced in a broad class of macroeconomic models.

The empirical analysis of the fiscal multiplier gathered momentum after the work of Blanchard and Perotti (2002), who estimated a VAR for the US economy with a careful identification approach to the effect of discretionary fiscal policy changes. They found that, consistent with a Keynesian view, output and consumption increase while investment falls in response to a positive government spending shock. These results are consistent with those obtained by Burnside, Eichenbaum and Fisher (2004), Fatás and Mihov (2001), Galí, López-Salido and Vallés (2007) and Perotti (1999), among others. Using a similar methodology Perotti (2004) found coincident results for these variables for Australia, Canada, the United Kingdom and Germany. Mountford and Uhlig (2009) use a sign restriction methodology to identify the effects of fiscal shocks and find that private consumption does not change significantly in response to an unexpected increase in government spending. Ramey and Shapiro (1998), Edelberg, Eichenbaum and Fisher (1999) and McGrattan and Ohanian (2003) have focussed on particular and well identified episodes of military spending increases in the United States and conclude that such fiscal expansions have a significant and positive short-run effect on output, that fades away after some years.

In contrast with these results, another stream of the literature has found that contractionary policies have expansionary effects on output, i.e. that fiscal policy may have non-Keynesian effects. Beginning with the work of Giavazzi and Pagano (1990), many studies have analyzed the macroeconomic effect of fiscal consolidations. In their survey for this literature, Hemming, Kell and Mahfouz (2002) conclude that there are many examples in which fiscal contractions have had expansionary effects on output, private consumption and investment. As Perotti (1999) found, the initial conditions of some key variables can explain why fiscal expansions have a positive effect in 'good times' but a negative one in 'bad times', when fiscal consolidations are needed.

The financial crisis has aroused renewed interest in the effects of fiscal policy as the debate involving Romer and Bernstein (2009), Cogan, Cwik, Taylor and Wieland (2010), Uhlig (2010) and Taylor (2011) demonstrates. Alesina and Ardagna (2010) find that there is almost the same probability of the effect of fiscal stimuli resulting in an output expansion as in a contraction and that the outcome depends crucially on the particular components of government spending and taxes that change. Barro and Redlick (2009) measure the impact of fiscal policy by looking at very long series for the US and a careful identification procedure focusing on the role of military spending. They find small consumption multipliers leading to output multipliers of approximately 0.4-0.7. Interestingly, they find that changes in tax revenue have a smaller impact on output than variations in the marginal tax rate; they conclude that labor supply dominates aggregate demand as a mechanism for the transmission of fiscal shocks. Romer and Romer (2009, 2010), following a narrative approach, find strong output responses to tax changes in the US. The same approach has inspired the recent work by Leigh *et al.* (2010), who have looked at many episodes in a broad sample of developed countries and find that, albeit small, output multipliers are unambiguously positive and that fiscal contraction has a negative impact on output.

Some authors have looked to other determinants of the effectiveness of fiscal policies. Auerbach and Gorodnichenko (2010) estimate state-dependent fiscal multipliers, documenting a higher effectiveness of government spending shocks in recessions than in expansions. Still, important differences between historical episodes are lumped together by these authors. There is widespread consensus about the importance of the monetary policy reaction to fiscal shocks as a major determinant of the size of the multipliers (Woodford, 2010), which become unusually large if the economy hits the zero bound of the nominal interest rate (Christiano, Eichenbaum and Rebelo, 2009).

Our interpretation of the literature is that fiscal expansions generally have a positive, albeit not too large effect on output. This idea is also supported by the recent survey of Ramey (2011) who offers a range between 0.8 and 1.5 for the output multiplier corresponding to a temporary rise in government purchases. Beyond that, the precise value of the fiscal multiplier is difficult to gauge. Tagkalakis (2008) finds empirical support, using a panel of nineteen OECD countries, for the idea that fiscal policy can have asymmetric effects on consumption in recessions and expansions in the presence of binding liquidity constraints. The papers by Caldara and Kamps (2008), Coenen et al. (2010) and Cogan et al. (2010) are cited by Leeper (2010) as a proof of the difficulty of producing a simple answer to the question of whether, or to what extent, fiscal policy is effective as a stabilization tool, a situation he calls the "fiscal morass". Also, in their empirical survey, Spilimbergo et al. (2009) find that "the size of the fiscal multiplier is country-, time-, and circumstance-specific". A similar result is reached in the papers by both Ilzetski et al. (2011) and Favero et al. (2011). They conclude that the impact of government expenditure shocks or fiscal consolidation depends crucially on key country characteristics, such as the level of development, exchange rate regime, openness to trade, public debt dynamics and fiscal reaction functions.

Less attention has been paid to the effect of financial conditions on the fiscal multiplier. As regards the role of financial conditions, Afonso, Baxa and Slavik (2011) report evidence of nonlinearities in the effects of fiscal shocks on economic activity depending on a set of initial conditions determined by the existence of financial stress, diverse levels of government indebtedness and different implicitly assumed monetary policy behavior.

The ultimate effects of fiscal expansions on the economy crucially depend on the reaction of employment. Despite that, the response of labor market variables to fiscal shocks has received less attention in the literature. However, the scant empirical literature on this issue points towards a government spending shock having a positive effect on vacancies and employment and a negative effect on unemployment (see Monacelli, Perotti and Trigari, 2010, and Ravn and Simonelli, 2008). Using a different sample span, Brückner and Pappa (2010) find a positive effect on employment, although the unemployment rate may not fall due to an increase in the participation rate.

The model we describe in the next section explores the connection of consumption and output fiscal multipliers with the financial conditions of the economy as represented by the degree of household indebtedness. The economic mechanism explaining the magnitude of the fiscal multiplier depends crucially on the labor market reactions of economic agents to the fiscal shock.

## 3. The model

We model a decentralized closed economy in which households and firms trade one final good and two factors of production: 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 costly, in terms of resources and time, 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. Firm investment in vacant posts is endogenously determined and so are job inflows. Job destruction is considered exogenous.

The model goes one step beyond Mankiw's model of savers and spenders (Mankiw, 2000). 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 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 and the owners of physical capital, while impatient households are net borrowers. Due to some underlying friction in the financial market, borrowers face a binding constraint in the amount of credit they can take, which 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 $\tau^b$ denote the proportions of lenders and borrowers 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.

### 3.1 Patient households

The representative household faces the following maximization program,

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

subject to

$$\begin{aligned} & c_t^l + j_t^l \left(1 + \frac{\phi}{2}\left(\frac{j_t^l}{k_{t-1}^l}\right)\right) + q_t\left(x_t^l - x_{t-1}^l\right) - b_t^l - b_t^p = \\ & w_t l_1 n_{t-1}^l + r_t k_{t-1}^l + d_t^l - (1 + r_{t-1}^n)\left(\frac{b_{t-1}^l}{1+\pi_t} + \frac{b_{t-1}^p}{1+\pi_t}\right) + trh_t^l - \zeta_t^l \end{aligned} \tag{2}$$

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

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

Lower case variables in the maximization problem above are normalized by the within group working-age population ($N_t^l$). In our notation, variables and parameters indexed by $b$ and $l$ denote, respectively, 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. 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. As we will explain later while the household bargains over $l_{1t}$, the amount of time devoted to job seeking ($l_2$) is assumed to be exogenous, such that individual households take it as given. Future utility is discounted at a rate of $\beta^l \in (0,1)$, the parameter $-\frac{1}{\eta}$ measures the negative of the Frisch elasticity of the labor supply and $\phi_x$ is the weight of housing in life-time utility. The subjective value of leisure imputed by workers may vary across employment statuses ($\phi_1 \neq \phi_2$).

Maximization of (1) is constrained as follows. First, the budget 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 physical capital ($k_t^l$), which is owned solely by patient households who get $r_{t-1}k_{t-1}^l$ in return, where $r_t$ represents the gross return on physical capital. Given that firms make extraordinary profits, we assume that lenders receive these in the form of dividends $d_t^l$. Second, there are loans/debt in the economy. Thus, patient households lend in real terms $-b_t^l$ (or borrow $b_t^l$) to the private sector and $-b_t^p$ to the public sector. They receive back $-(1+r_{t-1}^n)b_{t-1}^l$ from the private sector, 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 $t$ ($\pi_t$) 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, there is a fixed amount of real estate in the economy[4] and 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 $j_t^l\left(1+\frac{\phi}{2}\left(\frac{j_t^l}{k_{t-1}}\right)\right)$. Total investment outlays are affected by increasing marginal costs of installation. There

[4] As in Iacoviello (2005), the assumption of an aggregate fixed housing stock is not crucial to the propagation mechanism of shocks in the economy.

are also adjustment costs stemming from changing the housing stock that we model as:

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

Households receive (pay) lump sum transfers (taxes) from (to) the government $\left( trh_t^l \right)$.

The remaining constraints faced by Ricardian households concern the laws of motion for capital and employment. Each period private capital stock $k_{t-1}^l$ depreciates at the exogenous rate $\delta$ 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 fraction of employed and unemployed optimizing workers in the economy at the beginning of period $t$. Each period, jobs are destroyed at the exogenous rate $\sigma$. Likewise, new employment opportunities come at the rate $\rho_t^w$, which represents the probability that one unemployed worker will find a job. Although the job-finding rate $\rho_t^w$ is taken as exogenous by individual workers, at aggregate level it is endogenously determined according to the following Cobb-Douglas matching function[5],

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

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,

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

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 the holdings of housing:

$$\lambda_{1t}^l = \frac{1}{c_t^l} \tag{7}$$

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

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

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

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

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

According to condition (7) the current marginal utility of consumption is the inverse of actual consumption. 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. Euler 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) represents the dynamics of the demand for housing.

For later use we define the marginal value of employment for a worker $\lambda_{ht}^{l}$, as:

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

where $\lambda_{ht}^{l}$ measures the marginal contribution of a newly created job to the utility of the household. The first term 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 ($\lambda_{1t}^{l}$). The second term on the right-hand side of (12) 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 the employment status will persist in the future, conditional to the probability that the new job will not be lost.

### 3.2 Impatient households

Impatient households discount the future more heavily than patient ones, so their discount rate satisfies $\beta^b < \beta^l$ and face the following maximization program,

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

subject to the specific liquidity constraint, a borrowing limit and the law of motion of employment, as reflected in

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

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

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

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. Both the parameter $\phi_x$, which accounts for housing weight in life-time utility, and the housing adjustment function are the same as those 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). In the mortgage market, the maximum loan that an individual can get is a fraction of the liquidation value of the amount of housing held by the representative household; thus $m^b \in [0,1]$ in (15) represents the loan-to-value ratio. As shown in Iacoviello (2005), without uncertainty the assumption $\beta^b < \beta^l$ guarantees that the borrowing constraint holds with equality.

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

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

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

$$\lambda_{1t}^b = \frac{1}{c_t^b} \tag{18}$$

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

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

where $\mu_t^b$ is the Lagrange multiplier of the borrowing constraint and the marginal value of employment for an impatient household worker ($\lambda_{ht}^b$) can be obtained as,

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

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

### 3.3 Aggregation

Aggregate consumption and employment are a weighted average 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 $X$ is the fixed stock of real estate in the economy. For the variables that exclusively concern patient households, aggregation is merely performed 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, we consider an aggregator (trade union) that combines the surpluses from employment of both types of households, in terms of consumption, and use this aggregate in the negotiation of hours and wages:

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

Lump sum transfers are aggregated in the usual way as

$$trh_t = \tau^b trh_t^b + \left(1 - \tau^b\right) trh_t^l$$

where we also assume that transfers are distributed according to the population size in each group such that $trh_t^b = trh_t^l = trh_t$. Finally, the aggregate public debt is given by,

$$b_t = -\left(1 - \tau^b\right) b_t^p$$

### 3.4 Production

The productive sector is organized in three different levels: (1) firms in the wholesale sector use labor and capital to produce a homogenous good that is sold in a competitive flexible price market at a price $P_t^w$; (2) the homogenous good is bought by firms (indexed by $\widetilde{j}$) in the intermediate sector and converted, without the use of any other input, into a firm-specific variety that is sold in a monopolistically competitive market, in which prices are sticky; (3) finally there is a competitive retail aggregator that buys differentiated varieties ($y_{\widetilde{j}t}$) and sells a homogeneous final good ($y_t$) at price $P_t$.

*The competitive retail sector*

The competitive retail aggregator buys differentiated goods from firms in the intermediate sector and sells a homogeneous final good $y_t$ at price $P_t$. Each variety $y_{\widetilde{j}t}$ is purchased at a price $P_{\widetilde{j}t}$. Profit maximization by the retailer implies

$$Max_{y_{\widetilde{j}t}} \left\{ P_t y_t - \int P_{\widetilde{j}t} y_{\widetilde{j}t} d_{\widetilde{j}} \right\}$$

subject to,

$$y_t = \left[ \int y_{\tilde{j}t}^{(1-1/\theta)} d_{\tilde{j}} \right]^{\frac{\theta}{\theta-1}} \tag{29}$$

where $\theta > 1$ is a parameter that can be expressed in terms of the elasticity of substitution between intermediate goods $\varkappa \geq 0$, as $\theta = (1+\varkappa)/\varkappa$. The first-order condition gives us the following expression for the demand of each variety:

$$y_{\tilde{j}t} = \left( \frac{P_{\tilde{j}t}}{P_t} \right)^{-\theta} y_t \tag{30}$$

Also from the zero profit condition of the aggregator, the retailer's price is given by:

$$P_t = \left[ \int_0^1 \left( P_{\tilde{j}t} \right)^{1-\theta} d\tilde{j} \right]^{\frac{1}{1-\theta}} \tag{31}$$

*The monopolistically competitive intermediate sector*

The monopolistically competitive intermediate sector comprises $\tilde{j} = 1, ...\tilde{J}$ firms each of which buys the production of competitive wholesale firms at a common price $P_t^w$ and sells a differentiated variety $y_{\tilde{j}t}$ at price $P_{\tilde{j}t}$ to the final competitive retailing sector described above. Variety producers stagger prices. Following Calvo (1983), only some firms set their prices optimally each period. Those firms that do not reset their prices optimally at $t$ adjust them according to a simple indexation rule to catch up with lagged inflation. Thus, each period a proportion $\omega$ of firms simply set $P_{\tilde{j}t} = (1+\pi_{t-1})^{\varsigma} P_{\tilde{j}t-1}$ (with $\varsigma$ representing the degree of indexation and $\pi_{t-1}$ the inflation rate in $t-1$). The fraction of firms (of measure $1-\omega$) that set the optimal price at $t$ seek to maximize the present value of expected profits. Consequently, $1-\omega$ represents the probability of adjusting prices each period, whereas $\omega$ can be interpreted as a measure of price rigidity. Thus, the maximization problem of the representative variety producer can be written as,

$$\max_{P^*_{\tilde{j}t}} E_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} (\beta\omega)^s \left[ P^*_{\tilde{j}t} \overline{\pi}_{t+s} y_{\tilde{j}t+s} - P_{t+s} mc_{\tilde{j}t,t+s} \left( y_{\tilde{j}t+s} + \kappa_f \right) \right] \tag{32}$$

subject to

$$y_{\tilde{j}t+s} = \left( P^*_{\tilde{j}t} \prod_{s'=1}^{s} (1+\pi_{t+s'-1})^{\varsigma} \right)^{-\theta} P^{\theta}_{t+s} y_{t+s} \tag{33}$$

where $P^*_{\tilde{j}t}$ is the price set by the optimizing firm at time $t$, $\overline{\pi}_{t+s} = \prod_{s'=1}^{s} (1+\pi_{t+s'-1})^{\varsigma}$, $mc_{\tilde{j}t,t+s} = \frac{P^w_{t+s}}{P_{t+s}} = \mu^{-1}_{t+s}$ represents the real marginal cost (inverse mark-up) borne at $t+j$ by the firm that last set its price in period $t$, $P^w_{t+s}$ the price of the good produced by the wholesale competitive sector, $\kappa_f$ is an entry cost which ensures that extraordinary profits vanish in imperfectly-competitive equilibrium, and $\Lambda_{t,t+s}$ is a price kernel which captures the marginal utility of an additional unit of profits accruing to households at $t+s$, i.e.,

$$\frac{E_t\Lambda_{t,t+s}}{E_t\Lambda_{t,t+s-1}} = \frac{E_t(\lambda_{1t+s}/P_{t+s})}{E_t(\lambda_{1t+s-1}/P_{t+s-1})} \tag{34}$$

The solution for this problem is

$$P^*_{\tilde{j}t} = \left(\frac{\theta}{\theta-1}\right) \frac{E_t \sum_{s=0}^{\infty} (\beta\omega)^s \Lambda_{t,t+s} \left[\mu^{-1}_{t+s} (P_{t+s})^{\theta+1} y_{t+s} \left(\prod_{s'=1}^{s} (1+\pi_{t+s'-1})^{\varsigma}\right)^{-\theta}\right]}{E_t \sum_{s=0}^{\infty} (\beta\omega)^s \Lambda_{t,t+s} \left[(P_{t+s})^{\theta} y_{t+s} \left(\prod_{s'=1}^{s} (1+\pi_{t+s'-1})^{\varsigma}\right)^{1-\theta}\right]} \tag{35}$$

Taking into account (31) and that $\theta$ is assumed time invariant, the corresponding aggregate price level is given by,

$$P_t = \left[\omega \left(P_{t-1}\pi^{\varsigma}_{t-1}\right)^{1-\theta} + (1-\omega)\left(P^*_t\right)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{36}$$

From (31) and (36) we can obtain an expression for aggregate inflation of the form,

$$\pi_t = \gamma^f E_t\pi_{t+1} + \varrho\widehat{mc}_t + \gamma^b\pi_{t-1}$$

where $\gamma^f = \frac{\beta}{1+\varsigma\beta}$, $\gamma^b = \frac{\varsigma}{1+\varsigma\beta}$ and $\varrho = \frac{(1-\beta\omega)(1-\omega)}{\omega(1+\varsigma\beta)}$.

*The competitive wholesale sector*

The competitive wholesale sector consists of $j = 1, ...J$ firms each selling a different quantity of a homogeneous good at the same price $P^w_t$ to the monopolistically competitive intermediate sector. Firms in the perfectly competitive wholesale sector carry out the actual production using labor and capital. Factor demands are obtained by solving the cost minimization problem faced by each competitive producer (we drop the firm index $j$ for simplicity),

$$\min_{k_t,v_t} E_t \sum_{t=0}^{\infty} (\beta^l)^t \frac{\lambda^l_{1t+1}}{\lambda^l_{1t}} \left(r_{t-1}k_{t-1} + w_t n_{t-1} l_{1t} + \kappa_v v_t\right) \tag{37}$$

subject to

$$y_t^n = Ak_{t-1}^{1-\alpha}(n_{t-1}l_{1t})^{\alpha} - \kappa_f \tag{38}$$

$$n_t = (1-\sigma)n_{t-1} + \rho_t^f v_t \tag{39}$$

where, in accordance with the ownership structure of the economy, future profits are discounted at the relevant rate $\left((\beta^l)^t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l}\right)$ of the patient household. Producers use two inputs, private capital and labor, combined in a standard Cobb-Douglas constant-returns-to-scale production function. $\rho_t^f$ is the probability that a vacancy will be filled in any given period $t$. It is worth noting that the probability of filling a vacant post $\rho_t^f$ is exogenous from the perspective of the firm. However, as far as the overall economy is concerned, this probability is endogenously determined according to the following Cobb-Douglas matching function:

$$\rho_t^w(1-n_{t-1}) = \rho_t^f v_t = \chi_1 v_t^{\chi_2}\left[(1-n_{t-1})\, l_2\right]^{1-\chi_2} \tag{40}$$

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

$$V(\Omega_t^f) = \max_{k_t, v_t} \left\{ y_t - r_{t-1}k_{t-1} - w_t n_{t-1} l_{1t} - \kappa_v v_t + \beta^l E_t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} V(\Omega_{t+1}^f) \right\} \tag{41}$$

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

$$r_t = (1-\alpha) mc_{t+1} \frac{y_{t+1}}{k_t} \tag{42}$$

$$\frac{\kappa_v}{\rho_t^f} = \beta^l E_t \frac{\lambda_{1t+1}^l}{\lambda_{1t}^l} \frac{\partial V_{t+1}}{\partial n_t} \tag{43}$$

where the demand for private capital is determined by (42). It is positively related to the marginal productivity of capital $(1-\alpha)\frac{y_{t+1}}{k_t}$ which, in equilibrium, must equate the gross return on physical capital. Expression (43) reflects that firms choose the number of vacancies in such a way that the marginal recruiting cost per vacancy, $\kappa_v$, 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 job in $t$ for a firm $(\lambda_{ft})$ is,

$$\lambda_{ft} \equiv \frac{\partial V_t}{\partial n_{t-1}} = \alpha mc_t \frac{y_t}{n_{t-1}} - w_t l_{1t} + (1-\sigma)\beta^l E_t \frac{\lambda^l_{1t+1}}{\lambda^l_{1t}} \frac{\partial V_{t+1}}{\partial n_t} \tag{44}$$

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 $t$, corrected for the probability that the job will continue in the future. Now using (44) one period ahead, we can rewrite condition (43) as:

$$\frac{\kappa_v}{\rho^f_t} = \beta^l E_t \left[ \frac{\lambda^l_{1t+1}}{\lambda^l_{1t}} \left( \alpha mc_{t+1} \frac{y_{t+1}}{n_t} - w_{t+1} l_{1t+1} + (1-\sigma) \frac{\kappa_v}{\rho^f_{t+1}} \right) \right] \tag{45}$$

### 3.5 Trade in the labor market: the labor contract

The key departure of search models from the competitive paradigm is that trading in the labor market is subject to transaction costs. Each period, the unemployed engage in job seeking activities in order to find vacant posts spread over the economy. A costly search 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 each other out, i.e.,

$$\rho^f_t v_t = \rho^w_t (1 - n_{t-1}) = \chi_1 v_t^{\chi_2} \left[ (1 - n_{t-1}) \, l_2 \right]^{1-\chi_2} = \sigma n_{t-1} \tag{46}$$

As 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. There is risk-sharing at the household level and hence consumption within each household type is independent of the employment status. Although patient and impatient households may have different reservation wages, they delegate the bargain process with firms to trade unions. 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 suffer the same unemployment rates[6]. Thus, following standard practice, the Nash bargain process

[6] Instead of relying on a trade union, we could have used the notion of collective bargaining on a single con-

maximizes the weighted product of the parties' surpluses from employment.

$$\max_{w_t, l_{1t}} \left( \left(1-\tau^b\right) \frac{\lambda^l_{ht}}{\lambda^l_{1t}} + \tau^b \frac{\lambda^b_{ht}}{\lambda^b_{1t}} \right)^{\lambda^w} \left(\lambda_{ft}\right)^{1-\lambda^w} = \max_{w_t, l_{1t}} \left(\lambda_{ht}\right)^{\lambda^w} \left(\lambda_{ft}\right)^{1-\lambda^w} \tag{47}$$

where $\lambda^w \in [0,1]$ reflects workers' bargaining power. The first term in brackets represents the worker's surplus (as a weighted average of borrowers' and lenders' surpluses), while the second is the firm's surplus. More specifically, $\lambda^l_{ht}/\lambda^l_{1t}$ and $\lambda^b_{ht}/\lambda^b_{1t}$ respectively denote the earning premium (in terms of consumption) of employment over unemployment for a patient and an impatient worker.

The solution of the Nash maximization problem gives the optimal real wage and hours worked (Boscá, Doménech and Ferri, 2011):

$$\begin{aligned} w_t l_{1t} = {} & \lambda^w \left( \alpha m c_t \frac{y_t}{n_{t-1}} + \frac{\kappa_v v_t}{(1-n_{t-1})} \right) \\ & +(1-\lambda^w) \left[ \left( \frac{(1-\tau^b)}{\lambda^l_{1t}} + \frac{\tau^b}{\lambda^b_{1t}} \right) \left( \phi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} - \phi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta} \right) \right] \\ & +(1-\lambda^w)(1-\sigma-\rho^w_t)\tau^b E_t \frac{\lambda^b_{ht+1}}{\lambda^b_{1t+1}} \left( \beta^l \frac{\lambda^l_{1t+1}}{\lambda^l_{1t}} - \beta^b \frac{\lambda^b_{1t+1}}{\lambda^b_{1t}} \right) \end{aligned} \tag{48}$$

$$\alpha m c_t \frac{y_t}{n_{t-1} l_{1,t}} = \left[ \frac{1-\tau^b}{\lambda^l_{1t}} + \frac{\tau^b}{\lambda^b_{1t}} \right] \phi_1 (1-l_{1t})^{-\eta} \tag{49}$$

Unlike the Walrasian outcome, the wage prevailing in the search equilibrium is related (although not equal) to the marginal rate of substitution of consumption for leisure and the marginal productivity of labor, depending on worker bargaining power $\lambda^w$. Putting aside the last term on the right hand side, the wage 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. They differ in the marginal utility of consumption ($\lambda^l_{1t}$ and $\lambda^b_{1t}$). If the marginal utility of consumption is high, the workers are ready to accept a relatively low wage.

tract to avoid multi-person Nash bargaining with asymmetric information on outside options. In any case, our approach makes it possible to circumvent problems associated with incentives for workers to reveal preferences and firms to perform screening. In addition, as Stähler and Thomas (2011) show in a model with *RoT* consumers, assuming individual bargaining between each worker and the firm does not change the steady-state results at all and only slightly changes the dynamics of wages.

The third term on the right hand side of (48) is part of the reservation wage that depends only on the existence of impatient workers (only if $\tau^b > 0$ this term is different from zero). It 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 will continue 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 hours and wage negotiation provide them to improve their lifetime utility, by narrowing the gap in utility with respect to patient consumers. In this sense, they compare the discounted intertemporal marginal rate of substitution had they not been income constrained $\left(\beta^l \frac{\lambda^l_{1t+1}}{\lambda^l_{1t}}\right)$ to the expected rate given their present rationing situation $\left(\beta^b \frac{\lambda^b_{1t+1}}{\lambda^b_{1t}}\right)$. For example if, *caeteris paribus,* $\beta^l \frac{\lambda^l_{1t+1}}{\lambda^l_{1t}} > \beta^b \frac{\lambda^b_{1t+1}}{\lambda^b_{1t}}$ the third term in (48) is positive, which indicates that impatient workers put additional pressure on the average reservation wage as a way to ease their period-by-period constraint in consumption. The size of this inequality term is positively related to the earning premium of being matched next period $\left(\frac{\lambda^b_{ht+1}}{\lambda^b_{1t+1}}\right)$, because it increases the value of a match to continue in the future, and negatively related to the job finding probability $(\rho^w_t)$, that reduces the loss of breaking up the match. Finally, notice that when $\tau^b = 0$, all consumers are patient and, therefore, the solutions for the wage rate and hours simplify to the standard ones (see Andolfatto, 2004).

### 3.6 Policy instruments and the accounting identity

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

$$1 + r^n_t = \left(1 + r^n_{t-1}\right)^{r_R} \left( (1+\pi_{t-1})^{1+r_\pi} \left(\frac{y_{t-1}}{\overline{y}}\right)^{r_y} (1+\overline{r}^n) \right)^{1-r_R} \tag{50}$$

where $\overline{y}$ and $\overline{r}^n$ are steady-state levels of output and interest rate, respectively. The parameter $r_R$ captures the extent of interest rate inertia, and $r_\pi$ and $r_y$ represent the 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.

$$y_t = A_t k^{1-\alpha}_{t-1} (n_{t-1} l_{1t})^\alpha = c_t + j_t \left(1 + \frac{\phi}{2}\left(\frac{j_t}{k_{t-1}}\right)\right) + g_t + \kappa_v v_t \tag{51}$$

Government revenues and expenditures each period are made consistent by means of the intertemporal budget constraint

$$b_t = g_t + trh_t + \frac{(1 + r_{t-1}^n)}{1 + \pi_t} b_{t-1} \tag{52}$$

where $trh_t$ stands for lump-sum transfers/taxes. In order to enforce the government's intertemporal budget constraint, the following fiscal policy reaction function is imposed

$$trh_t = trh_{t-1} - \psi_1 \left[ \frac{b_t}{gdp_t} - \overline{\left( \frac{b}{gdp} \right)} \right] - \psi_2 \left[ \frac{b_t}{gdp_t} - \frac{b_{t-1}}{gdp_{t-1}} \right] \tag{53}$$

where $\psi_1 > 0$ captures the speed of adjustment from the current ratio towards the desired target $\overline{\left( \frac{b}{gdp} \right)}$. The value of $\psi_2 > 0$ is chosen to ensure a smooth adjustment of current debt towards its steady-state level.

## 4. Calibration

*Parameters from previous studies*

The benchmark is calibrated using standard values in the literature for some parameters and matching some relevant data moments for the US economy. Thus, we take the value from Iacoviello (2005) 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 adjustment cost for housing capital $\phi_h = 0.0$ and the value $\tau^b = 0.36$ for the fraction of impatient consumers in the economy. In keeping with the results estimated in Iacoviello and Neri (2010), we choose the two values for the loan-to-value ratio that characterize the low and high indebtedness regime: $m^b = 0.735$ and $m^b = 0.985$ respectively. We take a very standard value for the Cobb-Douglas parameter $\alpha = 0.7$. We take the depreciation rate of physical capital $\delta = 0.025$ and the elasticity of matching to vacant posts $\chi_2 = 0.5$ from Monacelli *et al* (2010), whereas the exogenous transition rate from employment to unemployment, $\sigma = 0.15$, comes from Andolfatto (1996) and Cheron and Langot (2004). These authors also provide some average steady-state values, such as the probability of a vacant position becoming a productive job, which is assumed to be $\overline{\rho}^f = 0.9$, the fraction of time spent working, $\overline{l_1} = 1/3$, and the fraction of time households spend searching $l_2 = 1/6$. The long-run employment ratio is computed to be $\overline{n} = 0.75$ as in Choi and Rios-Rull (2008). Furthermore, we assume that equilibrium unemployment is socially-efficient (see Hosios, 1990) and, as such, $\lambda^w = 0.5$ is equal to $1 - \chi_2$. For the intertemporal labor elasticity of substitution, we consider $\eta = 2$ implying that average individual labor supply elasticity $\left( \eta^{-1} \left( 1/\overline{l_1} - 1 \right) \right)$ is equal to 1, the same as in Andolfatto (1996). The adjustment costs parameter for productive investment $\phi = 5.95$, is taken from QUEST II, which considers the same function as ours for capital installation costs. Parameters affecting the New Phillips Curve are also standard in the literature. We set a value of $\theta = 6$ for the elasticity of final goods implying a steady state markup of $\frac{\theta}{\theta-1} = 1.2$. Hence, the steady state value for the marginal cost is obtained as $\overline{mc} = \frac{\theta-1}{\theta}$. The probability of not changing prices, $\omega$, is set to 0.75, meaning that prices change every four quarters on average, whereas we take an intermediate value, $\varsigma = 0.4$, for inflation indexation.

*Calibrated parameters from steady-state relationships*

We normalize both steady-state output ($\overline{y}$) and real housing prices ($\overline{q}$) to one. Steady-state government expenditure $\overline{g}/\overline{y}$, is set to 17 per cent of output (*US Bureau of Economic Analysis* data for 2009). We obtain the long-run value for vacancies from (46) $\overline{v} = \sigma\overline{n}/\overline{\rho}^f$. 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) or Choi and Rios-Rull (2008), and very close to the value of 0.44 implied by the calibration of Monacelli, Perotti and Trigari (2010). From this ratio we obtain a value of $\kappa_v = 0.04$ and using the steady-state version of equation (45), we can solve for the value of wages ($\overline{w}$). 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 $\chi_1 = 1.56$.

The the long-run value of total factor productivity, $A = 1.521$, is calibrated from the production function (51), using (3) and (9) to obtain the steady-state value of Tobin's $q$ ratio, $\frac{\overline{\lambda}_2^l}{\overline{\lambda}_1^l}$, the return on capital ($\overline{r}$) from (8) and the steady-state value for the capital stock ($\overline{k}$) from (42). The capital stock together with the depreciation rate and the adjustment cost parameter allow us to calculate the value of gross investment for the steady state, and, using (51), the level of consumption $\overline{c}$. The steady-state value of the nominal interest rate $\overline{r}^n$, is related to the intertemporal discount rate of lenders through the steady-state version of equation (10). The value for the transfers in the steady-state $\overline{trh}$ are such that from (52) the resulting debt to output ratio is 60 per cent on annual terms. In order to compute $\kappa_f$, we aggregate the income restriction of both households in the steady-state, to obtain

$$c + j\left(1 + \delta\frac{\phi}{2}\right) + g_t = nwl + rk + \kappa_f$$

where $\kappa_f = \left(1 - \tau^b\right) d^l$.

Let $\gamma_l$ be the ratio of assets of patient households in the steady-state to total output ($\overline{b}^l = \gamma_l\overline{y}$) and conditional to the value of $\gamma_l$, we can obtain the steady-state values of several variables. Equation (24) yields $\overline{b}^b$. 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 in 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 then obtain the borrowers' steady-state housing holdings $\overline{x}^b$ from (15), and the long-run equilibrium value of the collateral constraint shadow price $\overline{\mu}^b$ from (19). This makes it possible to compute the parameter that accounts for the housing weight in life-time utility $\phi_x$, from the last first-order condition of borrowers' optimization program (equation (20)). The value of the parameter $\phi_x$ 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). Notice that the values we obtain for $\phi_x$ and $X$ depend on the value we assign to the ratio of assets of patient households in the steady state to total output $\gamma_l$. 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 $\gamma_l$, such that the total stock of housing over yearly output is 140 per cent. The resulting value for $\phi_x$ is 0.10.

As regards preference parameters in the household utility function, $\phi_1 = 1.595$ is calculated from the steady-state version of expression (49). A system of three equations implying the steady state of expressions (12) (21) and (48) is solved for $\phi_2$, $\overline{\lambda}_h^b$ and $\overline{\lambda}_h^l$. The resulting value for $\phi_2$ is 1.043. Therefore the calibrated values for $\phi_1$ and $\phi_2$ are similar to those in Andolfatto (1996) and other related research in the literature. Such values imply that the value for leisure imputed by an employed worker is well above that imputed 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). We choose a value of 0, for the parameter measuring the interest rate reaction to output $r_y$, and assume $\psi_1 = 0.01$ and $\psi_2 = 0.2$ for the fiscal rule. Finally, the government expenditure shock persistence $\rho_g$ is equal to 0.75, as in Brückner and Pappa (2010).

## 5. Results

### 5.1 Fiscal policy in models with financially restricted consumers.

In this subsection we present impulse-response functions to a (one per cent of GDP) transitory public expenditure shock of some key macroeconomic variables: output, consumption, real wages, hours per worker, unemployment and vacancies[7]. The aim of this exercise is to compare the effects of the fiscal shock under three different modeling strategies: a basic search model with homogeneous consumers[8], a search model with a 0.36 share of RoT consumers[9] and a search model with indebted consumers (0.36 share of impatient consumers and a loan-to-value ratio of 0.985). All models share price rigidity that lasts for four quarters.

The results are depicted in Figure 1. The output response to the public consumption shock is positive in all three models. However, the expansionary effect varies substantially across models, ranging from a high impact multiplier near 2 per cent in the RoT model, to approximately 0.8 points in the basic search model with Ricardian consumers and an intermediate value of around 1.2 per cent in an economy with credit constrained individuals. These differences in output multipliers are explained by the different responses of consumption across models. In a standard search model, populated only with optimizing individuals, the consumption response to the fiscal shock is negative (impact consumption multiplier of around $-0.2$), due to the negative wealth effect associated with expectations of future tax rises to finance the increase in government expenditure. On the contrary, the consumption response in the search model augmented with RoT consumers is highly positive (approximately 1.8 per cent on impact). Finally, in the model with borrowing restrictions, the impact on consumption is positive (around 0.4 points), but more modest than in the presence of households that do not participate in the financial market.

In order to gain some economic intuition from this result it is worth looking at the different consumption patterns of the three type of agents in these models, which we can write as

$$c_t^l = \left[ \beta^l E_t \left( \frac{\frac{r_t^n+1}{1+\pi_{t+1}}}{c_{t+1}^l} \right) \right]^{-1} \tag{54}$$

$$c_t^{RoT} = w_t l_{1t} n_{t-1}^{RoT} \tag{55}$$

[7] In this paper we do not assess the dynamic properties of the model. In a companion paper we conduct an exhaustive analysis of a similar model subject to technology shocks and find that the proposed structure matches the data moments of most labor market variables, both before and after the mortgage market deregulation in the 80s (Andrés, Boscá and Ferri, 2011).

[8] Our benchmark model with impatient consumers that are credit constrained can be tranformed into a standard search and matching model with homogeneous consumers by setting $\tau^b = 0$.

[9] Eliminating preferences for housing from the utility function ($\phi_x = 0$), setting the temporal discount rate $\beta^b = \beta^l$ and assuming that a share of households, $\tau^b$ ,consume just their current income converts the benchmark model into a serch model with a $\tau^b$ share of RoT consumers.

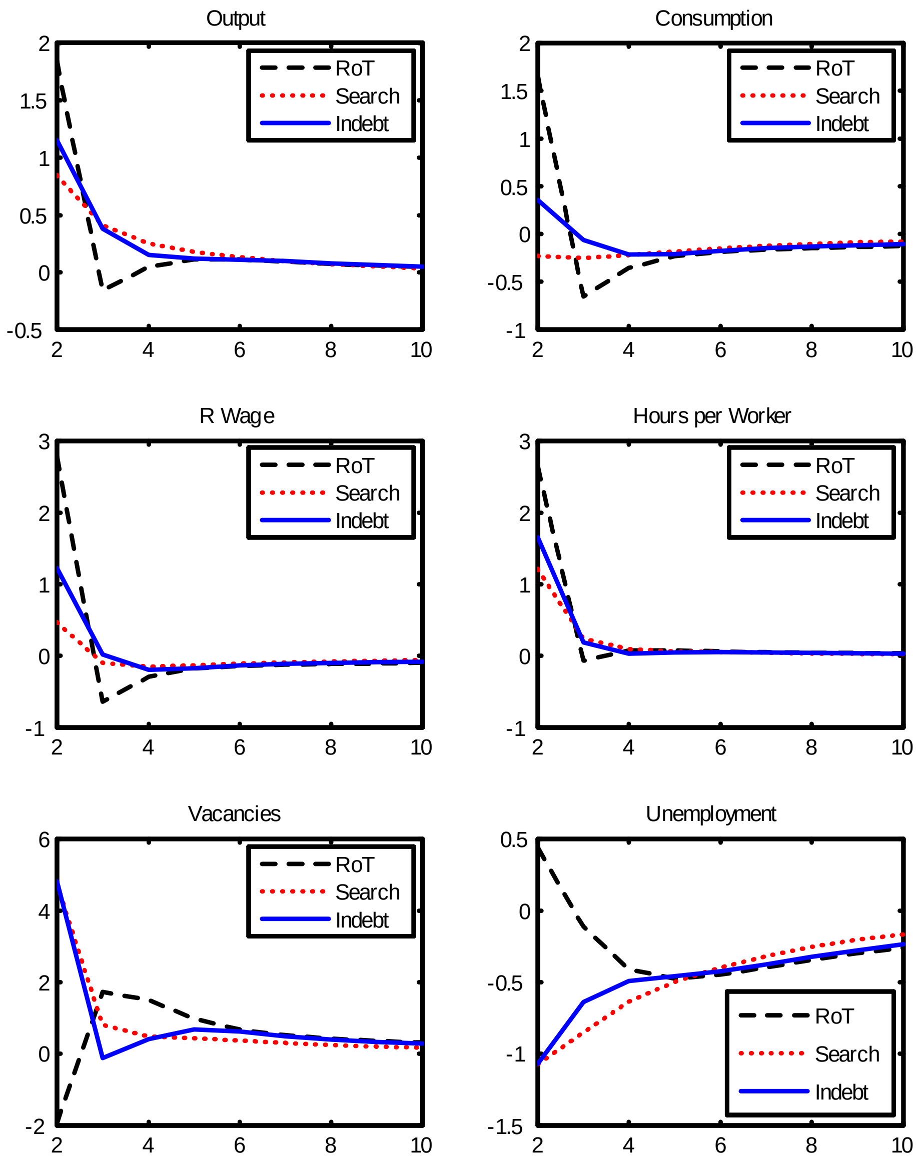



**Figure 1:** *Effects of a transitory public consumption shock: basic search model, search model with RoT's, and search model with borrowers and lenders.*

$$c_t^b \approx \Theta \left( w_t l_{1t} n_{t-1}^b + nw_t \right) \tag{56}$$

$$nw_t = \left[ q_t x_{t-1}^b - m^b \frac{E_{t-1}\left(q_t\left(1+\pi_t\right)\right) x_{t-1}^b}{\left(1+\pi_t\right)} \right] \tag{57}$$

Patient household consumption (54) is driven by expectations of future income since they allocate their wealth optimally across time depending on income expectations and the real interest rate. RoT household consumption responds one-to-one to changes in their labor income ($w_t l_1 n_{t-1}^{RoT}$) every period (55). The consumption possibilities of impatient households (56) are determined not only by their current labor income but also by their net worth [10]. Net worth, (57), is defined as the value of households' asset holdings net of debt. As a consequence of the fiscal stimulus, the negative wealth effect on lenders pulls the price of assets down, more than offsetting the capital gains on outstanding debt caused by higher but sluggish inflation. The negative response of net worth weakens the consumption response of leveraged agents as compared with that of fully constrained non-leveraged agents. Alternatively we can explain this result by looking at the reaction of the borrowing limit (15) after the fiscal shock. Both the (current and expected) deterioration in the relative price of houses $q_t$, and the increase in the real interest rate reduce the amount of credit that impatient consumers can obtain in the market. The negative financial impact of the fiscal shock on indebted households (either reflected in their net worth or in their borrowing possibilities) dampens the reaction of their consumption[11].

This pattern of consumption responses is essential to understand the differences in the dynamics of the main labor market variables. The increase in aggregate demand pushes the relative price of the competitive sector up with respect to the non-competitive sector $\left(\frac{P_t^w}{P_t}\right)$ and the demand for labor (49). Also, the increase in consumption of constrained agents raises their demand for leisure, thus reinforcing the relative bargaining power of the union (48), which results in a substantial wage rise. This effect is significantly smaller in the basic search model, in which the increase in the marginal utility of consumption of Ricardian consumers weakens their bargaining position.

The quantitative differences at the intensive margin (average hours) lead to opposite predictions regarding the response of the extensive margin, vacancies and unemployment, as depicted in the final row of plots in Figure 1. Large increases in wages and hours

[10] Equation (56) is as an approximation that holds exactly under linear preferences on labor supply and a frictionless labor market. In the presence of search and matching frictions the marginal propensity to consume ($\Theta$) is not constant, but varies over the cycle (see Appendix 1).

[11] As we shall discuss later, the size of this net worth effect hinges crucially upon the value of $m^b$.

worked discourage new vacancy posting and reduce total employment as in the RoT model, whereas in both the pure search model and in the model with leveraged households unemployment falls. In order to understand these different responses we must look at the dynamic response of the $\frac{P^w_t}{P_t}$ ratio which is a key determinant of the vacancy posting decision. The RoT model generates large swings in this ratio that first rises, due to the sluggish response of aggregate prices, $P_t$, and then falls sharply as aggregate prices start increasing following the strong increase in consumption on impact. This reduces the incentive to post vacancies (see equation (45)), which in turn contributes to generating higher unemployment[12]. The response of the marginal cost is much more muted in the other two models due to the modest reaction of aggregate consumption and hence of $P_{t+1}$. Thus, although $\frac{P^w_{t+1}}{P_{t+1}}$ also falls once the upward adjustment of prices is underway, it remains above the steady-state value, encouraging vacancy posting and reducing unemployment.

The previous analysis can be summarized as follows. First, it is possible to obtain a Keynesian output multiplier for government expenditure (a multiplier higher than one) and a positive response of aggregate private consumption in a model characterized by the presence of impatient consumers that participate in financial markets. In that case, the consumption response is positive, but lower than that predicted by the standard model with rule-of-thumb consumers. Therefore, macroeconomic models that use RoT consumers may be exacerbating the effects of fiscal policy. Second, while the use of RoT consumers has become accepted in DSGE models on the basis of their ability to match a positive correlation between consumption and government spending, they may generate results in terms of the reaction of some labor market variables, in particular vacancies and unemployment, that are at odds with what is observed in the data. Thus, although some departure from the pure intertemporal substitution model is needed to generate sound effects of fiscal innovations, the role of private leverage is vital to improve our understanding of both the output and unemployment fiscal multipliers. Neither too much nor the absence of intertemporal substitution seem realistic settings to study complex issues such as those involved in the reaction to fiscal shocks. In what follows we look at the role of the determinants of private indebtedness in more detail.

### 5.2 Fiscal policy and private indebtedness.

We now turn our attention to the study of the impact of the degree of private indebtedness on the magnitude of fiscal multipliers. Figure (2) depicts the impact fiscal multipliers of our variables of interest as a function of the share of borrowers ($\tau^b$) and for two different values of the loan-to-value (a low $m^b = 0.735$ and a high $m^b = 0.985$). These parametric

[12] $P_{t+1}$ is expected to rise as prices in the non-competitive sector begin to adjust. The opposite is expected for $P^w_{t+1}$ due to a sharp decrease in wages and an increase in unemployment, which drag consumption and aggregate demand down.

changes in the intensive (loan-to-value ratio) and extensive (share of borrowers in total population) borrowing margins capture variations in the amount of household indebtedness in the economy. We define the fiscal multiplier on a variable $x$ ($\varrho_x$) as the ratio between the initial change in the variable from its steady state $\dot{x}_0$, and the initial variation of government spending $\dot{g}_0$, that is $\varrho_x = \frac{\dot{x}_0}{\dot{g}_0}$.

The results in Figure 2 indicate that the fiscal multipliers to a transitory government expenditure shock are very sensitive to the degree of private indebtedness of the economy. When the borrowing capacity of borrowers is high (high loan-to-value ratio) the output multiplier (first column, second row in the figure) is less than one only if the share of borrowers in the population is very low (less than 25 per cent). However, increasing the share of restricted consumers makes the output multiplier grow steadily to values around 1.75 when half of the population is subject to borrowing constraints. On the contrary, if the loan-to-value is low ($m^b = 0.735$), the impact output multiplier is always less than one, no matter what the share of borrowers in the economy. Output behavior can be better understood by looking at the response of aggregate consumption to the shock. The borrowing capacity of an impatient household, and hence its consumption possibilities, increases with the loan-to-value ratio, which is reflected in the vertical distance, for a given share of borrowers, between the two lines depicting borrowers' consumption. Additionally, the share of impatient households in the population $\tau^b$, positively affects the response of aggregate consumption to the shock. This is due to a two-fold effect. On the one hand, a higher $\tau^b$ puts additional pressure on wages, increasing borrowers' income and consumption. On the other hand, $\tau^b$ directly affects the weight of borrowers' consumption in aggregate consumption. Notice that in the wage equation the influence of $\tau^b$ is more intense the higher the loan-to-value ratio, because $\tau^b$ is multiplying the inverse of the marginal utility of consumption, $\frac{1}{\lambda_{1t}^b}$ (which increases with $m^b$). As a result the impact of the fiscal shock on wages, consumption and output increases faster with $\tau^b$ when $m^b$ is high.

The pattern of wages and hours worked closely mimics that of the consumption of constrained households. When the impact multiplier on consumption is high, there is a sharp increase in aggregate demand that pushes relative prices $\frac{P_t^w}{P_t}$ up and which translates into higher impact multipliers on hours per worker. Interestingly, a positive government expenditure shock always produces a positive multiplier in terms of vacancies and employment (negative multiplier for unemployment). In this case, the impact multiplier function is very similar for a high and low loan-to-value and very flat for a share of borrowers lower than 0.4. This happens because vacancy posting at period $t$ and hence (un)employment depend crucially on expectations about tomorrow's relative

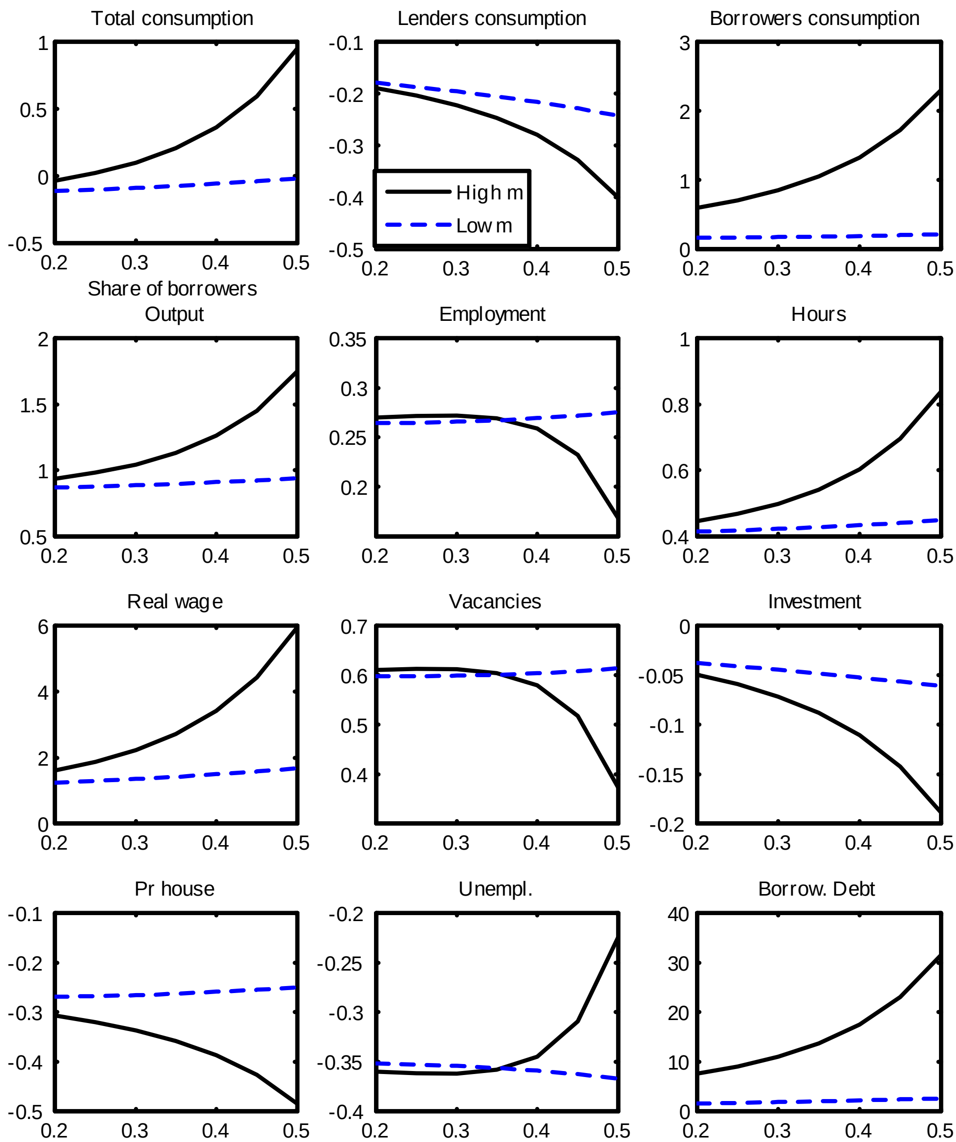



**Figure 2:** *Impact multiplier as a function of the share of borrowers*

prices ($\frac{P^w_{t+1}}{P_{t+1}} = mc_{t+1}$) and labor costs ($w_{t+1}l_{1t+1}$), which are very similar for high and low loan-to-value ratios, except when the share of borrowers in the economy is high enough. Regarding housing prices, we observe a fall following the fiscal expansion in all cases. However, the effect is stronger for high loan-to-value ratios and especially so as the share of borrowers rises. The explanation for this finding can be found in the reaction of the real interest rate, which increases more strongly when both $m^b$ and $\tau^b$ are high. This encourages savers to postpone current consumption and reduces the demand for houses.

All the previous results refer to impact multipliers, which are the most commonly used in the literature. Recently Uhlig (2010) has argued that short run multipliers can be misleading. Thus, in figure A.1 (Appendix 2) we check the sensitivity of our results to calculate the present value fiscal multipliers at four and twenty quarters[13], and we find a similar pattern for them to the impact multiplier.

### 5.3 Fiscal multipliers, price stickiness and persistence.

The fiscal multiplier also depends on other characteristics of the economy that interact with the magnitude of the financial friction. Here we study two such features that have received special attention in the literature. First, the effect of the degree of price stickiness, the relevance of which in explaining the business cycle properties of the US economy has been analyzed in a search and matching framework by Krause and Lubik (2007). Second, the effect of the persistence of the shock, which is a key policy parameter that determines the effects on economic activity of expansionary or consolidation fiscal packages and which has been studied by Harms (2002), Galí et al. (2007) and Mayer, Moyen and Stähler (2010), among others.

Figure 3 represents the impact multipliers as a function of the price rigidity parameter ($\omega$) for the benchmark calibration of the share of borrowers (0.36) and for the two regimes related to the loan-to-value ratio. The first important result is that the impact multipliers for high and low loan-to-value ratios are very similar when the value of $\omega$ is lower than 0.5. Second, the impact multipliers become stronger as price stickiness increases above the 0.5 threshold, in particular in an economy with high $m^b$. Therefore, in highly leveraged economies these multipliers can be considerably higher than in low leveraged economies if price rigidity is important. Third, the model is able to generate a crowding-

[13] We define the net present value fiscal multiplier for variable $x$ at date $t$ as

$$\varrho_{xt} = \frac{\sum_{s=0}^{t} (1 + r^n_t)^{-s}\, \dot{x}_s}{\sum_{s=0}^{t} (1 + r^n_t)^{-s}\, \dot{g}_s}$$

in in consumption (and a Keynesian output multiplier) for values of the price rigidity parameter higher than 0.6 (when $m^b = 0.985$) or higher than 0.8 (when $m^b = 0.735$). Fourth, the vacancies and (un)employment multipliers are always positive (negative) for any degree of price rigidity.

The main intuition behind all these results is that increasing price rigidity weakens the positive response of the expected real interest rate and cushions the reduction in the marginal cost in the next period $\frac{P^w_{t+1}}{P_{t+1}}$ (as compared to its current value). The former effect dampens the fall in lenders' consumption and housing prices. As the borrowing capacity of impatient households depends on the value of their collateral, the milder reaction of housing prices also helps to increase the consumption of borrowers (in comparison to an economy with larger swings in asset prices). The latter effect, i.e. that related to the behavior of relative prices $\frac{P^w_{t+1}}{P_{t+1}}$, explains why vacancies and employment increase by more with price rigidity.

Figure 4 presents the effects of the degree of persistence of fiscal shocks on the impact multipliers of the variables of interest. In keeping with previous figures, results are shown for a high and low loan-to-value ratio while keeping our benchmark calibration for the share of borrowers and the degree of price rigidity. As can be seen, in an economy with a low loan-to-value ratio and, thus, with limited indebtedness capacity of impatient consumers, aggregate consumption impact multipliers are always negative and do not vary notably with the degree of persistence of fiscal shocks. This crowding-out effect on consumption results in output multipliers that are always lower than 1 in this scenario. For a high $m^b$ the effects of the persistence of fiscal policy are more visible. In general the multipliers obtained in a high leverage regime are more pronounced than those for a low leverage regime, whatever the value of the persistence parameter. However, the value of the multipliers in both regimes tends to converge when the fiscal stimulus is highly persistent. In other words, when $m^b = 0.985$, consumption, output, wage and hours multipliers decrease substantially with the degree of persistence, whereas vacancies and employment multipliers increase. Thus, when $\rho_g$ is close to one, multipliers are very similar in both leverage regimes.

In order to understand the economics behind these results, we have to once again appeal to the reactions in real interest rates $\frac{r^n_t+1}{1+\pi_{t+1}}$ and relative prices, $\frac{P^w_{t+1}}{P_{t+1}}$. The degree of persistence of fiscal shocks affects the consumption of savers in the same manner as in Galí *et. al* (2007): higher persistence is associated with stronger negative wealth effects that lower consumption. In our model, there is an additional mechanism at work, which operates mainly through the consumption of indebted households. Higher persistence of fiscal policy means that public expenditure will remain high tomorrow, implying persistently higher real interest rates and thus lower current housing prices. These two effects

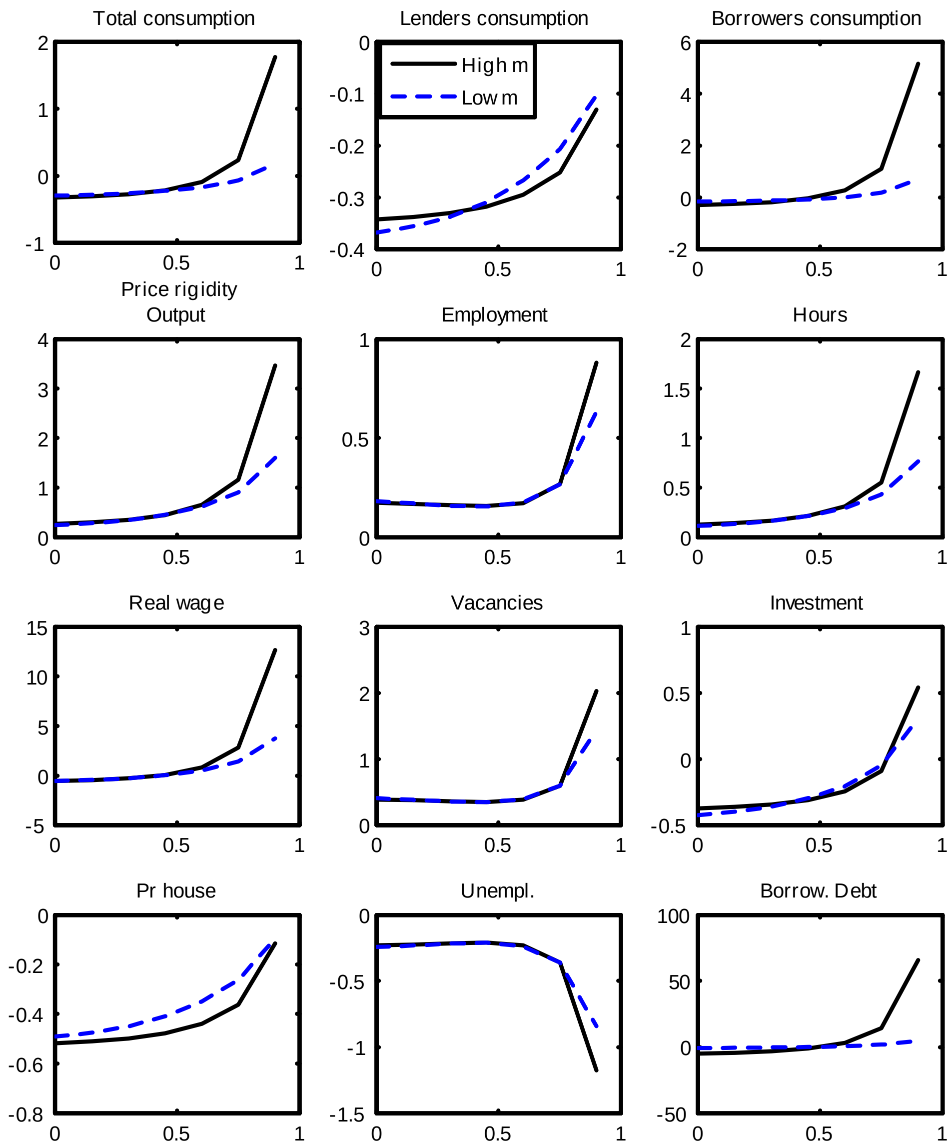



**Figure 3:** *Impact multiplier as a function of price rigidity*

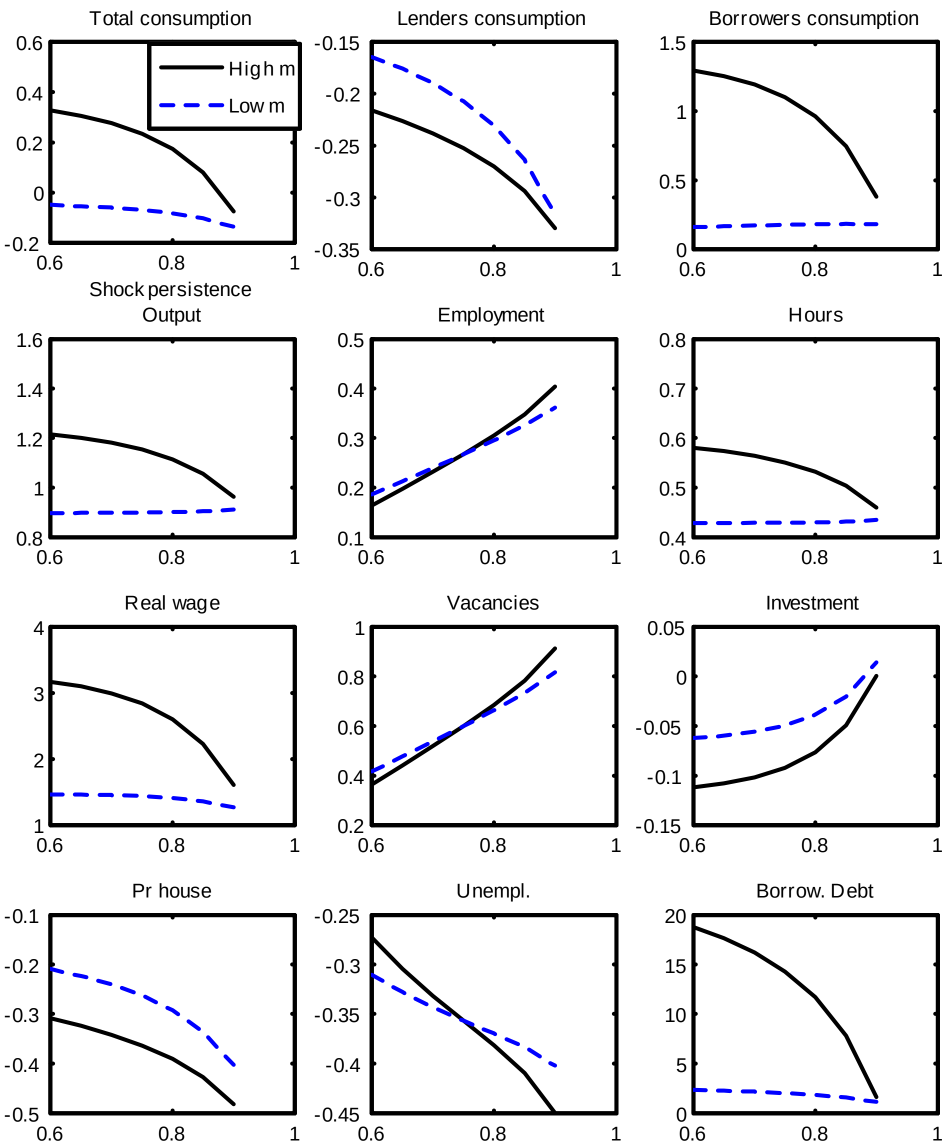



**Figure 4:** *Impact multiplier as a function of the shock persistence*

erode the borrowing and consumption capacities of impatient households and also result in lower aggregate output and consumption multipliers.

What happens in the labor market? First, the mechanism explained above, operating through the marginal utility of consumption, is responsible for reducing the impact multipliers on wages and hours when persistence increases. Second, a more persistent government spending shock implies that aggregate demand in $t+1$ remains higher and thus, relative prices will fall less tomorrow, improving the willingness of firms to posting vacancies. As a consequence, if fiscal policy is more persistent in a high leveraged economy, the impact multipliers of employment and unemployment are greater in absolute value[14].

### 5.4 Keynesian fiscal multipliers?

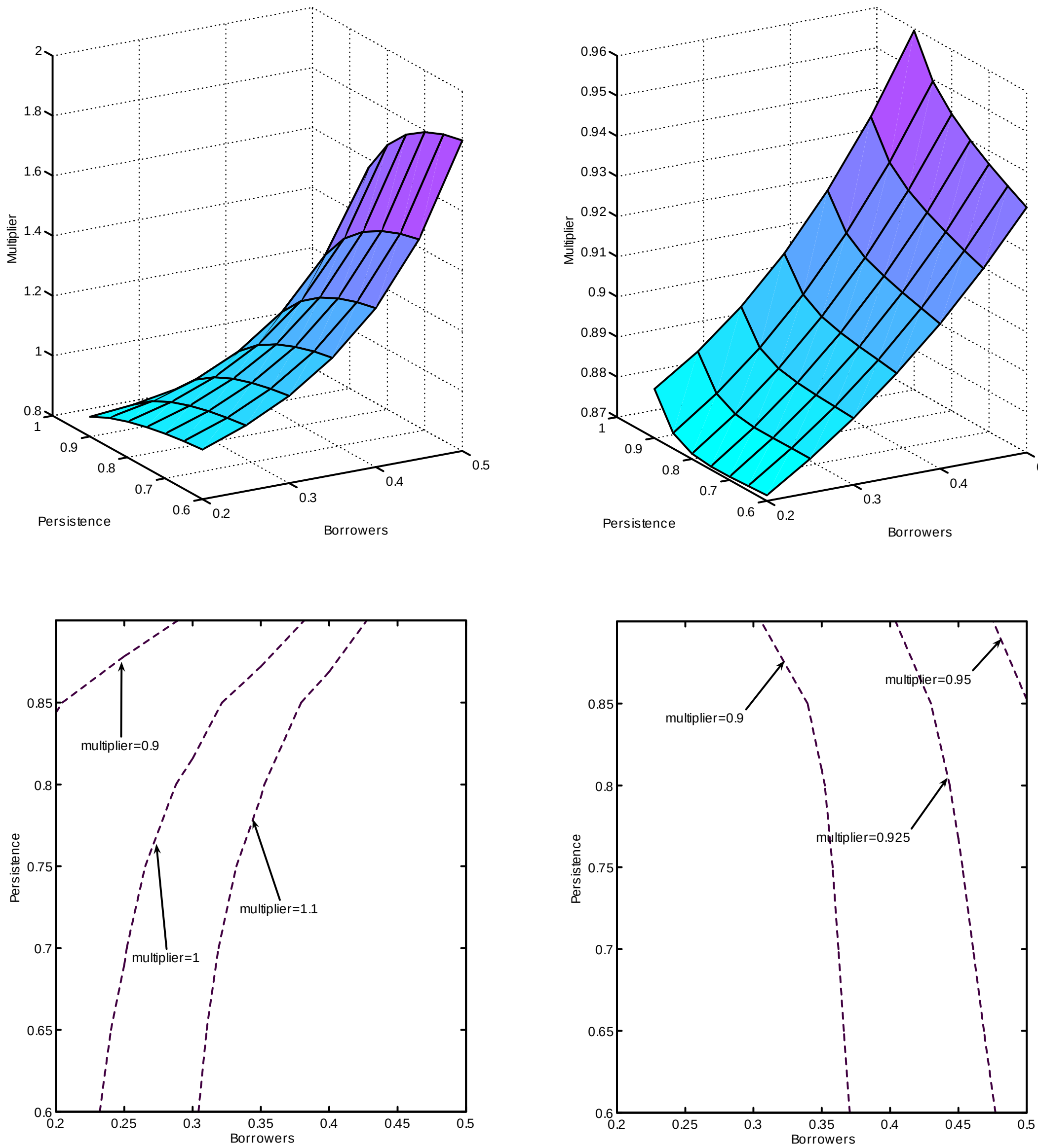
In this section we present some additional results about the impact output multiplier in terms of the interaction of three key parameters in our model. Figure 5 shows the values of the output multiplier as a function of the share of borrowers and the degree of persistence of the fiscal shock, keeping price rigidity at the benchmark value and $m^b = 0.985$. In the first panel in the top of the figure, we depict a tridimensional plot showing the value of the multiplier along the two dimensions. In particular, we are interested in the parameter combinations that deliver a fiscal multiplier on output greater than one (Keynesian multiplier). In the second panel of the figure we represent contours of the previous figure for three different values of the output multiplier (0.9, 1.0 and 1.1). As is clear from this graph, a Keynesian multiplier can be obtained for a wide range of combinations of number of borrowers and government spending shock persistence. For instance, if the share of borrowers is higher than 0.4, we obtain a multiplier higher than one regardless of the degree of persistence. However, if the share of borrowers is around 0.25, we need shock persistence to be lower than 0.6 to obtain the Keynesian multiplier. The last panel in the figure displays similar contours, but now from a tridimensional picture for an economy with lower borrowing capacity ($m^b = 0.735$). As we can see, in this case there are no combinations of reasonable values of both parameters that generate Keynesian output multipliers.

Figure 6 depicts the impact multipliers that result from the interaction among the share of borrowers and the degree of price rigidity. We keep persistence at its baseline value. As a general result, for parameters of price rigidity higher than 0.8 we always obtain Keynesian output multipliers, as can be observed in the contour plots in the lower panels of Figure 6. Interestingly, changes in the share of borrowers only affect the values of

[14] A sensitivity analysis of the results in this subsection to the time span considered to calculate the fiscal multipliers can be found in Figures A.2 and A.3 in Appendix 2.

the output multiplier if the price rigidity parameter is above a threshold near 0.6. The combination of a very high loan-to-value ratio with high price rigidity and a large proportion of constrained consumers causes the fiscal multiplier to skyrocket.

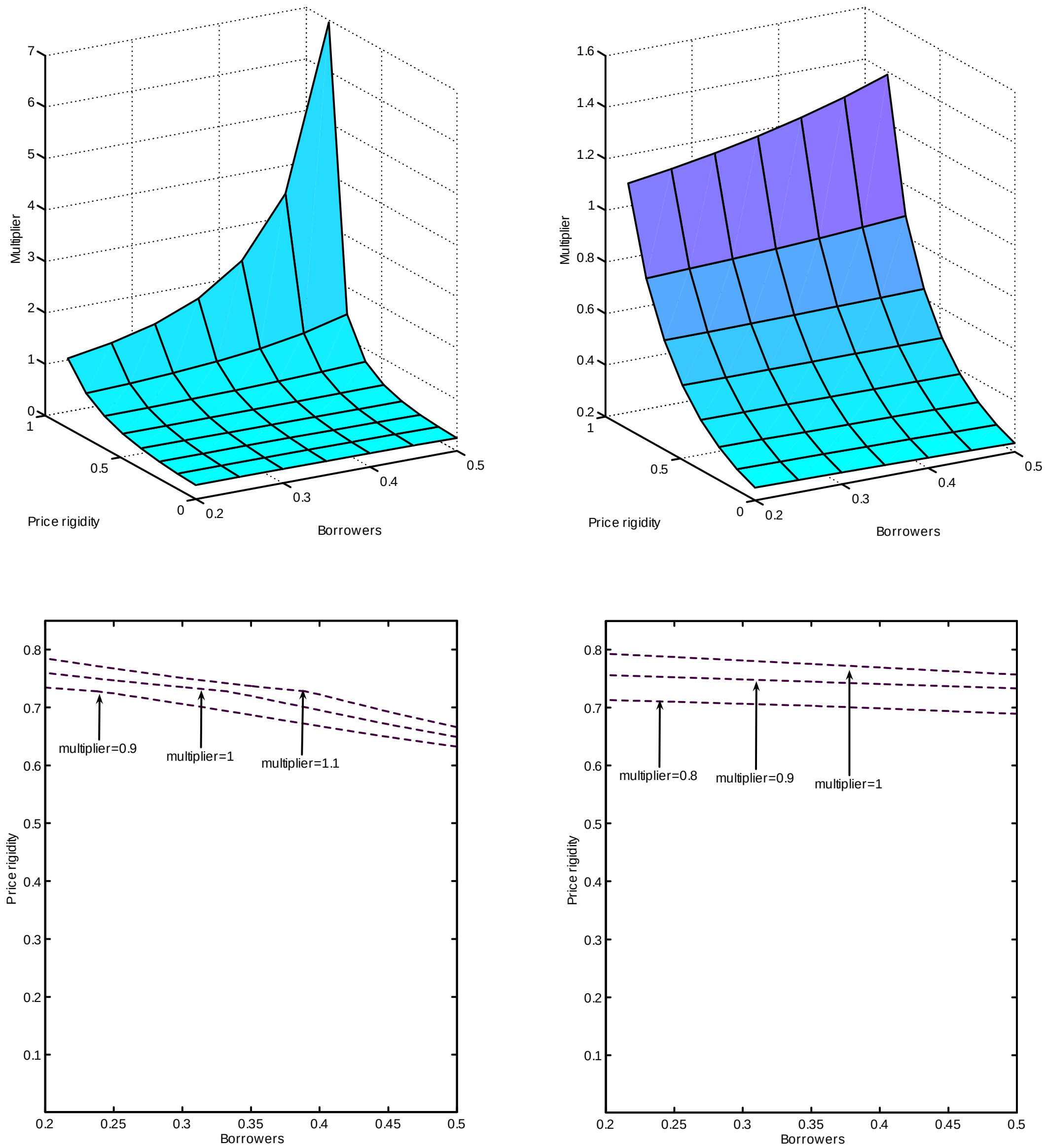
Finally, Figure 7 analyzes the effect of alternative combinations of the persistence of the shock and price stickiness on output multipliers, keeping the share of borrowers at its standard level. The graphs show that a price rigidity parameter roughly above 0.75 always generates a Keynesian multiplier whatever the persistence of the fiscal shock. Moreover, when price rigidity is approximately above 0.6, increasing the persistence of the shock reduces the value of the multiplier. However, the opposite is true when prices are very flexible. In that case higher persistence contributes to increase the multiplier. Again, in the low leverage regime ($m^b = 0.735$), persistence does not interact with price rigidity to produce significant changes in the multiplier.




High loan-to-value

High loan-to-value

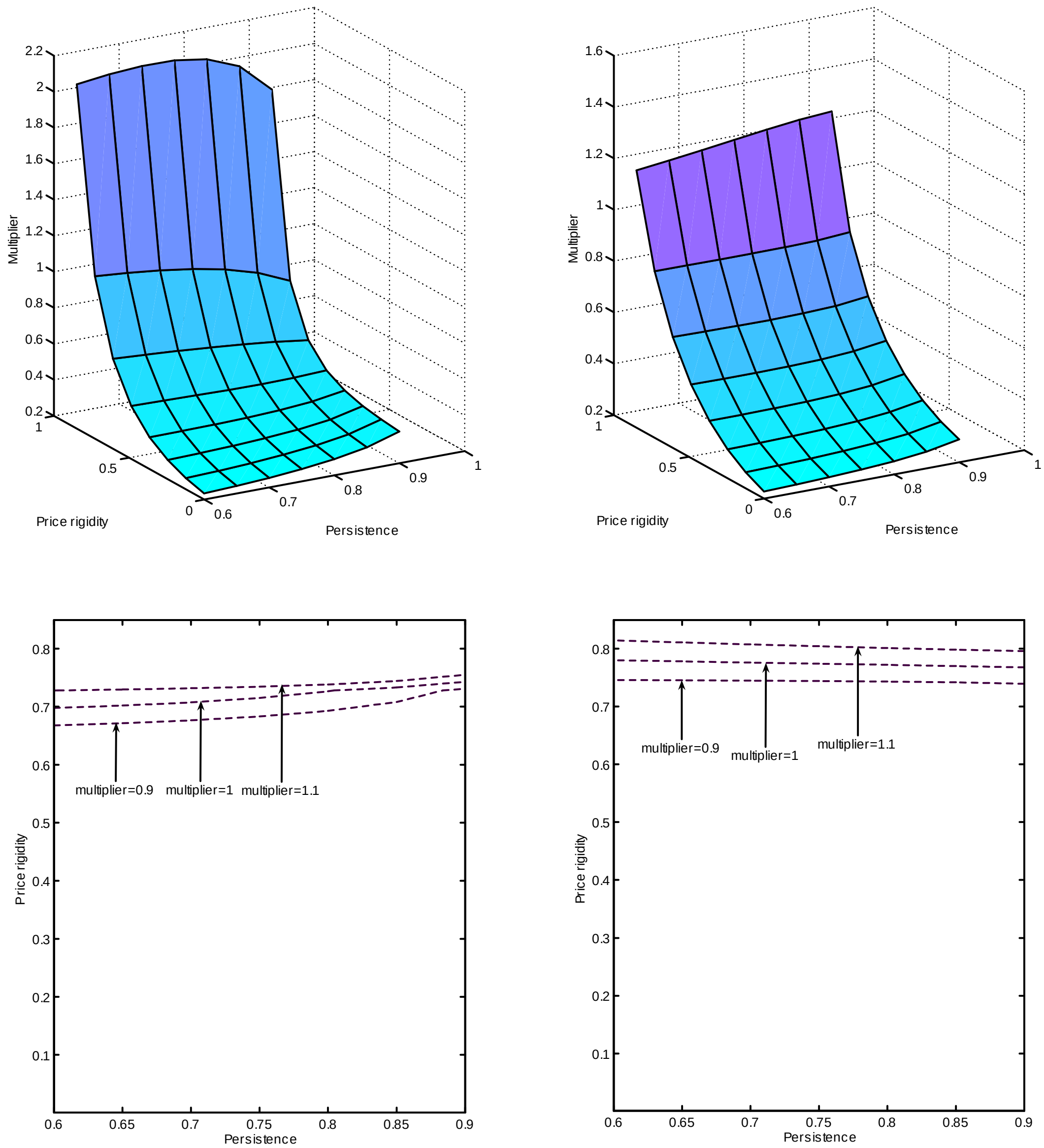
**Figure 5:** *Impact fiscal multiplier as a function of the share of borrowers and persistence*




High loan-to-value

Low loan-to-value

**Figure 6:** *Impact fiscal multiplier as a function of the share of borrowers and price rigidity*




High loan-to-value

Low loan-to-value

**Figure 7:** *Impact fiscal multiplier as a function of persistence and price rigidity*

### 5.5 Fiscal consolidation and borrowing capacity.

In this section we use our model to examine the effects of fiscal consolidation driven by a cut in public expenditure under two different scenarios regarding the borrowing capacity of households. We also consider two alternative strategies about the path followed by the government to reduce spending. In the first, the government reduces spending by little in the present, but announces that it will be reduced by more in the future. In the second, it is assumed that most of the government spending reduction takes place in the first periods. Using Hall's words (see Hall, 2009) we name the first scenario as a "back-loading consolidation strategy" and the second as a "front-loading consolidation strategy"[15]. In both cases we assume that the total cut in government expenditure is the same, although the timing along a period of five years is quite different. More precisely, and to stick to real numbers, we simulate a five-year back-loaded fiscal consolidation, which is the inverse of the fiscal stimulus in the American Recovery and Reinvestment Act, as calculated by Cogan et. al. (2010, Figure 2). In the case of the front-loaded consolidation strategy, government expenditure reductions follow an autorregressive pattern, with our benchmark persistence parameter $\rho_g = 0.75$.

Figure 8 depicts the temporal pattern of government spending cuts for the two scenarios considered quarterly. We feed our model with each of the strategies displayed in the figure and calculate the effects on GDP under our two values of the loan-to-value ratio ($m^b = 0.985$ and $m^b = 0.735$). By comparing the results for both values of the loan-to-value ratio we intend to establish the influence of the capacity of households to borrow on the output effects of a fiscal consolidation.

Table 1 presents the results yearly. According to the panel on the left-hand side of the table, when the fiscal consolidation follows a back-loading strategy, borrowing opportunities in the economy do not seem to play an important role in the GDP effects of the consolidation. However, when government follows a very aggressive strategy of fiscal consolidation, reducing government spending a great deal in the initial quarters, the effects on GDP are very dependent on households' borrowing opportunities. In particular, fiscal consolidation is less harmful under a low indebtedness capacity situation. After five years, a fiscal consolidation in a situation of a low loan-to-value ratio saves around 0.7 percent of lost GDP, with respect to scenario of high indebtedness capacity. Finally, the results also indicate that in a situation of low borrowing (low loan-to-value ratio) the front-loading strategy is less harmful than hypothetical back-loaded policy.

[15] The question of delays in government spending is also a central point in Leeper et al (2010).

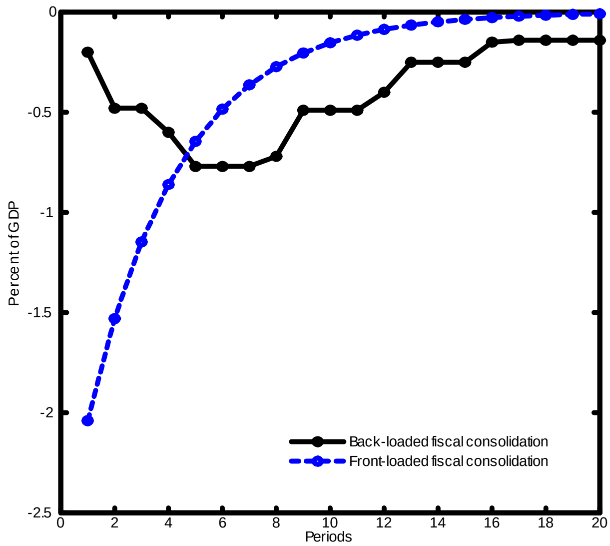



**Figure 8:** *Back-loaded fiscal consolidation and front-loaded fiscal consolidation*

TABLE 1 — OUTPUT EFFECTS OF FISCAL CONSOLIDATION

| | Back-loaded fiscal consolidation | | | Front-loaded fiscal consolidation | | |
|---|---|---|---|---|---|---|
| Year | Reduction[1] in $g_t$ | Effect[2] on GDP | | Reduction[1] in $g_t$ | Effect[2] on GDP | |
| | | Low $m^b$ | High $m^b$ | | Low $m^b$ | High $m^b$ |
| 2012 | -0.44 | -1.12 | -1.00 | -1.29 | -3.44 | -3.72 |
| 2013 | -0.76 | -1.68 | -1.68 | -0.44 | -0.56 | -0.72 |
| 2014 | -0.47 | -0.88 | -0.88 | -0.14 | -0.16 | -0.28 |
| 2015 | -0.23 | -0.36 | -0.40 | -0.04 | -0.04 | -0.12 |
| 2016 | -0.14 | -0.28 | -0.36 | -0.01 | -0.01 | -0.04 |
| Sum | -2.03 | -4.32 | -4.32 | -2.03 | -4.21 | -4.88 |

[1] As a percentage of yearly GDP. [2] Accumulated gains (percent of initial GDP).

### 5.6 Fiscal policy and a credit crunch.

Finally, we use our model to evaluate the capacity of fiscal policy to affect the economy in a situation where private agents are forced into deleveraging due to a credit crunch. To this end, we endogenize the loan-to-value ratio as $m_t^b = (1 + \varepsilon_t^m)m^b$, where $\varepsilon_t^m$ follows an AR(2) process

$$\varepsilon_t^m = \phi_1^m \varepsilon_{t-1}^m + \phi_2^m \varepsilon_{t-2}^m + \nu_t^m$$

with parameters $\phi_1^m = 1.83$ and $\phi_2^m = -0.836$, and initial conditions for $\varepsilon_{t-1}^m$ and $\varepsilon_{t-2}^m$ equal zero. Starting from a high indebtedness capacity in the economy ($m^b = 0.985$) and $\nu_t^m = 0$, the loan-to-value ratio is temporarily reduced according to two different magnitudes of the initial shock. In the first case (the slashed line in Figure 9), we hit the AR(2) process reducing $\nu_t^m$ by a one percentage point of $m^b$. This generates a maximum reduction of approximately 4 percentage points of $m^b$ after 10 quarters, returning very slowly afterwards to the initial value. We call this shock pattern a situation of mild credit crunch. In the second case (dotted line in Figure 9), the initial fall in $m^b$ amounts to 4 percent, the loan-to-value ratio reaching a minimum value of 0.8. We call this scenario a severe credit crunch[16].

In order to isolate the effects of fiscal policy on relevant macroeconomic variables, we run two simulations for each of the two credit crunch scenarios described above. First, we simulate the effects on variables when we add the credit crunch to a (one percent of GDP) positive fiscal shock. We obtain the response of the variables as relative deviations from their steady-state values $(\frac{\dot{x}_t}{\overline{x}})^{f,cc}$. The impact effects corresponding to the previous response in the initial period are displayed in columns 2B and 2C in Table 2. Second, we obtain the response in the case of only a credit crunch shock $(\frac{\dot{x}_t}{\overline{x}})^{cc}$ (see columns 3B and 3C in Table 2 for the initial impact). The net effect of fiscal policy is then computed as the difference between both responses $\left[(\frac{\dot{x}_t}{x_{ss}})^{f,cc} - (\frac{\dot{x}_t}{x_{ss}})^{cc}\right]$. Columns 1B and 1C in Table 2 capture the initial impacts of this net effect, which should be compared with column 1A, representing the net effects of fiscal policy when the credit crunch shock is absent.

In Figure 10 we perform the same comparison between the net effects of fiscal policy for a time span of 10 quarters. The main message stemming from this exercise is that fiscal policy in the presence of a severe credit crunch can still generate positive and significant effects on consumption and output as suggested, for example, in Eggertsson and Krugman (2010). However, the net effects of fiscal policy on these variables do not augment with the intensity of the deleveraging effort in the economy. This is so despite the net effect of government spending on borrowers' debt, house prices and the stock of houses favoring consumption expenditure the more intense the credit crunch is. The intuition that public spending impulses can help to prevent a more intense deterioration of the net worth in the presence of a severe contraction of private credit is confirmed by the results in Figure 10. However, this is insufficient to ensure a stronger response from borrower consumption and output due to the reaction of labor income and especially real wages and hours worked. The net multiplier is, if anything, somewhat smaller the worse

16 As pointed out by Eggertsson and Krugman (2010), when the economy sufferers a rapid period of private deleveraging it can easily run into the zero bound for the interest rate. This exercise has been designed so that the nominal interest rate does not hit the zero bound in any of the periods considered.

the deterioration of credit conditions in the economy[17]. Interestingly, the extensive margin of employment reacts more positively to the fiscal shock the more severe the credit crunch is. This is so because fiscal policy does not affect real wages as much in this case, which in turn moderates the (negative) impact on vacancy posting. Hence, although the differential output effect of fiscal stimuli in the event of a sharp credit contraction does not show up in this model, this policy can play a more important role in sustaining employment in a creditless slump.

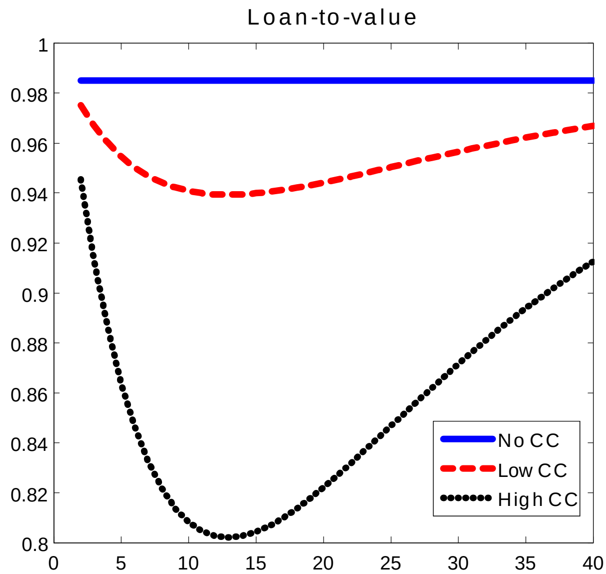



**Figure 9:** *Three credit crunch scenarios*

[17] Note, however, that our experiment abstracts from reaching the zero bound, in which case fiscal policy can recover vitality, as Chrsitiano, Eichenbaum and Rebelo (2009) or Woodford (2010) show.

TABLE 2 — IMPACT EFFECTS OF FISCAL POLICY UNDER A CREDIT CRUNCH

| | No Credit Crunch | Low Credit Crunch | | | High Credit Crunch | | |
|---|---|---|---|---|---|---|---|
| Variable | (1A) | (1B) | (2B) | (3B) | (1C) | (2C) | (3C) |
| Consumption | 1.13 | 0.95 | -3.37 | -4.32 | 0.65 | -13.84 | -14.49 |
| Output | 1.57 | 1.48 | -0.74 | -2.22 | 1.33 | -6.18 | -7.51 |
| Total Hours$^{(*)}$ | 2.29 | 2.25 | 0.21 | -2.05 | 2.18 | -5.17 | -7.35 |
| Real Wage | 2.14 | 1.78 | -3.23 | -5.01 | 1.12 | -14.91 | -16.03 |
| House Prices | -0.39 | -0.34 | -1.02 | -0.68 | -0.26 | -2.98 | -2.72 |
| Real Interest (bp) | 3.50 | 7.74 | -11.17 | -12.75 | 19.13 | -40.31 | -38.86 |
| Inflation (bp) | 30.25 | 26.68 | -27.81 | -54.49 | 20.75 | -149.9 | -170.6 |
| Borrow. Debt | -0.21 | -0.13 | -3.62 | -3.49 | 0.04 | -14.22 | -14.26 |

(1A), (1B) and (1C): Net Effects of Fiscal Shock.
(2B) and (2C): Fiscal shock and Credit Crunch.
(3B) and (3C): Credit Crunch.

(*) The reduction in total hours is accompanied by a small positive reaction of employment after the credit crunch.

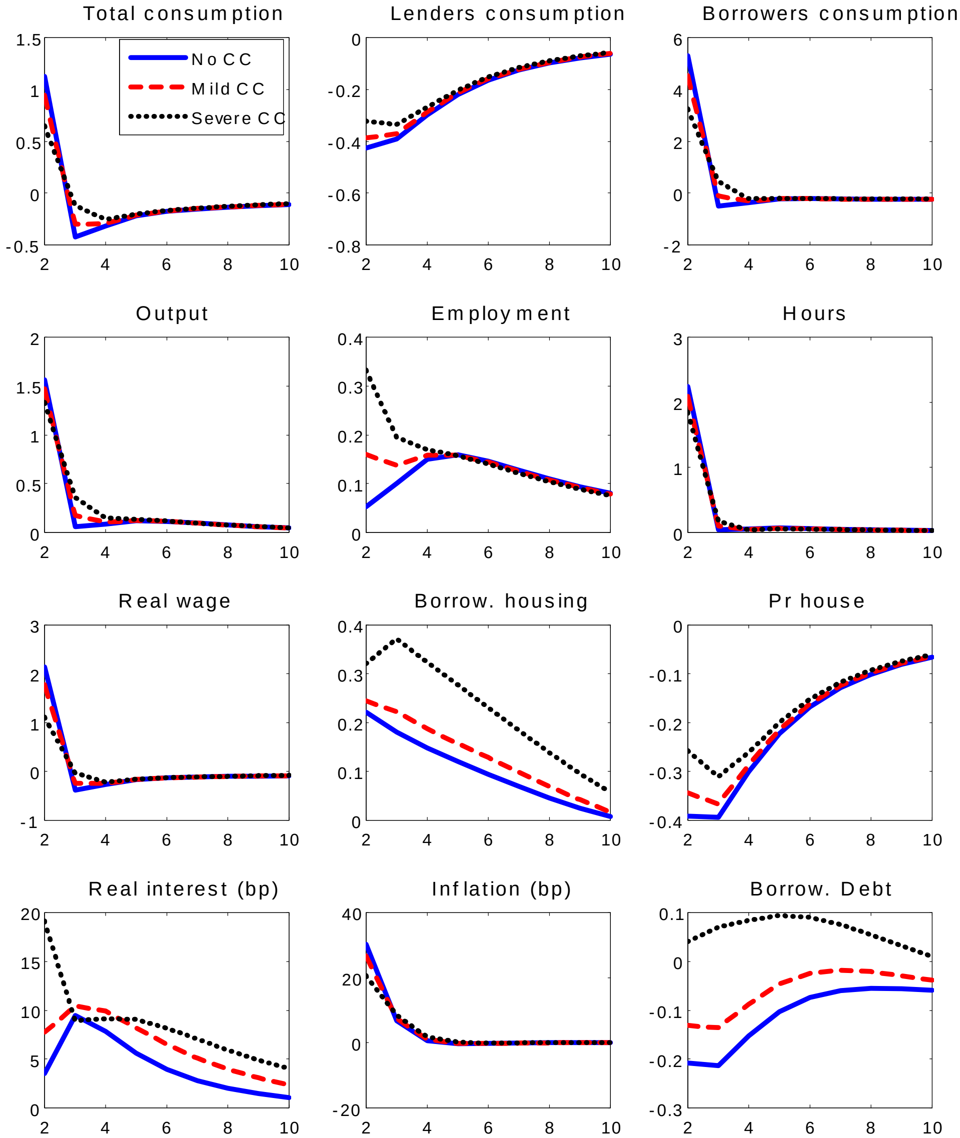



**Figure 10:** Net effects of fiscal policy under a credit crunch

## 6. Conclusions

Fiscal policy multipliers are small in neo-Keynesian models with many Ricardian features. The intertemporal substitution mechanisms wipes out the expansionary effects of fiscal stimuli depressing investment and consumption. Alternatively, models with consumers that do not participate in the financial market (RoT) are capable of producing strong fiscal responses of output. Unfortunately these models have two major flaws, one in terms of the assumptions made and the other empirical. These models overlook an important feature of modern economies in which many households do not base their consumption decisions either on the basis of their permanent income or of their labor income only, since they have limited but non-zero borrowing capacity. This implies that some of these agents carry a given amount of debt and presumably some asset holdings, that affect their consumption possibilities. The current recession after a period of easy financial conditions that has caught many households highly leveraged is a good case in point. On empirical grounds and under fairly general conditions, the RoT model fails to deliver theoretical impulse responses of vacancies and employment to fiscal shocks consistent with those in the data.

In this paper we augment the search and matching model with a proportion of total households that are more impatient than others who borrow up to a limit given by the expected collateral value of their asset (housing) holdings. The interaction between the consumption decisions of agents with limited access to credit and the process of wage bargaining and vacancy posting delivers three main results: (a) higher initial leverage makes it more likely to find output multipliers higher than one; (b) a positive government expenditure shock always produces a positive multiplier for vacancies and employment; (c) output (employment) multipliers decrease (increase) markedly with the degree of shock persistence and increase with the degree of price stickiness. We carry out two simple exercises with our model and find that: first, the GDP cost of fiscal consolidations is, if anything, higher when the loan-to-value ratio is also high; and second, the use of fiscal stimuli can partially counteract the negative effect on output of a credit crunch, but the fiscal multiplier (net of the deleveraging effect) does not increase, and even falls, with the severity of the credit crunch. Finally, the presence of an intensive and an extensive margin of employment in the model explains why many of the factors that weaken the output response to increases in government spending shocks do in many cases reinforce the (un)employment multipliers.

## Appendix 1: Derivation of the borrowers' consumption function

From the borrowers' problem we have (assume $\phi_h = 0$)

$$\lambda_{1t}^b = \frac{1}{c_t^b} \tag{1.1}$$

$$\lambda_{1t}^b = \beta^b E_t \lambda_{1t+1}^b \left( \frac{1 + r_t^n}{1 + \pi_{t+1}} \right) + \mu_t^b \left(1 + r_t^n\right) \tag{1.2}$$

$$\lambda_{1t}^b q_t = \frac{\phi_x}{x_t^b} + \mu_t^b m^b E_t q_{t+1} \left(1 + \pi_{t+1}\right) + \beta^b E_t q_{t+1} \lambda_{1t+1}^b \tag{1.3}$$

$$b_t^b \leq m^b E_t \left( \frac{q_{t+1} \left(1 + \pi_{t+1}\right) x_t^b}{1 + r_t^n} \right) \tag{1.4}$$

From (1.2)

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

Using this expression in (1.3)

$$\begin{aligned} \lambda_{1t}^b q_t \quad = \quad & \frac{\phi_x}{x_t^b} + m^b E_t q_{t+1} \frac{\left(1 + \pi_{t+1}\right)}{1 + r_t^n} \left( \lambda_{1t}^b - \beta^b E_t \lambda_{1t+1}^b \frac{1 + r_t^n}{1 + \pi_{t+1}} \right) \\ & + \beta^b E_t q_{t+1} \lambda_{1t+1}^b \end{aligned} \tag{1.5}$$

Define in (1.4) $\Omega_{t+1} = m^b E_t \frac{q_{t+1}(1+\pi_{t+1})}{1+r_t^n}$ so that

$$b_t^b \leq m^b E_t \left( \frac{q_{t+1} \left(1 + \pi_{t+1}\right) x_t^b}{1 + r_t^n} \right) = \Omega_{t+1} x_t^b \tag{1.6}$$

Substituting into (1.5)

$$\begin{aligned} \lambda_{1t}^b q_t \quad = \quad & \frac{\phi_x}{x_t^b} + \left( \lambda_{1t}^b - \beta^b E_t \lambda_{1t+1}^b \frac{1 + r_t^n}{1 + \pi_{t+1}} \right) \Omega_{t+1} \\ & + \beta^b E_t q_{t+1} \lambda_{1t+1}^b \end{aligned}$$

or

$$\lambda_{1t}^b \left(q_t - \Omega_{t+1}\right) = \frac{\phi_x}{x_t^b} + \beta^b \left( E_t q_{t+1} \lambda_{1t+1}^b - E_t \lambda_{1t+1}^b \frac{1 + r_t^n}{1 + \pi_{t+1}} \Omega_{t+1} \right)$$

Using (1.1)

$$\frac{q_t - \Omega_{t+1}}{c_t^b} = \frac{\phi_x}{x_t^b} + \beta^b E_t \left( \frac{q_{t+1} - \frac{1+r_t^n}{1+\pi_{t+1}} \Omega_{t+1}}{c_{t+1}^b} \right) \tag{1.7}$$

From the budget constraint

$$c_t^b + q_t x_t^b - b_t^b = w_t l_{1t} n_{t-1}^b + q_t x_{t-1}^b - \frac{(1+r_{t-1}^n)}{1+\pi_t} b_{t-1}^b$$

Using (1.6)

$$c_t^b + q_t x_t^b - \Omega_{t+1} x_t^b = w_t l_{1t} n_{t-1}^b + q_t x_{t-1}^b - \frac{(1+r_{t-1}^n)}{1+\pi_t} \Omega_t x_{t-1}^b$$

Define the net worth as

$$nw_t = q_t x_{t-1}^b - \frac{(1+r_{t-1}^n)}{1+\pi_t} b_{t-1}^b = q_t x_{t-1}^b - \frac{(1+r_{t-1}^n)}{1+\pi_t} \Omega_t x_{t-1}^b$$

$$nw_t = \left( q_t - \frac{(1+r_{t-1}^n)}{1+\pi_t} \Omega_t \right) x_{t-1}^b \tag{1.8}$$

Thus

$$c_t^b + q_t x_t^b - \Omega_{t+1} x_t^b = w_t l_{1t} n_{t-1}^b + nw_t \tag{1.9}$$

Guess

$$c_t^b = \Theta(.) \left( w_t l_{1t} n_{t-1}^b + nw_t \right) \tag{1.10}$$

which states that borrowers' consumption is a function of the networth and the current income. From (1.7) and (1.8)

$$\frac{q_t - \Omega_{t+1}}{c_t^b} - \frac{\phi_x}{x_t^b} = \beta^b E_t \left( \frac{\frac{nw_{t+1}}{x_t^b}}{c_{t+1}^b} \right) = \beta^b E_t \left( \frac{nw_{t+1} + w_{t+1} l_{1t+1} n_t^b - w_{t+1} l_{1t+1} n_t^b}{x_t^b c_{t+1}^b} \right) \tag{1.11}$$

Using the negotiated wage equation (48) one can represent the labor income as a function of consumption and other variables. Let write this relationship as

$$w_t l_{1t} n_{t-1} \approx c_t^b H(.) \tag{1.12}$$

where $H(.)$ is a function itself that fluctuates along the business cycle. Substituting into (1.11)

$$\frac{q_t - \Omega_{t+1}}{c_t^b} - \frac{\phi_x}{x_t^b} = \beta^b E_t \left( \frac{\frac{1}{\Theta(.)} c_{t+1}^b - c_{t+1}^b H(.)}{x_t^b c_{t+1}^b} \right) = \beta^b E_t \left( \frac{\frac{1}{\Theta(.)} - H(.)}{x_t^b} \right)$$

or

$$q_t x_t^b - \Omega_{t+1} x_t^b = \left( \phi_x + \beta^b \left( \frac{1}{\Theta(.)} - H(.) \right) \right) c_t^b$$

Making use of (1.9)

$$c_t^b + \left( \phi_x + \beta^b \left( \frac{1}{\Theta(.)} - H(.) \right) \right) c_t^b = w_t l_{1t} n_{t-1}^b + n w_t$$

or

$$c_t^b = \left( 1 + \phi_x + \beta^b \left( \frac{1}{\Theta(.)} - H(.) \right) \right)^{-1} \left( w_t l_{1t} n_{t-1}^b + n w_t \right)$$

In order the guess (1.10) to be verified

$$\Theta(.) = \left( 1 + \phi_x + \beta^b \left( \frac{1}{\Theta(.)} - H(.) \right) \right)^{-1}$$

or

$$\Theta(.) = \frac{1 - \beta^b}{1 + \phi_x - \beta^b H(.)}$$

Hence,

$$c_t^b = \frac{1 - \beta^b}{1 + \phi_x - \beta^b H(.)} \left( w_t l_{1t} n_{t-1}^b + n w_t \right) \tag{1.13}$$

Given that equation (1.13) is an approximation to the real consumption function, in Figure A.0 we have depicted the impulse-response functions to a (one per cent of GDP) transitory public expenditure shock of borrowers consumption and the sum of labor income and net worth these consumers. As can be seen, our approximation is quite exact in the case of a high loan-to-value-ration, while there is a certain gap in a low loan-to-value scenario.

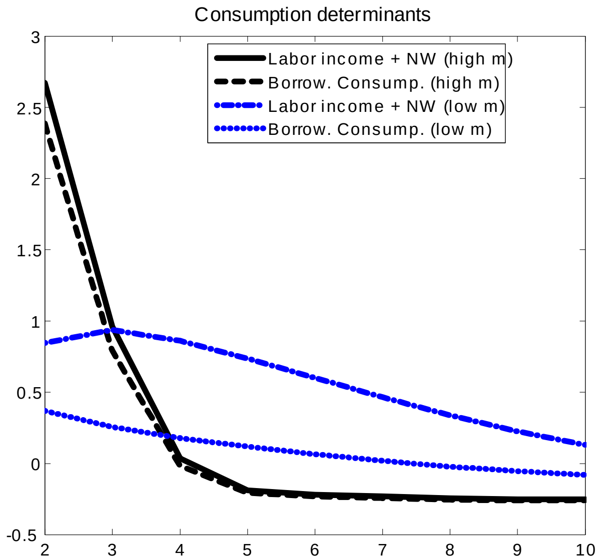
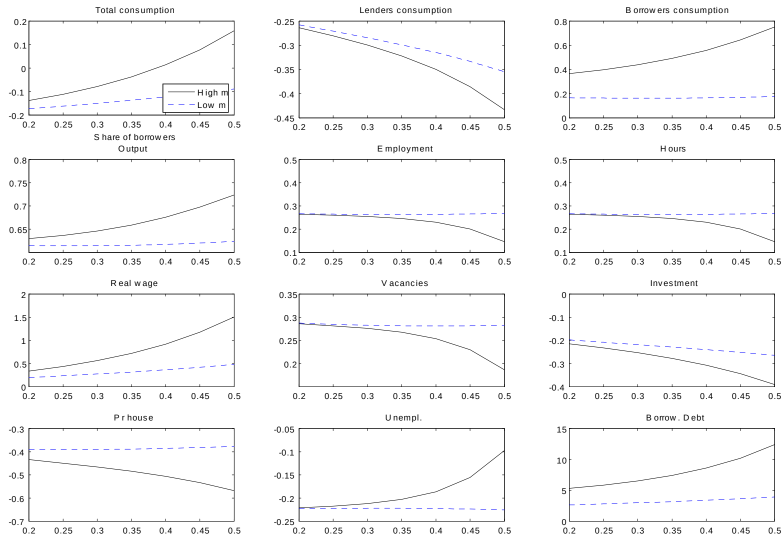
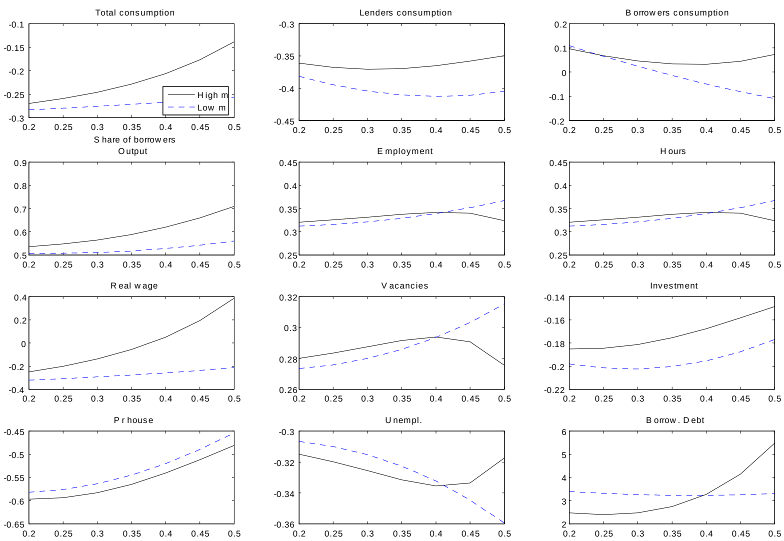



**Figure A.0:** *Response of labor income, net worth and borrowers consumption to a fiscal shock.*

# Appendix 2: One-year and five-year multipliers

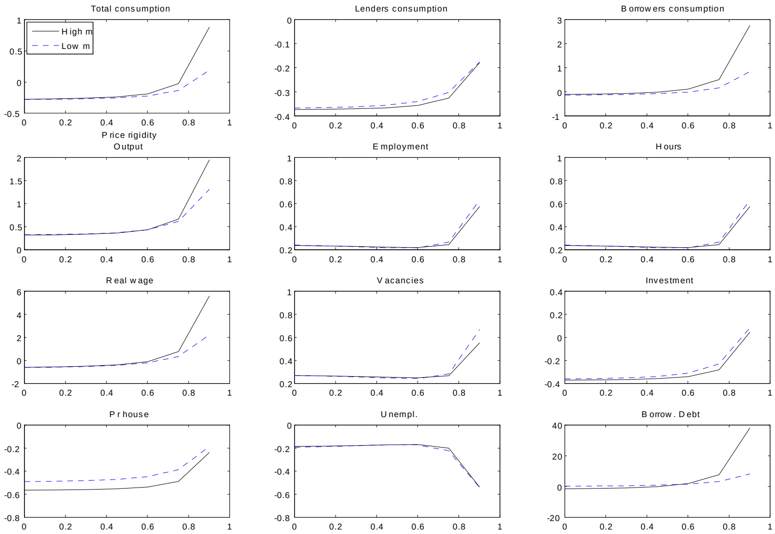



One-year multiplier as a function of the share of borrowers

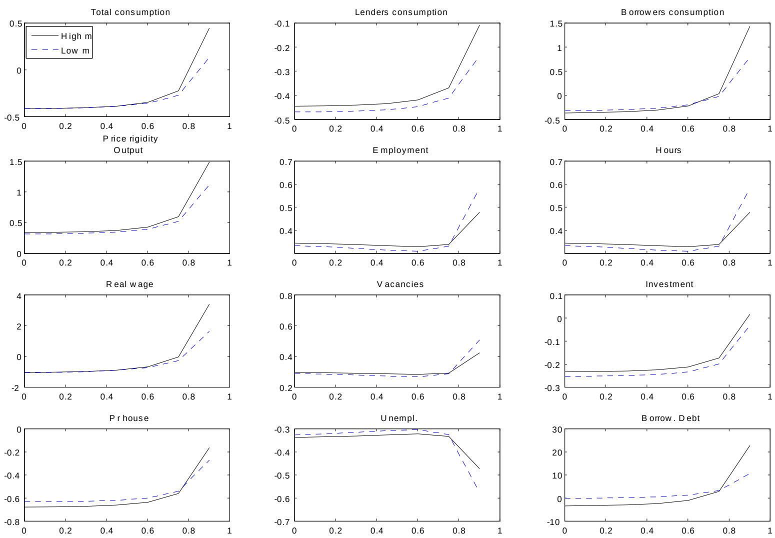



Five-year multiplier as a function of the share of borrowers

**Figure A.1:** Multipliers as a function of the share of borrowers

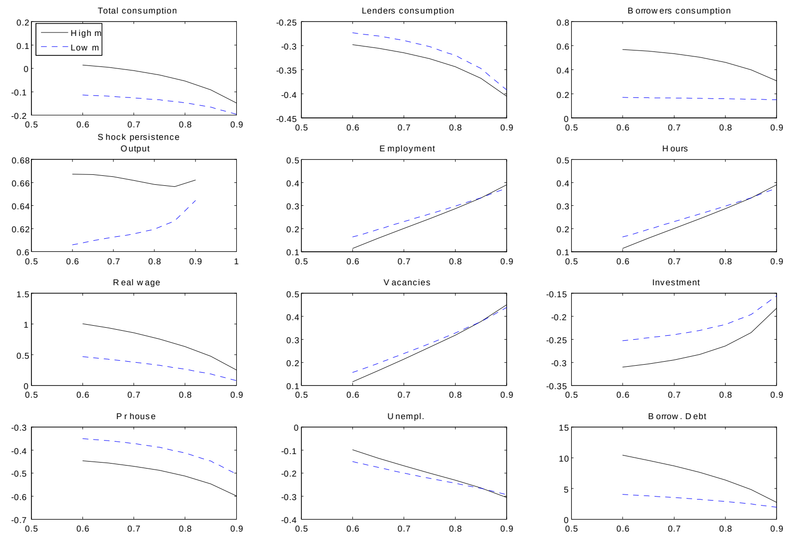



One-year multiplier as a function of price rigidity

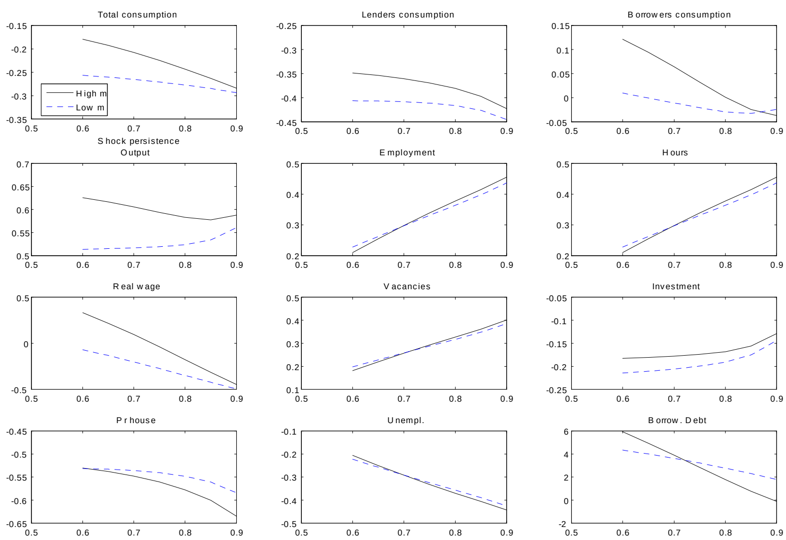



Five-year multiplier as a function of price rigidity

**Figure A.2:** Multipliers as a function of price rigidity




One-year multiplier as a function of the shock persistence




Five-year multiplier as a function of the shock persistence

**Figure A.3:** Multipliers as a function of the shock persistence

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