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Giovanni Melina
Birkbeck, University of London
and
University of Surrey

Stefania Villa
Birkbeck, University of London
and
University of Foggia

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Giovanni Melina†
Birkbeck, University of London
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Stefania Villa
Birkbeck, University of London
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Abstract

This paper studies how fiscal policy affects credit market conditions. First, it conducts a FAVAR analysis showing that the credit spread responds negatively to an expansionary government spending shock, while consumption, investment, and lending increase. Second, it illustrates that these results are not mimicked by a DSGE model where the credit spread is endogenized via the inclusion of a banking sector exploiting lending relationships. Third, it demonstrates that introducing deep habits in private and government consumption makes the model able to replicate empirics. Sensitivity checks and extensions show that core results hold for a number of model calibrations and specifications. The presence of banks exploiting lending relationships generates a financial accelerator effect in the transmission of fiscal shocks.

Keywords: Fiscal policy, deep habits, credit spreads, lending relationships.

JEL Codes: E44, E62

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†Corresponding author.
E-mail addresses: g.melina@ems.bbk.ac.uk (G. Melina), s.villa@ems.bbk.ac.uk (S. Villa).

1 Introduction

During the Great Moderation the mainstream business cycle literature assigned a rather limited role to fiscal policy as a stabilizing tool. It was argued that fiscal policy was either ineffective – on the grounds of Ricardian equivalence arguments – or inherently not timely, due to its intrinsic design and implementation lags combined with the typical short length of recessions. As output and inflation showed a small variability and monetary policy was able to maintain both price and output gap stability, any policy instrument other than the monetary policy rate was considered to play only a minor role (Blanchard et al., 2010).

As the recent crisis began, governments around the world shared serious concerns because: (i) the crisis was taking a global and profound dimension; (ii) it was expected to be long-lasting; and (iii) the monetary policy interest rate had almost reached its limits as in many cases, including the US and the UK, it was soon effectively at the zero lower bound. As a result, fiscal policy was at least a dimension along which governments could do more. Indeed, the fiscal stimulus provided by the *American Recovery and Reinvestment Act* (ARRA) was described as 'the boldest countercyclical fiscal action in American history' (Romer, 2009, p. 5).

Another important feature of the latest crisis was the role that the banking sector had in magnifying the effects of the crisis itself. It is a well-established fact in the empirical literature that the credit spread, i.e. the difference between the loan rate and the deposit rate, widens during downturns (Gertler and Lown, 1999; Aliaga-Diaz and Olivero, 2010; Villa and Yang, 2011). Following the collapse of Lehman Brothers, the spread skyrocketed. Lenza et al. (2010) reported that the spread between unsecured deposit rates (EURIBOR) and overnight indexed swap (OIS) rates at the three-month maturity approached 200 basis points in the Euro Area. Analogous spreads were even higher in the US and UK. Recent empirical evidence shows that the contraction in the supply of credit to firms contributed significantly to the decline in the GDP growth during the financial crisis (Ciccarelli et al., 2010).

The literature offers a variety of studies focusing on the behavior of the credit spread over the business cycle. In particular, Aliaga-Diaz and Olivero (2010) provide empirical evidence that banks *hold up* borrowers, because the former gain an "information monopoly" over customers' creditworthiness and the latter find it costly to switch to a new funding source. This piece of evidence agrees with the analysis of Santos and Winton (2008), who empirically show that during recessions banks raise their lending margins more for bank-dependent borrowers than for those with access to public bond markets because of the informational *hold-up* effect rather than a greater risk of the first type of borrowers. On the contrary, in expansions, banks have the incentive to lower their mark-up (the credit spread) in order to expand their customer base and charge them higher mark-up in the future, once they have been *held-up*. On the theoretical side, these empirical regularities are matched in Dynamic Stochastic General Equilibrium (DSGE) models featuring lending relationships by Aksoy et al. (2009) and Aliaga-Diaz and Olivero (2010). While the latter study the financial accelerator role of countercyclical credit spreads as a propagation mechanism in a Real Business Cycle (RBC) model, the former build a New Keynesian (NK) model with staggered prices and cost channels to study the implications of lending relationships for monetary policy making. In these models lending relationships are introduced via the modeling device that firms form deep habits in their borrowing decision, in a way analogous to households decision in Ravn et al. (2006). Such a device represents a reduced-form tool to incorporate the *borrower's hold-up* problem into the model. In fact, the outcome of this mechanism is that firms are held up in lending relationships, which can be strategically exploited by banks.

In the literature, there is no direct investigation on the relationship between the fiscal stimulus and credit spreads. This paper attempts to fill in this gap on one hand by estimating the response of a number of measures of the credit spread to a government spending expansion in a factor augmented vector auto-regressive (FAVAR) model of the US economy. On the other hand, it develops a DSGE model with lending relationships and fiscal policy able (i) to match the empirical findings, and (ii) to provide a theoretical framework that allows one to study how the fiscal stimulus is transmitted via the banking sector.

The estimated impulse responses from the FAVAR provide evidence that the credit spread falls in response to a government spending expansion, while consumption, investment, and lending increase. The paper shows that the flexible-price RBC model and its sticky-price NK extension, both augmented with lending relationships, predict the opposite. However, when the model also incorporates deep habits in consumption, the picture considerably changes, as the negative response of the credit spread can now be matched. As also explored by Cantore et al. (2011), the model with deep habits in consumption also matches a series of findings documented by some of the recent empirical literature. In particular, private consumption is crowded in by government spending (Blanchard and Perotti, 2002; Galí et al., 2007; Pappa, 2009; Monacelli et al., 2010; Fragetta and Melina, 2011), the increase in hours worked due to the fiscal expansion is accompanied by a boost in real wages (Pappa, 2005; Galí et al., 2007; Caldara and Kamps, 2008; Pappa, 2009; Fragetta and Melina, 2011), and the price mark-up drops (Monacelli and Perotti, 2008; Canova and Pappa, 2011).

The difference in the transmission mechanism between canonical models and models featuring deep habits in consumption lies in the behavior of the price mark-up. In both classes of models, an expansionary government spending shock triggers a negative wealth effect caused by the absorption of resources that makes consumption, leisure and investment less affordable. When deep habits in consumption are activated even under flexible prices, an expansionary government spending shock curbs the price mark-up. This translates into a rise in labor demand stronger than the rise in labor supply and into a larger rise in the demand for investment. The subsequent increase in the real wage triggers a strong substitution effect away from leisure and into consumption, hence the crowding-in of the latter. Banks face a rise in the demand for loans and this raises the loan rate. However, they also incorporate the information of high future returns on capital and hence their ability of making high future profits. At this point, lending relationships come into play: banks are willing to give up some of the current profits to expand their customer base by locking in more customers. This results into a fall of the credit spread and an expansion of equilibrium lending. As a result, the presence of banks exploiting lending relationships generates a financial accelerator effect in the transmission of the government spending shock.

This transmission mechanism is firstly analyzed in a flexible-price benchmark model with lump-sum taxation and a balanced government budget. Robustness checks and extensions show that core results hold for a number of calibrations and specifications. In particular the paper analyzes: (i) the introduction of government debt and distortionary taxation; (ii) the sensitivity of the results to parameter values governing deep in habits in consumption and in lending; and (iii) a NK extension of the model with sticky prices.

The remainder of the paper is structured as follows. Section 2 presents the empirical estimates. Section 3 illustrates the model. Section 4 describes the calibration. Section 5 presents the results in the flexible-price benchmark. Section 6 presents robustness checks and extensions. Finally, Section 7 concludes.

2 Empirical evidence

The empirical literature provides evidence of counter-cyclical credit spreads (Gertler and Lown, 1999; Aliaga-Diaz and Olivero, 2010, among others), but does not cover the more specific issue of how credit spreads react to fiscal policy shocks. This section attempts to fill in this gap by estimating the response of the credit spread to a government spending shock in a FAVAR model of the US economy:

$$\begin{pmatrix} \mathbf{Y_t} \\ \mathbf{F_t} \end{pmatrix} = \mathbf{A}(L) \begin{pmatrix} \mathbf{Y_{t-1}} \\ \mathbf{F_{t-1}} \end{pmatrix} + \mathbf{v_t}, \tag{1}$$

where $\mathbf{Y_t}$ is a $M \times 1$ vector of observed variables, $\mathbf{F_t}$ is a $K \times 1$ vector of unobserved factors, $\mathbf{A}(L)$ is a conformable polynomial in the lag operator and $\mathbf{v}_t$ is an error term.

The estimation employs quarterly US data over the period 1954q1-2007q4. The starting date avoids the years from 1945 to the Korean war, considered to be turbulent from a fiscal point of view (see Perotti, 2007, for a discussion). The end date falls before the start of the *great recession*.

Vector $\mathbf{Y_t}$ contains the baseline Blanchard-Perotti variables – the log of real per-capita total spending; the log of real per-capita output; and the log of real per-capita net taxes – to which measures of the credit spread are added one at a time. Government spending (BEA NIPA table 3.1, line 16) and net taxes exclude social transfers in order to remove most of the automatic stabilizer component. Net taxes are obtained as government current receipts (BEA NIPA table 3.1, line 1) less current transfers (line 17) and interest payments (line 22). The series are transformed in real per-capita terms by dividing their nominal values by the GDP deflator and the civilian population.

The measure of the credit spread included in the baseline specification of model (1) is computed as the difference between the three-month bank prime loan rate (BPLR) and the quarterly Treasury bill rate (TBR). The choice of this particular spread is suggested by the type of lending relationships analyzed in this paper, i.e. bank-firm relationships. As a robustness check, the model is nevertheless estimated also with three alternative measures of the credit spread: (i) Moody's seasoned Baa corporate bond yield (Baa) minus Moody's seasoned Aaa corporate bond yield (Aaa); (ii) Baa minus long-term Treasury constant maturity rate (TCMR); and finally (iii) Aaa minus TCMR.[1]

[1] Moody's Aaa and Baa corporate bond yields include bonds with remaining maturities as close as possible to 30 years. Moody's drops bonds if the remaining life falls below 20 years. The long-term Treasury constant maturity rate for the largest part of the observations refers to bonds with a maturity of 30 years. Missing values are filled in with the 20-year Treasury constant maturity rate. The two series are nevertheless virtually coincident for the periods in

Number	Eigenvalue	% of variance explained	Cumulative %
1	3.87	77.33	77.33
2	1.06	21.19	98.52
3	0.05	0.91	99.43
4	0.02	0.49	99.92
5	0.00	0.09	1.00

Table 1: Principal components analysis

The unobserved factors $\mathbf{F_t}$ are related to a $N \times 1$ vector $\mathbf{X_t}$ of potentially relevant observed variables by:

$$\mathbf{X_t} = \mathbf{\Lambda F_t} + \mathbf{e_t}, \tag{2}$$

where $\mathbf{F_t}$ are estimated as the principal components of the correlation matrix of the $\mathbf{X_t}$, and $\mathbf{e_t}$ is a vector of error terms. Following common practice, the loadings $\mathbf{\Lambda}$ are identified as eigenvectors (see Bernanke et al., 2005; Laganà and Mountford, 2005; Smith and Zoega, 2009, among others). Vector $\mathbf{X_t}$ contains a number of macroeconomic variables that, together with the variables collected in $\mathbf{Y_t}$, makes the empirical model closer to the theoretical model presented in the next section. In particular, $\mathbf{X_t}$ includes standardized values of (i) the log of real per-capita private consumption; (ii) the log of per-capita hours of work (the series constructed by Francis and Ramey (2009) and available on Valerie Ramey's webpage); (iii) the log real per-capita private domestic investment; (iv) the log of real per-capita lending;[2] and (v) the log of the real hourly wage (average hourly wage of production workers produced by the US Bureau of Labor Statistics).[3] Table 1 reports the eigenvalues associated to the principal components of $\mathbf{X_t}$ and the proportion of total variance explained. In model (1) the first two components are included as these cumulatively explain almost 99% of total variance.

Government spending shocks are identified by using the assumption proposed by Blanchard and Perotti (2002) that government spending is unable to react to output and other shocks within a quarter due to implementation and decision lags typical of the budgeting process. If identification is

which both of them are available.

[2]As in Christiano et al. (2010), total lending is the sum of total credit market instruments from the liabilities side of the balance sheet of nonfarm nonfinancial corporate business and total credit market instruments from the liabilities side of the balance sheet of nonfarm noncorporate business.

[3]GDP, the GDP deflator, the interest rates used to compute the measures of the credit spread, private consumption, investment and lending are extracted from the ALFRED database of the Federal Reserve Bank of St. Louis. All series are seasonally adjusted by the source. Following the fiscal VAR literature, model (1) is estimated using the levels of the variables. Hence, also principal components are extracted from the levels of the observables. Bai and Ng (2004) and Banerjee and Marcellino (2009) show that, even if observables are trended principal components can be consistently estimated provided that they cointegrate with observables. Johansen cointegration rank tests find cointegration at conventional levels of significance.

achieved via a Choleski decomposition, this assumption translates into ordering government spending first. The same approach to identification has been employed by Monacelli et al. (2010).

After estimating the reduced form of the FAVAR, including four lags of the endogenous variables and a constant, its structural representation and correspondent identification of the structural shocks is obtained via a Choleski triangularization, as already discussed. To achieve this, the variables are ordered as follows: (i) government spending; (ii) output; (iii) taxes; (iv) the factors; and (v) credit spread. Ordering taxes third is justified by the fact that the tax revenue is immediately (within the quarter) affected by shocks to output; while ordering the credit spread last allows it to be contemporaneously affected by all structural shocks, including those coming from consumption/saving decisions and labor market conditions captured by the factors.[4]

Figure 1 plots the impulse responses of the endogenous variables of the FAVAR to a positive shock to government spending in a forty-quarter horizon. The impulse responses of the variables underlying the factors are derived from the responses of the factors themselves and by exploiting equation (2) and the estimated loadings.[5] The responses of output, net taxes, private consumption, private investment and lending are positive and generally significant at a 90% level. While hours worked react positively to a government expenditure expansion, the real wage response is mildly negative on impact and then increases, though not significantly, as in the SVAR estimates reported by Galí et al. (2007). All measures of the credit spread barely move on impact or experience a slight positive (though not significant) increase. After a quarter, however, BPLR-TBR, Baa-Aaa and Baa-TCMR fall and remain below baseline for several quarters. Aaa-TCMR experiences an initial significant decline but it quickly returns to baseline. The peak response of all measures of the credit spread is negative and significant.

The same analysis is replicated over the more recent subsample 1980q1–2007q4 and the associated impulse response functions are plotted in Figure 2. In general results are qualitatively similar, though the increase in real output, private consumption, investment and lending following the government

[4]As a robustness check alternative variable orderings are used in the Choleski decomposition – namely ordering the factors before output; and/or swapping output with taxes; and/or ordering the measures of the credit spread before output – obtaining only negligible differences with respect to the impulse responses reported.

[5]In figures 1 and 2 the impulse responses of the endogenous variables in the baseline FAVAR containing spread BPLR-TBR are reported. The responses of the other measures of the credit spread are obtained by estimating FAVARs including one alternative measure of the credit spread at a time. The responses of the other endogenous variables obtained from the alternative FAVAR specifications are not reported as these are virtually coincident to the responses obtained from the baseline FAVAR.

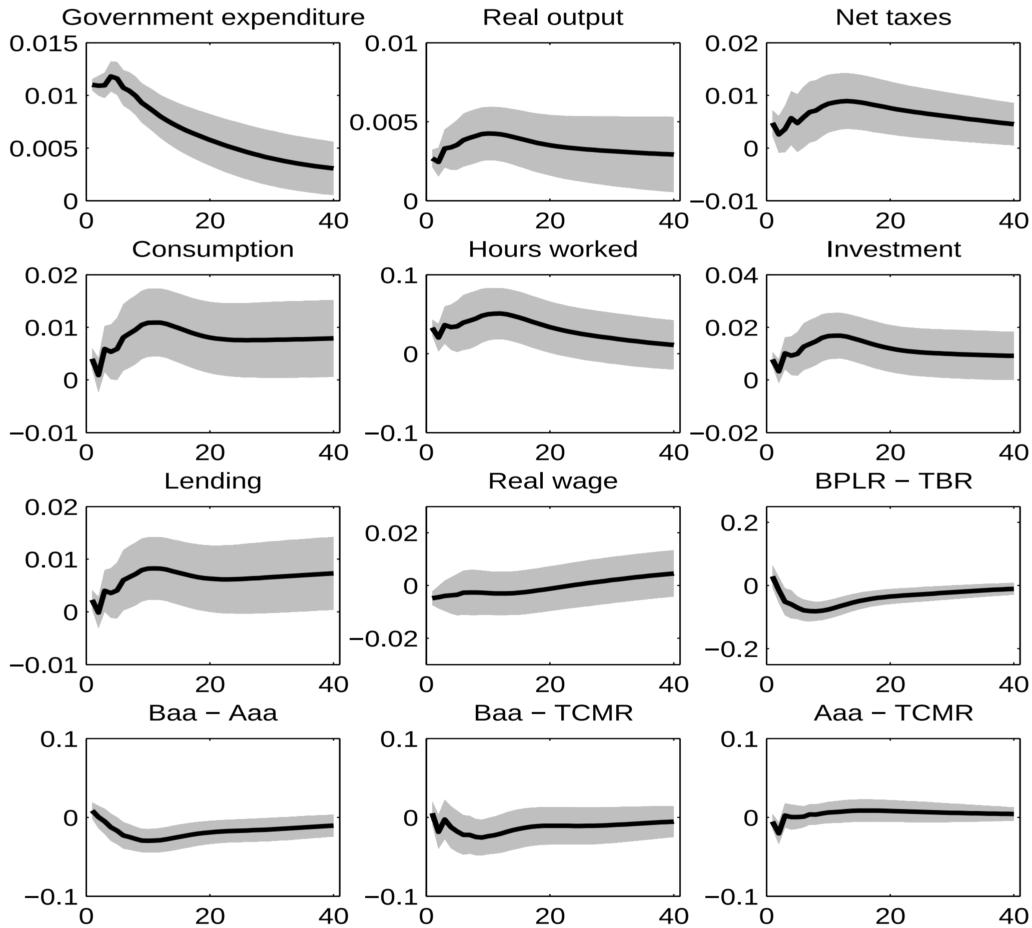

Figure 1: Estimated impulse responses from the FAVAR over the full sample (1954q1–2007q4) to a one-standard deviation shock to government spending (shaded areas represent 90% confidence intervals).

expenditure expansion is shorter-lived. As far as the responses of the credit spreads are concerned, results are generally robust to the sample change. In particular, the baseline measure BPLR-TBR reacts negatively and significantly also on impact, while measure Aaa-TCMR, after an impact fall, experiences a temporary not significant increase before falling again significantly below baseline. All credit spread measures exhibit a negative and significant peak also in the more recent subsamble.

In recent years the empirical literature has debated a great deal on which identification schemes should be used to analyze the macroeconomic effects of fiscal policy. Among others, Ramey (2009) and Mertens and Ravn (2011) criticize the Blanchard-Perotti (BP) approach on the grounds that it

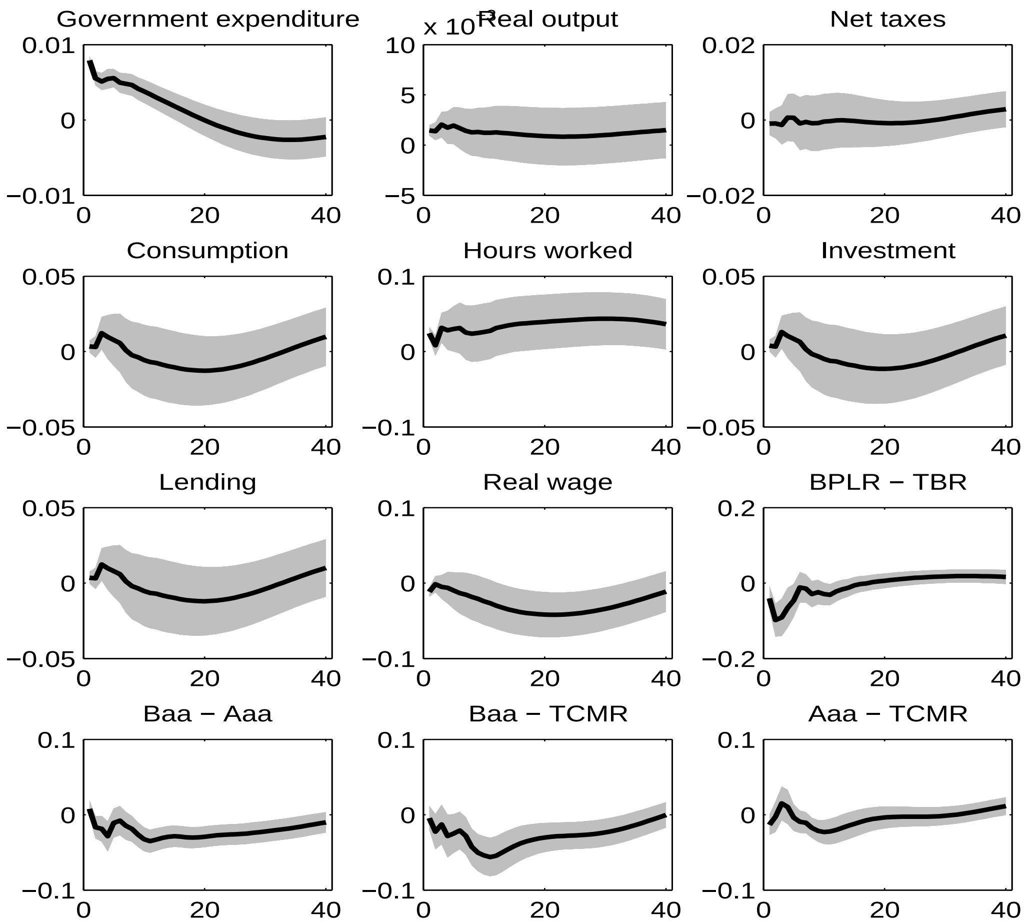

Figure 2: Estimated impulse responses from the FAVAR over the a subsample (1980q1–2007q4) to a one-standard deviation shock to government spending (shaded areas represent 90% confidence intervals).

fails to take into account anticipation effects, and advocate the use of the narrative approach, which instead uses dummy variables to isolate episodes of discretionary fiscal policy, such as military build-ups or changes in the tax system. Mertens and Ravn (2011), on one hand show that anticipation effects may invalidate structural VAR (SVAR) estimates of impulse responses; on the other hand they also show that anticipation effects generally do not overturn the existing findings from the fiscal SVAR literature, largely employing the BP approach.

Nevertheless, in order to address at least partially the issue of anticipation of government expenditure shocks, the FAVAR is estimated also including – as exogenous variables – the Ramey-Shapiro

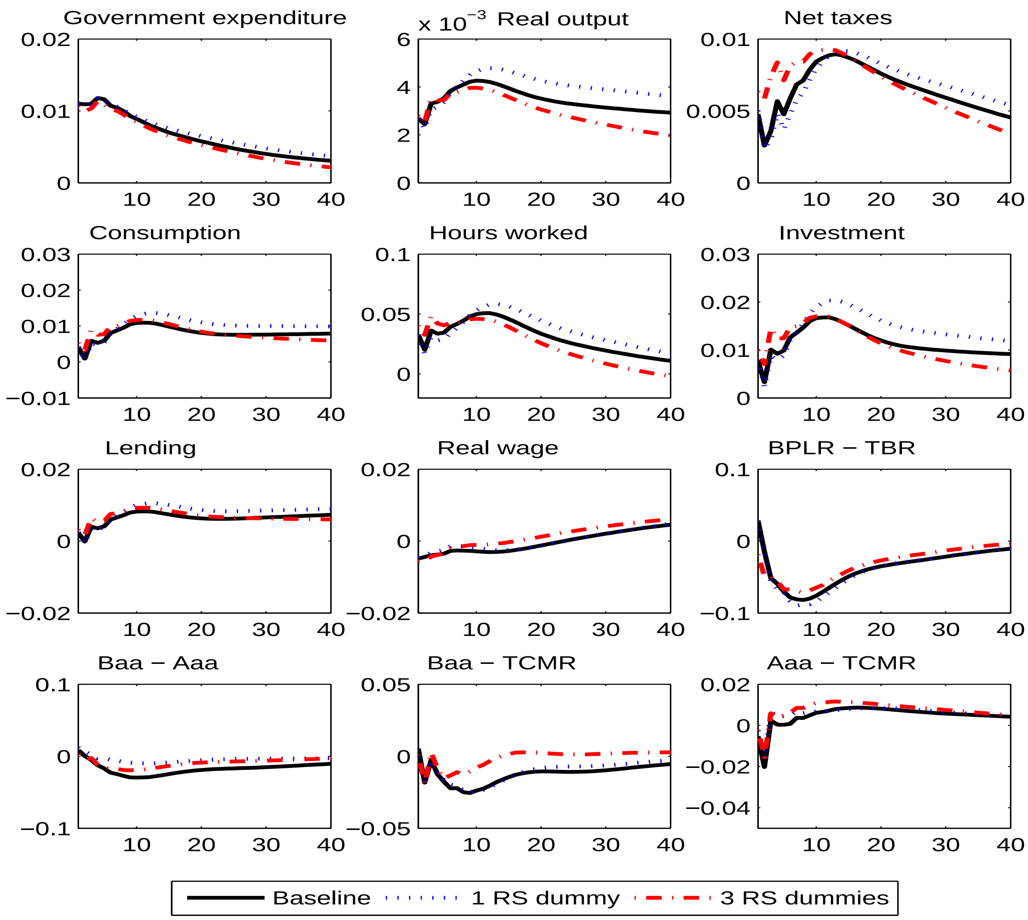

Figure 3: Sensitivity to the introduction of the Ramey-Shapiro (RS) dummy: estimated mean impulse responses from the FAVAR over the full sample (1954q1–2007q4) to a one-standard deviation shock to government spending (1 RS = 1 dummy (0-4 lags) taking value one on each RS episode; 3 RS = 1 separate dummy (0-4 lags) for each of the 3 RS episodes in the sample).

(RS) episodes in the forms of either (i) 1 RS, as Edelberg et al. (1999), Eichenbaum and Fisher (2005), and Ramey (2009), i.e. lags zero to four of the RS dummy variable that takes value one in those quarters in which large military build-ups took place in the US, making expenditure shocks anticipated (1965q1, escalation of the Vietnam war; 1980q1, Carter-Regan military build-up upon the Soviet invasion of Afghanistan; 2001q3, 9/11 attack); or (ii) 3 RS, as in Perotti (2007)[6] and Monacelli et al. (2010), lags zero to four of each of three separate dummy variables isolating the same episodes. Mean impulse responses are plotted in Figure 3. To a certain extent, compared to the baseline specification, the addition of the RS dummies alters the dynamics or the magnitude of

[6]Perotti (2007) allows the responses to each RS episode to have both a different intensity and a different shape.

the impulse responses estimated from the FAVAR. However, the signs of the impulse responses are preserved and quantitative differences are generally small.

In sum, this section provides evidence that in post-WWII US data a government spending expansion boosts lending alongside private consumption and investment and triggers a fall – that is generally delayed – of the credit spread.

3 Model

This section presents the DSGE model. The economy is populated by: (i) households; (ii) the government; (iii) entrepreneurs; (iv) final good firms; and (v) banks. Households consume, save by choosing deposits and government bonds, and supply labor. Consumption and wage income are taxed by the government. Households exhibit habits at the level of each variety of private and government consumption goods, i.e deep habits, as in Ravn et al. (2006). The government allocates spending over the varieties of consumption goods, issues bonds and raises tax revenues. Its expenditures include government purchases and lump-sum transfers to households. Entrepreneurs borrow from banks to produce a homogeneous wholesale output sold in a perfectly competitive market. They minimize their borrowing costs by choosing their demand for loans and exhibit deep habits in lending following Aksoy et al. (2009) and Aliaga-Diaz and Olivero (2010). This represents a reduced form way to incorporate the effects of informational asymmetries on borrowers' creditworthiness into a DSGE model. In fact, banks can be thought of accumulating this information by repeatedly lending to their customers and earning an informational monopoly that creates a *borrower's hold-up* effect. In other words, it becomes costly for borrowers to switch lenders as they should start the signaling process again. The deep habits framework is not a formal setup of asymmetric information, but it is still a useful and tractable way to replicate the *borrower's hold-up* effect. In addition, entrepreneurs maximize the flow of discounted profits by choosing the quantity of factors for production. Final goods firms buy the wholesale good from entrepreneurs, differentiate it and sell it in a monopolistically competitive market. Banks maximize the expected discounted value of lifetime profits by choosing deposits and the loan rate. Their balance sheet features loans on the assets side and deposits on the liabilities side. In the sticky-price version of the model a monetary authority sets the nominal interest rate according to a Taylor rule.

3.1 Households

The economy is populated by a continuum of households indexed by $j \in (0,1)$. Each household's preferences are represented by the following intertemporal utility function:

$$U_0^j = E_0 \sum_{t=0}^{\infty} \beta^t \left[U \left(X_t^c \right)^j, 1 - H_t^j \right], \tag{3}$$

where $\beta \in (0,1)$ is the discount factor and H_t^j is labor supply in terms of hours worked. Total time available to households is normalized to unity, thus $1 - H_t^j$ represents leisure time. Following Ravn et al. (2006), $(X_t^c)^j$ is a habit-adjusted consumption composite of differentiated goods indexed by $i \in (0,1)$:

$$(X_t^c)^j = \left[\int_0^1 (C_{it}^j - \theta S_{it-1}^c)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}, \tag{4}$$

where η is the elasticity of substitution across varieties, θ is the degree of deep habits in consumption, C_{it}^j is the real consumption expenditure at time t, and S_{it-1}^c denotes the stock of external habits, which evolves as:

$$S_{it}^c = \varrho S_{it-1}^c + (1-\varrho) C_{it}, \tag{5}$$

and ϱ measures the habit persistence. Such a form of consumption externality is also known as "catching up with the Joneses good by good".

Household j solves a two-stage optimization problem. First, they minimize total expenditure, $\int_0^1 P_{it} C_{it}^j di$, subject to equation (4). The optimal level of consumption for each variety for a given composite is then given by:

$$C_{it}^j = \left(\frac{P_{it}}{P_t} \right)^{-\eta} (X_t^c)^j + \theta S_{it-1}^c, \tag{6}$$

where $P_t \equiv \left[\int_0^1 P_{it}^{1-\eta} di \right]^{\frac{1}{1-\eta}}$ is the nominal price index . At the optimum, using equation (6) and the definition of nominal price index, the nominal value of the habit-adjusted consumption composite can be written as:

$$P_t \left(X_t^c \right)^j = \int_0^1 P_{it} \left(C_{it}^j - \theta S_{it-1}^c \right) di. \tag{7}$$

The second stage of households' optimization problem consists in the maximization of utility subject to the budget constraint. Household j's actual consumption expenditure at time t, C_t^j, is obtained by rearranging equation (7):

$$C_t^j = (X_t^c)^j + \underbrace{\theta \int_0^1 \frac{P_{it}}{P_t} S_{it-1}^c di.}_{\equiv \Omega_t^j} \tag{8}$$

The representative household enters period t with D_t^j units of real deposits in the bank; and real government bonds B_t^j. During period t, the household chooses to consume C_t^j, which is taxed at the sales tax rate, τ_t^c; supplies H_t^j hours of work; and allocates savings in (i) deposits at the bank, D_{t+1}^j, that pay the net interest rate R_{t+1}^D between t and $t+1$; and in (ii) government bonds B_{t+1}^j, that pay R_{t+1}^B between t and $t+1$.

Each period the representative household gains an hourly wage, W_t^j; dividend payments, $\int_0^1 \Pi_{it} di$, from final goods firms and $\int_0^1 \Pi_{bt} db$ from banks. Labor income is taxed at rate τ_t^w. In addition, the government grants transfers, TR_t, and imposes real lump-sum taxes, T_t. The household's intertemporal budget constraint can thus be expressed as:

$$\begin{aligned}(1+\tau_t^c)((X_t^c)^j + \Omega_t^j) + D_{t+1}^j + B_{t+1}^j \leq (1-\tau_t^w) W_t H_t^j + (1+R_t^D) D_t^j \\ + \left(1+R_t^B\right) B_t^j + \int_0^1 \Pi_{it} di + \int_0^1 \Pi_{bt} db + TR_t - T_t,\end{aligned} \tag{9}$$

where inequality (9) uses equation (8), i.e. that $\Omega_t^j = \theta \int_0^1 \frac{P_{it}}{P_t} S_{it-1}^c di$ and $C_t^j = (X_t^c)^j + \Omega_t^j$.

Maximization yields the following first-order conditions with respect to $(X_t^c)^j$, D_{t+1}^j, B_{t+1}^j and H_t^j:

$$U_{Xt}^j = \lambda_t^j (1+\tau_t^c), \tag{10}$$

$$E_t[\Lambda_{t+1}^j (1+R_{t+1}^D)] = 1, \tag{11}$$

$$E_t[\Lambda_{t+1}^j \left(1+R_{t+1}^B\right)] = 1, \tag{12}$$

$$-U_{Ht}^j = (1-\tau_t^w)\lambda_t^j W_t, \tag{13}$$

where λ_t^j is the Lagrange multiplier associated to the budget constraint and $\Lambda_{t,t+1} \equiv \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t}\right]$ is the stochastic discount factor.

Equations (11) and (12) imply a non-arbitrage condition between the interest rate on deposits and government bonds.

3.2 Government

Following Ravn et al. (2006) deep habits are present also in government consumption. This can be justified by assuming that households form habits also on consumption of government-provided goods. In each period t, the government allocates spending $P_t G_t$ over differentiated goods sold by retailers in a monopolistic market to maximize the quantity of a habit-adjusted composite good:

$$X_t^g = \left[\int_0^1 (G_{it} - \theta S_{it-1}^g)^{1-\frac{1}{\eta}} di\right]^{\frac{1}{1-\frac{1}{\eta}}}, \tag{14}$$

subject to the budget constraint $\int_0^1 P_{it} G_{it} \leq P_t G_t$, where S_{it-1}^g denotes the stock of habits for government expenditures, which evolves as:

$$S_{it}^g = \varrho S_{it-1}^g + (1-\varrho) G_{it}. \tag{15}$$

At the optimum:

$$G_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\eta} X_t^g + \theta S_{it-1}^g. \tag{16}$$

Aggregate real government consumption G_t evolves as an autoregressive process:

$$\log\left(\frac{G_t}{\bar{G}}\right) = \rho_G \log\left(\frac{G_{t-1}}{\bar{G}}\right) + \epsilon_t^g, \tag{17}$$

where $\bar{G}$ is the steady-state level of government spending ρ_G is an autoregressive parameter, and ϵ_t^g is a mean zero, i.i.d. random shock with standard deviation σ^G. Two scenarios are considered: (i) balanced budget; (ii) debt financing. In the first case, government spending is simply set equal to lump-sum taxes. In the latter case, the government budget constraint will read as follows:

$$B_{t+1} = R_t^B B_t + G_t + TR_t - T_t - \tau_t^c C_t - \tau_t^w W_t H_t, \tag{18}$$

while all tax instruments are set according to the following feedback rule, following Leeper et al. (2010):

$$\log\left(\frac{X_t}{\bar{X}}\right) = \rho_X \log\left(\frac{X_{t-1}}{\bar{X}}\right) + \rho_{XB}\frac{B_{t-1}}{Y_{t-1}} + \epsilon_t^X, \quad X_t = (T,\ \tau^c, \tau^w), \tag{19}$$

where ρ_X are autoregressive coefficients; $\bar{X}$ are steady state values; ϵ_t^X are serially uncorrelated, normally distributed shocks with zero mean and standard deviations σ^X, and ρ_{XB} is the responsiveness of instruments X to the debt-to-GDP ratio.

3.3 Entrepreneurs

Entrepreneurs are distributed over a unit interval and indexed by $e \in (0,1)$. They borrow from banks to produce a homogeneous wholesale output that they sell in a perfectly competitive market. Entrepreneurs solve two optimization problems: an intratemporal problem, giving rise to lending relationships, in which they decide the composition of their loan demand; and an intertemporal problem in which they maximize the flow of discounted profits by choosing the quantity of factors for production.

The intratemporal problem can be thought of being solved by the financial department of each firm e, which decides how much to borrow from each bank b given its overall loan demand. Following Aksoy et al. (2009) and Aliaga-Diaz and Olivero (2010), lending relationships arise due to the presence of deep habits in lending. Such a device represents a reduced-form tool to incorporate the borrower's hold-up problem into the model. In fact, the outcome of this mechanism is that firms are held up in lending relationships, which can be strategically exploited by banks. Santos and Winton (2008) and Aliaga-Diaz and Olivero (2010) find empirical evidence that banks hold up borrowers, because the former gain an "information monopoly" over customers' creditworthiness and the latter find it costly to switch to a new funding source. From a technical point of view, the problem is analogous to the intratemporal problem solved by households when they feature deep habits in consumption. The optimization problem consists in the following:

$$\min_{L^e_{bt}} \int_0^1 (1+R^L_{bt})L^e_{bt}, \tag{20}$$

$$s.t. \ \left[\int_0^1 \left(L^e_{bt} - \theta^L S^L_{bt-1}\right)^{1-\frac{1}{\eta^L}} db\right]^{1/(1-\frac{1}{\eta^L})} = \left(X^L_t\right)^e, \tag{21}$$

$$S^L_{bt} = \varrho^L S^L_{bt-1} + (1-\varrho^L)L_{bt}, \tag{22}$$

where R^L_{bt} is the net lending rate, L^e_{bt} is the demand by firm e for loans issued by bank b, θ^L is the degree of habit in lending, S^L_{bt} is the stock of (external) habit in lending, η^L is the elasticity of substitution across varieties of loans, $\left(X^L_t\right)^e$ is the demand for loans by firm e augmented by lending relationships and ϱ^L is the persistence of lending relationships. Equation (20) represents overall lending expenditure; equation (21) imposes deep habits in lending; and (22) imposes persistence in the stock of habit as in Aliaga-Diaz and Olivero (2010).

The solution to the above problem yields firm e's demand for loans from bank b:

$$L^e_{bt} = \left(\frac{1+R^L_{bt}}{1+R^L_t}\right)^{-\eta^L} \left(X^L_t\right)^e + \theta^L S^L_{bt-1}, \tag{23}$$

where $(1+R^L_t)$ is the price index for the loan composite and corresponds to the Lagrange multiplier attached to constraint (21) as standard with the Dixit-Stiglitz aggregator.

Entrepreneur e faces also an intertemporal problem by solving which she chooses capital K^e_{t+1} and employment H^e_t to maximize the expected discounted value of its lifetime profits. Recalling that in this economy firms are owned by households, the stochastic discount factor of the former, $\Lambda_{t,t+1}$, is given by the intertemporal marginal rate of substitution of the latter. The intertemporal optimization problem is summarized by the following:

$$\max_{H^e_t, K^e_{t+1}} E_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left\{ \begin{array}{c} \Phi_{t+s} F(K^e_{t+s}, H^e_{t+s}) - W_{t+s}H^e_{t+s} - I^e_{t+s} \\ + \left(X^L_{t+s}\right)^e - \int_0^1 (1+R^L_{bt+s})L^e_{bt+s}db + \Xi^e_{t+s} \end{array} \right\}, \tag{24}$$

$$s.t. \ K^e_{t+1} = I^e_t + (1-\delta)K^e_t, \tag{25}$$

$$\int_0^1 L^e_{bt+1}db \geq I^e_t + W_t H^e_t. \tag{26}$$

Equation (24) is the sum of discounted profits expressed in terms of net cash flows. $F(K_t^e, h_t^e)$ is an increasing and concave production function in capital and labor, Φ_t is the competitive real price at which the wholesale output is sold, $W_t H_t^e$ is the wage bill, I_t^e is the expenditure in investment goods, $\Xi_t^e \equiv \theta^L \int_0^1 \frac{1+R_{bt}}{1+R_t} S_{bt-1}^L db$ such that $\left(X_t^L\right)^e + \Xi_t^e = \int_0^1 L_{bt}^e db = L_t^e$, i.e. the amount of loans that flow into the entrepreneur's balance sheet, while $\int_0^1 (1+R_{bt}^L) L_{bt}^e db$ represents what they repay to banks. Equation (25) is a standard law of motion of capital, which depreciates at rate δ, while constraint (26) makes it necessary for firms to borrow from banks in order to finance investment expenditure and the wage bill. The latter represents a *financing constraint* needed for external credit to play a role in the model. Without the imposition of this constraint, firms would always find it optimal to satisfy their financing needs via internal funds. Thus (26) holds with equality in equilibrium.[7] Investment I_t^e is also a composite of differentiated goods but it is not subject to deep habit formation: $I_t^e = \left[\int_0^1 (I_{it}^e)^{1-\frac{1}{\eta}} di\right]^{\frac{1}{1-\frac{1}{\eta}}}$. Expenditure minimisation leads to the optimal level of demand of investment goods for each variety i:

$$I_{it}^e = \left(\frac{P_{it}}{P_t}\right)^{-\eta} I_t^e. \tag{27}$$

Substituting for equations (25) and (26) into (24) and taking the first-order conditions with respect to H_t^e and K_{t+1}^e lead to the following

$$\Phi_t F_{H,t} = W_t E_t \left[\Lambda_{t,t+1}(1+R_{t+1}^L)\right], \tag{28}$$

$$E_t \left[\Lambda_{t,t+1}(1+R_{t+1}^L)\right] = E_t \Lambda_{t,t+1} \left[\Phi_{t+1} F_{K,t+1} + \Lambda_{t,t+2}(1+R_{t+2}^L)(1-\delta) \right]. \tag{29}$$

Condition (28) equates the real value of the marginal product of labor to the cost of the marginal hour of work, which in turn depends on the real wage and the expected lending rate. Condition (29) equates the expected cost of borrowing one unit of capital to its expected benefit at the margin. The latter, in turn, incorporates (i) the expected real value of the marginal product of capital; and (ii) the expected marginal saving deriving from not having to borrow fraction $(1-\delta)$ of capital one period ahead. The real price Φ_t represents the shadow value of output and hence, given perfect

[7] Inequality (26) introduces the cost channel of both labor and investment in a reduced-form way. The labor cost channel has been introduced by Christiano et al. (2005), among others, while the investment cost channel is a feature of financial accelerator models, such as Bernanke et al. (1999).

competition in the wholesale market, it also represents its real marginal cost. The full cost channel imposed by constraint (26) makes entrepreneurs' equilibrium conditions intertemporal and the real marginal cost Φ_t an increasing function of the lending rate.

3.4 Final good firms

A continuum of final good firms $i \in (0,1)$ buy the wholesale good from entrepreneurs at the real price Φ_t, differentiate it and sell it in a monopolistically competitive market at price P_{it}. Price stickiness is introduced in the model as in Rotemberg (1982), i.e. by assuming that changing prices costs resources. In particular, it is assumed that final good firms face quadratic price adjustment costs $\frac{\xi}{2}\left(\frac{P_{it}}{P_{it-1}}-1\right)^2$, where parameter ξ measures the degree of price stickiness.[8] The real price Φ_t charged by entrepreneurs in the wholesale competitive market represents also the real marginal cost common to all final good firms, i.e. $MC_t = \Phi_t$. Final good firm i chooses C_{it+s}, S^c_{it+s}, G_{it+s}, S^g_{it+s} and P_{it+s} to maximize the following flow of discounted profits:

$$E_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left\{ \left(\frac{P_{it+s}}{P_{it+s-1}} - MC_{t+s} \right) (C_{it+s} + I_{it+s} + G_{it+s}) + \frac{\xi}{2} \left(\frac{P_{it+s}}{P_{it+s-1}} - 1 \right)^2 \right\}, \tag{30}$$

subject to the demand for good i in the form of private consumption C_{it}, (8), investment I_{it}, (27), and government consumption G_{it}, (16), and the laws of motion of the stocks of habit for households, (5), and the government, (15). This leads to the following first-order conditions:

$$\frac{P_{it}}{P_t} - MC_t + (1-\varrho)\lambda^c_t = \nu^c_t, \tag{31}$$

$$E_t \Lambda_{t,t+1} (\theta \nu^c_{t+1} + \varrho \lambda^c_{t+1}) = \lambda^c_t, \tag{32}$$

$$\frac{P_{it}}{P_t} - MC_t + (1-\varrho)\lambda^g_t = \nu^g_t, \tag{33}$$

$$E_t \Lambda_{t,t+1} (\theta \nu^g_{t+1} + \varrho \lambda^g_{t+1}) = \lambda^g_t, \tag{34}$$

[8] The use of price-adjustment costs as in Rotemberg (1982) is shared by virtually all papers featuring deep habits in consumption as it is a rather straight-forward addition from a technical point of view.

$$
\begin{aligned}
\frac{P_{it}}{P_t}(C_{it}+G_{it}) - \xi\left(\frac{P_{it}}{P_{it+s}}-1\right)\frac{P_{it}}{P_{it-1}} + (1-\eta)\left(\frac{P_{it}}{P_t}\right)^{1-\eta} I_t & \\
+\eta MC_t\left(\frac{P_{it}}{P_t}\right)^{-\eta} I_t - \eta\nu_t^c\left(\frac{P_{it}}{P_t}\right)^{-\eta} X_t^c - \eta\nu_t^g\left(\frac{P_{it}}{P_t}\right)^{-\eta} X_t^g & \\
+\xi\Lambda_{t,t+1}\left[\left(\frac{P_{it+1}}{P_{it}}-1\right)\frac{P_{it+1}}{P_{it}}\right] &= 0, \qquad (35)
\end{aligned}
$$

where ν_t^c, ν_t^g, λ_t^c andλ_t^g are the Lagrange multipliers on constraints (8), (16), (5) and (15), respectively.

Let MC_t^n denote the nominal marginal cost. The gross mark-up charged by final good firm i can be defined as $\mu_{it} \equiv P_{it}/MC_t^n = \frac{P_{it}}{P_t}/\frac{MC_t^n}{P_t} = p_{it}/MC_t$. In the symmetric equilibrium all final good firms charge the same price, $P_{it} = P_t$, hence the relative price is unity, $p_{it} = 1$. It follows that, in the symmetric equilibrium, the mark-up is simply the inverse of the marginal cost. By combining equations (31), (33) and (35), substituting for the demands for C_{it} and G_{it}, (6) and (16), and rearranging, the optimal pricing decision in the symmetric equilibrium can be written as follows:

$$
\begin{aligned}
(X_t^c + X_t^g + I_t)\left[1 - \frac{\eta}{\eta-1}MC_t\right] & \\
+\frac{\eta}{\eta-1}(1-\varrho)\left[\lambda_t^c X_t^c + \lambda_t^g X_t^g\right] - \frac{\theta}{\eta-1}\left(S_{t-1}^c + S_{t-1}^g\right) & \\
+\xi E_t\Lambda_{t,t+1}\left[\Pi_{t+1}\left(\Pi_{t+1}-1\right)\right] - \xi\Pi_t\left(\Pi_t - 1\right) &= 0, \qquad (36)
\end{aligned}
$$

where $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ is the gross inflation rate. Note that the third line in pricing equation (36) disappears when $\xi = 0$ and prices become fully flexible. Such a restriction is used in Section 5 where results are analyzed in the flexible-price benchmark.

3.5 Banking sector

The banking sector is borrowed from Aksoy et al. (2009) and Aliaga-Diaz and Olivero (2010). Each bank b chooses its demand for deposits, D_{bt+1}, and the loan rate, R_{bt+1}^L, to maximize the expected discounted value of its lifetime profits. Banks are owned by households as well; therefore, their stochastic discount factor, $\Lambda_{t,t+1}$, is given by the intertemporal marginal rate of substitution of the households. The optimization problem is summarized by the following:

$$\max_{D_{bt},R^L_{bt}} E_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left\{ D_{bt+s+1} - L_{bt+s+1} + (1+R^L_{bt+s})L_{bt+s} - (1+R_{t+s})D_{bt+s} \right\}, \tag{37}$$

$$s.t.\ L_{bt} = D_{bt}, \tag{38}$$

$$L_{bt} = \left(\frac{1+R^L_{bt}}{1+R^L_t} \right)^{-\eta^L} X^L_t + \theta^L S^L_{bt-1}. \tag{39}$$

Equation (37) represents the cash flow of the bank in each period, given by the difference between deposits and loans and the difference by earnings on assets, priced at the net rate R^L_{bt}, and interest payments on liabilities. Equation (38) represents the bank's balance sheet, where deposits on the liabilities side are equal to loans on the asset side. Equation (39) represents the bank-specific demand for loans.

Taking the first-order conditions with respect to L_{bt+1} and R^L_{bt+1} yields respectively:

$$\nu_{bt} = E_t \Lambda_{t,t+s} \left[\left(R^L_{bt+1} - R_{t+1} \right) + \nu_{bt+1} \theta^L (1-\varrho^L) \right], \tag{40}$$

$$E_t \left[\Lambda_{t,t+s} L_{bt+1} \right] = \nu_{bt} \eta^L E_t \left[X^L_{t+1} \right], \tag{41}$$

where ν_{bt} is the Lagrange multiplier associated with this maximization problem. Equation (40) states that the shadow value of lending an extra unit in period t is equal to the benefit from the spread earned on this operation plus the benefit of expected future profits arising from the fact that a share θ^L of this lending is *held-up* at time $t+1$. According to equation (41), the marginal benefit of increasing the loan rate should be equal to its marginal cost given by the reduced demand for loans evaluated at the shadow value ν_{bt}.

3.6 Monetary authority

When the model features price stickiness ($\xi > 0$), it is closed with a simple Taylor rule describing monetary policy setting as in Galí et al. (2007):

$$\log \left(\frac{1+R^n_t}{1+\bar{R}^n} \right) = \varrho_\pi \log \left(\frac{\Pi_t}{\bar{\Pi}} \right), \tag{42}$$

and a Fisher equation:

$$1 + R^B_{t+1} = E_t \left[\frac{1 + R^n_t}{\Pi_{t+1}} \right], \tag{43}$$

where R^n_t is the nominal interest rate.

3.7 Equilibrium

In the symmetric equilibrium, goods markets, the labor market, the credit market, and bond markets clear. The symmetric equilibrium consists of an allocation and a sequence of prices and co-state variables that satisfy the optimality conditions of households, the government, entrepreneurs, final goods firms and banks; the fiscal rules; and the stochastic processes.

The resource constraint completes the model:

$$Y_t = C_t + I_t + G_t + \frac{\xi}{2} \left(\frac{P_t}{P_{t-1}} - 1 \right)^2 . \tag{44}$$

Taking a log-linear approximation of the equilibrium system around steady-state values, and using the Blanchard-Kahn procedure, yields the following state-space solution

$$\hat{\mathbf{s}}_{t+1} = \mathbf{\Phi}_1 \hat{\mathbf{s}}_t + \mathbf{\Phi}_2 \epsilon_{t+1}, \tag{45}$$

$$\hat{\mathbf{d}}_t = \mathbf{\Phi}_3 \hat{\mathbf{s}}_t, \tag{46}$$

where vector $\hat{\mathbf{s}}_t$ includes predetermined and exogenous variables; vector $\hat{\mathbf{d}}_t$ contains the control variables; vector ϵ_t includes all random disturbances; and matrices $\mathbf{\Phi}_1$, $\mathbf{\Phi}_2$ and $\mathbf{\Phi}_3$ contain elements that depend on the structural parameters of the model.

4 Calibration

To calibrate the model numerical values are assigned to parameters in order to match a number of stylized facts for the US economy in the post-WWII era. Table 2 summarizes all the parameter values. The time period in the model corresponds to one quarter in the data.

The utility function $U(\cdot)$ specializes as $U(\cdot) = \frac{\left[C_t^{\omega}(1-H_t)^{1-\omega}\right]^{1-\sigma}}{1-\sigma}$, where $\sigma > 1$ is the constant relative risk aversion coefficient and ω is the elasticity of substitution between consumption and

Parameter		Value
Discount factor	β	0.99
Capital depreciation rate	δ	0.025
Production function parameter	α	0.66
Risk aversion	σ	2
Deep habits in consumption	θ	0.86
Consumption habit persistence	ϱ	0.85
Deep habits in lending	θ^L	0.72
Pers. of lending relationships	ϱ^L	0.85
Share of government spending	$\frac{G}{Y}$	0.20
S.S. sales tax rate	τ^c	0.05
S.S. labor income tax rate	τ^w	0.24
Persistence of gov spending	ρ_G	0.90
Persistence of tax shocks	ρ_X	0.95
Price stickiness	ξ	30
Monetary response to inflation	ϱ_π	1.5
Preference parameter	ω	set to target $H = 0.44$
Elasticity of substitution	η	set to target $\mu = 1.20$
Elast. of subst. in banking	η^L	set to target $R - r = 0.005$

Table 2: Calibration

leisure; while the production function is a standard Cobb-Douglas: $F(\cdot) = H_t^\alpha K_t^{1-\alpha}$.

Some parameters are standard in the business cycle literature. In particular, the subjective discount factor, β, is equal to 0.99, the capital depreciation rate, δ, to 0.025, the production function parameter, α, to 0.66 and the coefficient of relative risk aversion, σ, to 2.

The consumption deep habits parameters, θ and ϱ, are equal to 0.86 and 0.85, following the estimates used by Ravn et al. (2006). The parameter representing deep habits in lending relationships, θ^L, is set equal to 0.72, relying on the estimate provided by Aliaga-Diaz and Olivero (2010), while the persistence in lending relationships, ϱ^L, is set equal to 0.85, following again Aliaga-Diaz and Olivero (2010). However, Section 6 provides sensitivity analysis to the choice of the deep habits parameters for consumption and lending.

Steady-state values for the tax rates and the persistence parameters of fiscal shocks are borrowed from Fernández-Villaverde (2010) and Monacelli et al. (2010). Therefore, the steady-state tax rate on sales, τ^c, and on labor income, τ^w, are set to 0.05 and 0.24, respectively, while the persistence parameters of fiscal shocks, ρ_G and ρ_X, are set to 0.90, and 0.95, respectively which are also close to the persistence observed in the data. Steady-state government debt is set equal to zero in steady state, implying also that the government runs a balanced budget in steady state. In the benchmark scenario of lump-sum taxes and balanced budget explored in Section 5 tax rates are constantly set equal to zero, $\tau_t^C = \tau_t^W = 0$, $TR_t = 0$ without loss of generality, and $T_t = G_t$, such that no government debt accumulation is allowed. When tax distortion is explored in Section 6, results are presented using alternative responsiveness parameters of the tax rates to the debt-to-GDP ratio, ρ_{XB}.

The Rotemberg price stickiness parameter, ξ, is set equal to 30, which corresponds to the Calvo analogue of firms changing prices almost every three quarters (in the absence of deep habits), as in Smets and Wouters (2007).[9] The Taylor rule parameter is set as in Galí et al. (2007): $\varrho_\pi = 1.5$. In the flexible-price benchmark analyzed in Section 5, $\xi = 0$, and monetary policy becomes redundant.

The preference parameter, ω , is set to match steady state hours of work equal to 0.44 , as in Kydland and Prescott (1991). The elasticity of substitution across different varieties, η, is set in order to target a steady state gross mark-up equal to 1.20 as in Christiano et al. (2010).

The elasticity of substitution in the banking sector, η^L, is set in order to match a gross spread between the lending rate and the risk free rate of 0.005 (200 basis points per year) as in Bernanke et al. (1999). The same interest rate spread is targeted also by Aksoy et al. (2009) and Aliaga-Diaz and Olivero (2010). In addition to the explicitly-targeted steady-state values, the above calibration implies a consumption-output ratio of around 60% and a private investment-output ratio of around 20%.

5 Results in the flexible-price benchmark

This section presents the effect of an expansionary government spending shock (i) in the flexible-price benchmark model, i.e. the RBC model with monopolistic competition, deep habits in lending, and balanced budget (FP); and (ii) in the flexible-price benchmark model with deep habits in private and government consumption (FPDH). With respect to the fully-fledged model outlined in Section 3, this translates into setting $\theta = \rho = 0$ for the FP model; $\theta = 0.86$ and $\rho = 0.85$ for the FPDH

[9] Jacob (2010) shows that for a given value of Rotemberg adjustment costs, the introduction of deep habits reduces the response of prices to the marginal cost and hence it is impossible to compare the deep habits New-Keynesian Phillips Curve (NKPC) slope to the Calvo analogue. Hence, following Jacob (2010), it is the slope of the standard forward-looking NKPC that can be interpreted in quarterly terms. Namely, the log-linearized NKPC assumes the following form: $\hat{\Pi}_t = \beta E_t \hat{\Pi}_{t+1} + \kappa \hat{MC}_t$, where $\kappa = \frac{\eta-1}{\xi}$ under Rotemberg pricing and $\kappa = \frac{(1-\beta\xi^c)(1-\xi^c)}{\xi^c}$ under Calvo contracts, where ξ^c is the Calvo parameter that determines the average quarterly duration of contracts $\frac{1}{1-\xi^c}$. Given a certain ξ, it is straightforward to induce the implied analogous contract duration in the Calvo world.

model; and $\xi = \tau^c = \tau^w = \rho_{XB} = 0$ and $T_t = G_t$, $\forall t$ for both models.

The empirical evidence provided in Section 2 suggests that an expansionary government spending shock leads to a fall in the credit spread, to a rise in private consumption, investment, and lending, and to an initial fall in the real wage, followed by a subsequent increase. Recent empirical contributions in the fiscal literature provide extensive support for the crowding-in effect of government spending on private consumption (Blanchard and Perotti, 2002; Galí et al., 2007; Pappa, 2009; Monacelli et al., 2010; Fragetta and Melina, 2011). In addition, the increase in hours worked due to the fiscal expansion is generally accompanied by a boost in the real wage (Pappa, 2005; Galí et al., 2007; Caldara and Kamps, 2008; Pappa, 2009; Fragetta and Melina, 2011). Finally, there is evidence that the price mark-up drops after an increase in government expenditures (Monacelli and Perotti, 2008; Canova and Pappa, 2011). Figure 4 shows that in the FP model the above-mentioned variables react in a way opposite to the empirical findings. The signs of impulse responses flip, matching empirics, in the FPDH model, i.e. when deep habits in private and government consumption are activated.

On the size of the government spending multiplier, the empirical literature provides a variety of results. Recently, Hall (2009) finds a multiplier of around one. Barro and Redlick (2011) and Ramey (2009) estimate less-than-one multipliers for defense spending (between 0.5 and 0.7), while Blinder and Zandi (2010) argue that the general spending multiplier is around 1.5. However, flexible-price models calibrated for the US economy typically deliver spending multipliers smaller than available empirical estimates.

In the FP model, when the economy is hit by an expansionary government spending shock, a negative wealth effect, caused by the absorption of resources by the government, makes consumption and leisure less affordable, stimulates labor supply and causes a drop in the real wage, while the price mark-up stays constant by construction. As a result, output increases, but necessarily in a less than proportional way, as also Woodford (2011) shows from an analytical point of view. In Figure 4 the government spending shock is normalized to 1% of output so that the response of output itself can be read as a fiscal multiplier, at impact equal to around 0.2 in the flexible-price benchmark. In the credit market, the negative wealth effect affecting households' decision has the consequence of a drop in the supply of deposits and a subsequent surge in the deposit rate. It follows that banks, having observed that the availability of funds is shrinking, have an incentive to exploit their current

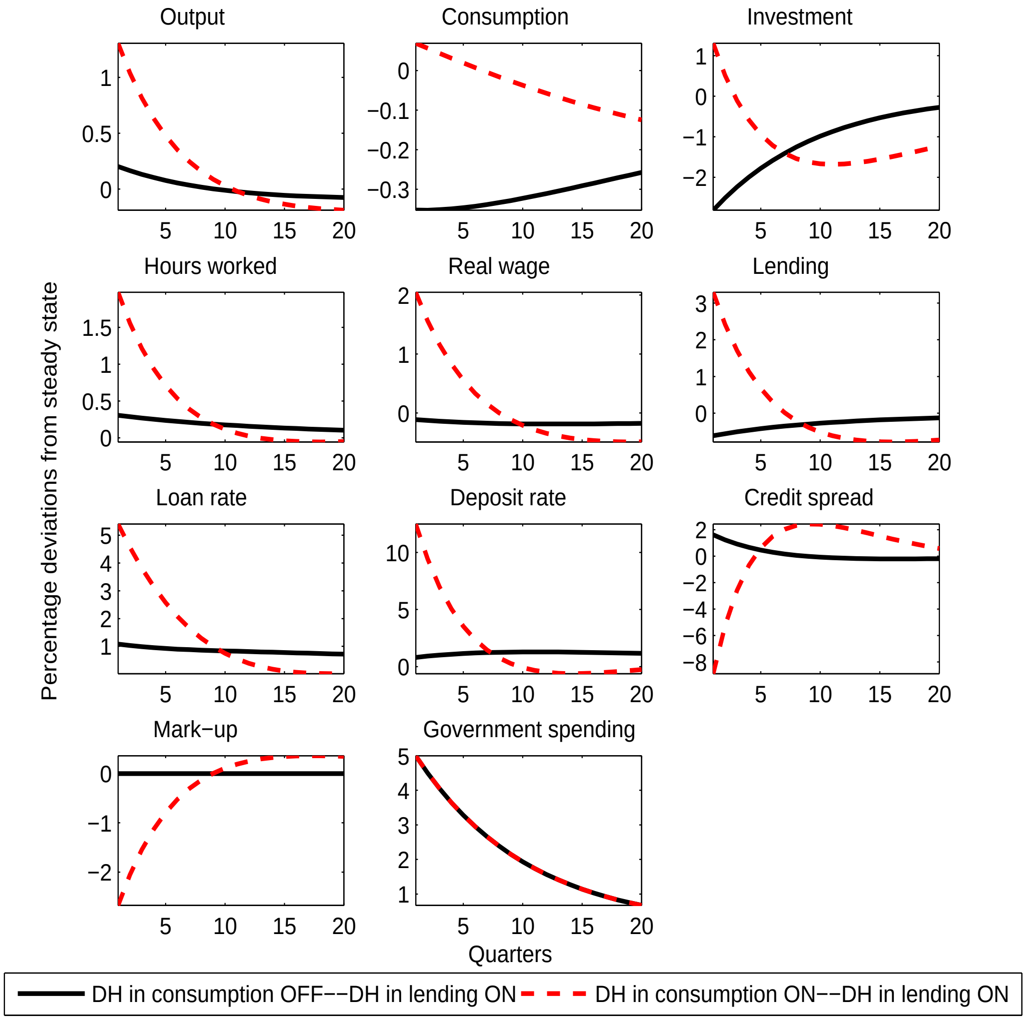

Figure 4: A government spending expansion in the flexible-price benchmark with lending relationships (1% of output).

customer base, by raising the loan rate more than proportionally to the increase in the deposit rate, this resulting in an upswing in the credit spread and a fall in the amount of lending and consequently of private investment.

In the FPDH model, all the empirical findings mentioned above are matched. Therefore, deep habits in private and government consumption are retained in the exercises performed in the remainder of the paper as a tool to get "facts" right. The seminal work by Ravn et al. (2006) demonstrates that, when deep habits in consumption are introduced into an otherwise standard RBC model, a government spending expansion yields a crowding-in of consumption as opposed to a crowding out, an increase in the real wage and a fall in the price mark-up. In the model outlined in this paper, this addition also leads to a fiscal multiplier of 1.3, a value in the high range of empirical estimates.

The differences in the transmission mechanism of a fiscal shock in a model with deep habits in consumption work through the fact that the price mark-up is countercyclical under deep habits even if the model features fully flexible prices. Under deep habits, the mark-up is countercyclical due to the co-existence of two effects: an *intratemporal effect* (or *price-elasticity effect*) and an *intertemporal effect*. The intratemporal effect can easily be understood by looking at the demand faced by an individual firm i:

$$AD_{it} = C_{it} + G_{it} + I_{it} = \left(\frac{P_{it,}}{P_t}\right)^{-\eta} \left(X_t^c + X_t^g + I_t\right) + \theta \left(S_{it-1}^c + S_{it-1}^g\right).$$

The right-hand side of the demand curve is given by the sum of a *price-elastic* term and a *price-inelastic* term. When the habit-adjusted aggregate demand $(X_t^c + X_t^g + I_t)$ rises, the "weight" of the price-elastic component of demand grows and the price elasticity of demand $\tilde{\eta}_{it} \equiv -\frac{\partial AD_{it}}{\partial p_{it}} \frac{p_{it}}{AD_{it}} = \eta - \theta \frac{\left(S_{it-1}^c + S_{it-1}^g\right)}{AD_{it}}$ increases, as opposed to remaining constant and equal to η as in the standard case ($\theta = 0$). The fact that the elasticity of demand is pro-cyclical is one determinant for the price mark-up being counter-cyclical. The other determinant comes from the intertemporal effect: the awareness of higher future sales coupled with the notion that consumers form habit at the variety level, makes firms inclined to give up some of the current profits – by temporarily lowering their mark-up – in order to lock-in new customers and charge them higher mark-ups in the future.

A government spending expansion, also under deep habits, causes a negative wealth effect. However, the drop in the mark-up, translates into a rise in labor demand stronger than the rise in labor supply and into a stronger rise in the demand for investment. As a result, the real wage increases and the demand for investment shifts outward. The increase in the real wage triggers a strong substitution effect away from leisure, which has become relatively more expensive, and into consumption, hence the crowding-in of the latter. Relative to the FP model, output is allowed to increase by more, because in the FPDH model hours worked increase by more and hence so does the marginal product of capital. Banks face a rise in the demand for loans – meant to finance investment and the wage bill – and this translates into a higher demand for deposits. This raises both the loan rate and the deposit rate. However, banks also incorporate the information of high future returns and hence their prospective ability of making high future profits. This makes them willing to give up some of the current profits in order to expand their customer base by locking in more customers into lending relationships. This results into a temporary fall of the credit spread and an expansion of equilibrium lending. The impulse responses delivered by the FPDH model show the same sign as the estimated impulse responses reported in Section 2, although empirical responses are generally hump-shaped.

6 Sensitivity and extensions

This section illustrates a series of modifications in the FPDH model in order to (i) disentangle the effects of a number of features of the model and (ii) analyze the robustness of the main results. Subsection 6.1 introduces government debt which can be financed by either lump-sum or distortionary taxation (labor income tax or consumption tax). It also shows how the dynamics of the impulse responses to a government expenditure expansion are affected by different degrees of responsiveness to government debt. Subsection 6.2 shows the sensitivity of the results to the values of the parameters measuring the degree of deep habits in consumption and in lending, and to the values of the persistence parameters of deep habits in consumption and in lending. Subsection 6.3 explores the robustness of the results to price stickiness and shows the financial accelerator effect.

6.1 Government debt and distortionary taxation

This subsection explores the issue of whether the results presented in Section 5 hold also when the government finances its expenditures partly by issuing government bonds and partly by adopting either lump-sum or distortionary taxation. The benchmark against which different model specifications are compared is the flexible-price benchmark model with deep habits in private and government consumption (FPDH) discussed in Section 5, which is a model with lump-sum taxes (LS) and a balanced government budget (BB).

Figure 5 illustrates the Ricardian equivalence result according to which, if taxation is not distortionary, the timing of tax collection necessary to finance a government expenditure expansion does not alter the equilibrium as private agents internalize the government budget constraint. The impulse responses reported are obtained by letting lump-sum taxes react to the government debt-to-GDP ratio according to feedback rule (19) with different calibrations of the responsiveness parameter ϱ_{TB}, keeping all other sources of taxation off. The path of the impulse responses is the same as

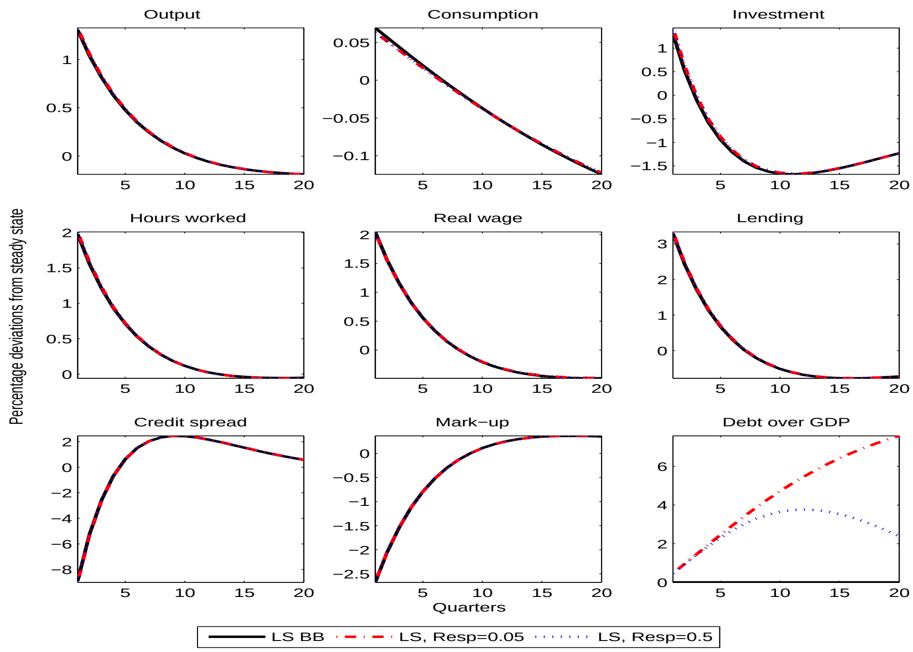

Figure 5: A government spending expansion (1% of output) financed by government debt and lump-sum taxes.

in the LS BB model, despite the fact that the accumulation of government debt is clearly more pronounced if the policy responsiveness is milder.

An analogous exercise consists in comparing impulse responses obtained in a model where the only sources of financing for the government are debt and the labor income tax, the rate of which, τ_t^w, evolves according to feedback rule (19) with different calibrations of the responsiveness parameter $\varrho_{\tau^w B}$. As Figure 6 shows, the dynamics of the impulse responses to a government expenditure expansion are affected by the introduction of the labor income tax and by the strength with which tax rate τ_t^w responds to the government debt-to-GDP ratio, compared to the LS BB case. In particular, feedback rule (19) implies on one hand that tax rate τ_t^w reacts to the debt-to-GDP ratio; on the other hand the reaction is delayed by the presence of the smoothing component. The latter, for some quarters, leads to a slight stronger increase in hours worked compared to the LS BB case, as agents are aware that the tax rate increases with a delay relative to the rise in debt-to-GDP. Via the marginal product of capital and loan demand, investment and lending show similar patterns. The impact output multiplier is marginally affected. After some quarters, however, hours of work decline by more relative to the LS BB case due to (i) higher intertemporal substitution of the labor

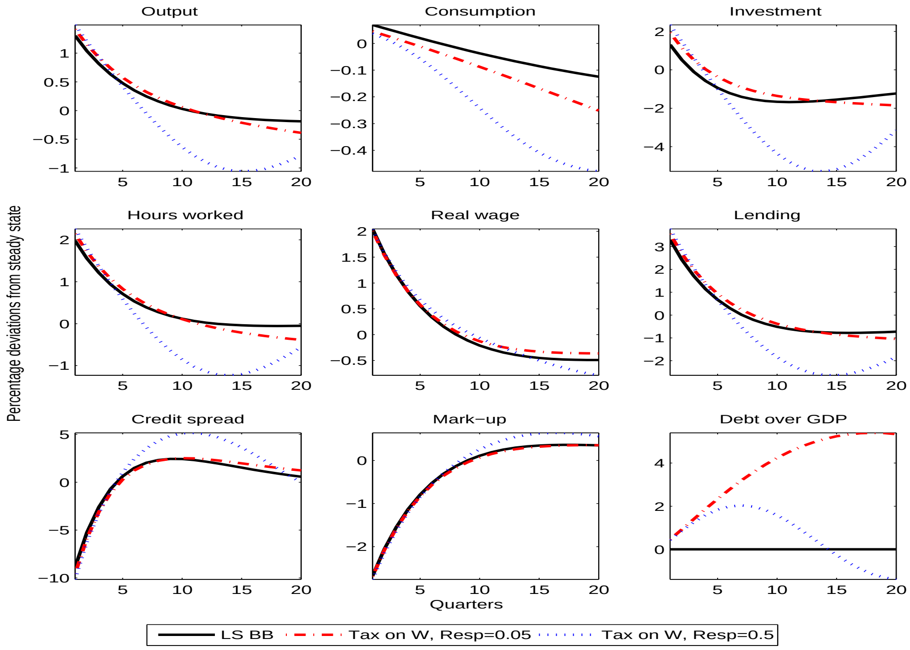

Figure 6: A government spending expansion (1% of output) financed by government debt and the labor income tax.

supply (as agents anticipate that in the long run the tax rate will converge back to its steady-state value); and (ii) intratemporal substitution of consumption with leisure, the latter being relatively more affordable. The drop of private consumption after the initial crowding-in is bigger than the LS BB case, both due to the negative income effect caused by the increase in the tax rate and by the mentioned substitution effects. The higher $\varrho_{\tau^w B}$, the bigger are these effects, which in turn translate into a stronger subsequent fall in output. A stronger decrease in hours worked is mirrored also in a stronger decline in investment and lending due to the fact that, from the supply side of the credit market, lower households' income leads to a fall in the financial resources being deposited; from the demand side, a lower level of hours worked translates into a lower marginal product of capital and a lower investment and loan demand. Despite the altered dynamics, the main empirical regularities matched by the FPDH model with LS and BB, including the fall in the credit spread, are robust to the introduction of the labor income tax and government debt, both with a mild response to the debt-to-GDP ratio ($\varrho_{\tau^w B} = 0.05$, which leaves the ratio well above steady state also after 20 quarters); and with a strong response ($\varrho_{\tau^w B} = 0.5$, which brings it to zero in less than 15 quarters).

Finally, Figure 7 reports the case in which the sources of financing for the government are debt

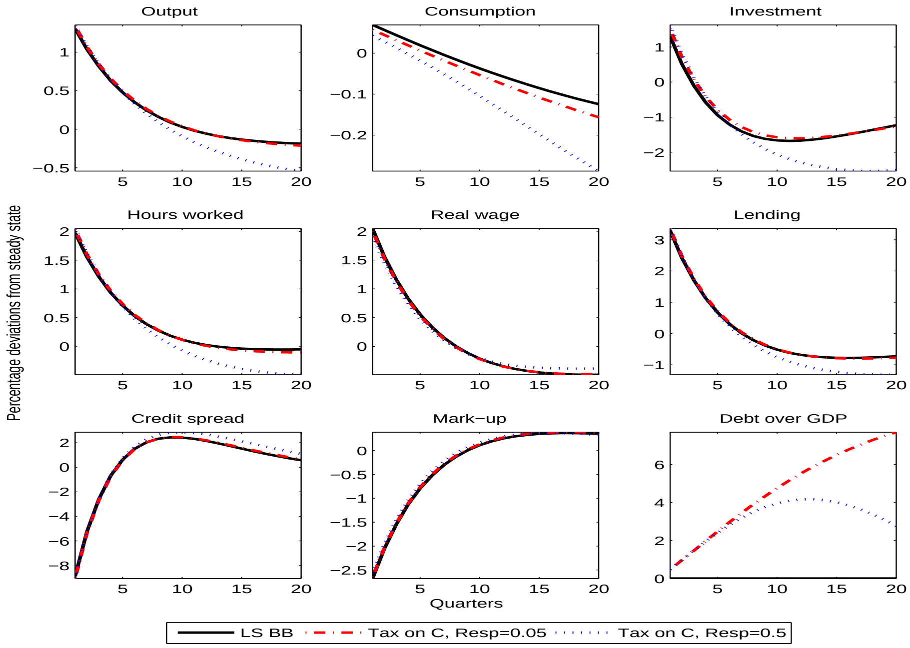

Figure 7: A government spending expansion (1% of output) financed by government debt and the consumption tax.

and the consumption tax, the rate of which, τ_t^c, also evolves according to feedback rule (19) with different calibrations of the responsiveness parameter $\varrho_{\tau^c B}$. Analogously to what happens when government expenditure is financed via labor income tax, the dynamics of the impulse responses to a government expenditure expansion are affected by the introduction of τ_t^c and by the magnitude of $\varrho_{\tau^c B}$, compared to the LS BB case. Namely, as the tax rate responds more aggressively to debt-to-GDP, i.e. it increases more, the substitution of consumption with leisure becomes stronger, making consumption and hours worked decrease by more, after their initial increase. The main empirical regularities matched by the FPDH model with LS and BB are robust also to the introduction of the consumption tax and different responsiveness to government debt.

6.2 Sensitivity to deep habits

This subsection shows the sensitivity of the results reported in Section 5 to the values of the parameters measuring the degree of deep habits in consumption, θ, and in lending, θ^L; and the persistence of deep habits in consumption, ϱ, and in lending, ϱ^L. Remaining parameters are calibrated as in the flexible-price benchmark model specification as in Section 5.

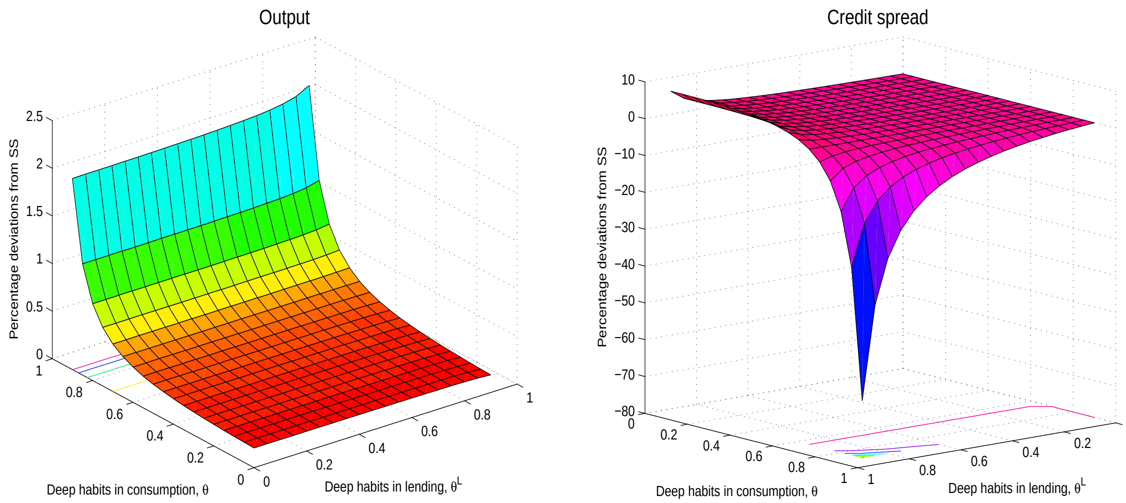

Figure 8: Sensitivity of output and credit spread to deep habits in consumption and deep habits in lending. Impact responses to a government spending expansion of 1% of output.

Figure 8 shows the impact responses of output and the credit spread to a government spending expansion (i) at different degrees of deep habits in consumption and (ii) at different degrees of deep habits in lending. The chart on the right-hand side shows that when deep habits in lending are off, i.e. $\theta^L = 0$, the impact response of the credit spread is zero at any value of deep habits in consumption, since the removal of deep habits in lending eliminates the effects of financial frictions and implies a constant spread by construction. As long as $\theta = 0$, if $\theta^L > 0$, the credit spread increases after an expansionary government spending shock as explained in Section 5. As θ^L increases, the positive effect on the credit spread is magnified. At any given positive θ^L, the impact response of the credit spread declines as the degree of deep habits in consumption, θ, increases, becoming negative for $\theta \geq 0.7$. As both θ and θ^L become large, the effects stemming (i) from stronger countercyclical movements in the price mark-up (due to stronger deep habit formation in consumption) – which boosts investment to a greater extent – and (ii) from stronger lending relationships – which make banks' future profits relatively more valuable than current profits – act into the same direction towards a stronger drop in the credit spread. The chart on the left-hand side shows that when deep habits in consumption and in lending are both off, the value of the impact output multiplier is of the order of 0.2. The higher the degree of deep habits in consumption the greater is the output multiplier for any given value of the degree of deep habits in lending. For $\theta < 0.7$, higher values of θ^L are associated with a reduction in the output multiplier, driven by the positive effect on the

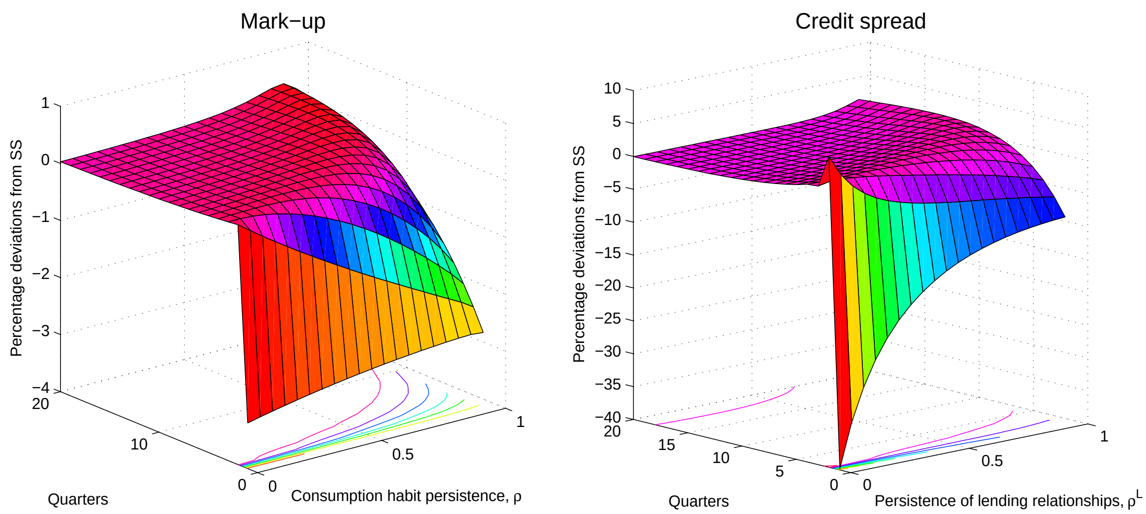

Figure 9: Sensitivity of mark-up to consumption habit persistence and of credit spread to the persistence of lending relationships. Responses to a government spending expansion of 1% of output.

credit spread. For $\theta \geq 0.7$, higher values of θ^L lead to increased output multipliers, consistently with the negative impact response of the credit spread that causes a larger expansion in lending. The amplification of the shocks when lending relationships are "on" is justified by the presence of an endogenous spread. The change in the spread leads to a greater change in lending and, therefore, investment and labor. This mechanism reinforces the increase in output, amplifying the expansionary effects of a government spending expansion. This financial accelerator effect is even more pronounced in the sticky price version of the model presented in Subsection 6.3. However, Figure 8 clearly shows that the magnitude of the impact output multiplier is mainly driven by the degree of deep habits in consumption.

Sensitivity of the results to the choice of the parameters measuring consumption habit persistence, ϱ, and the persistence of lending relationships, ϱ^L, is shown in Figures 9 and 10. Figure 9 shows the impulse responses for the first 20 quarters (i) of the mark-up at different values of ρ; and (ii) of the credit spread at different values of ϱ^L. When deep habits in consumption or in lending last for only one quarter, i.e. $\varrho = 0$ or $\varrho^L = 0$, the negative impact responses of the mark-up or of the credit spread are substantially magnified. In this case, final good firms or banks reduce their respective mark-ups – i.e. the price mark-up or the credit spread – to a greater extent in order to lock in as many of their customers as possible in firm-to-customer relationships. These, in fact, can be exploited for only one quarter, during which their customers are charged larger mark-ups.

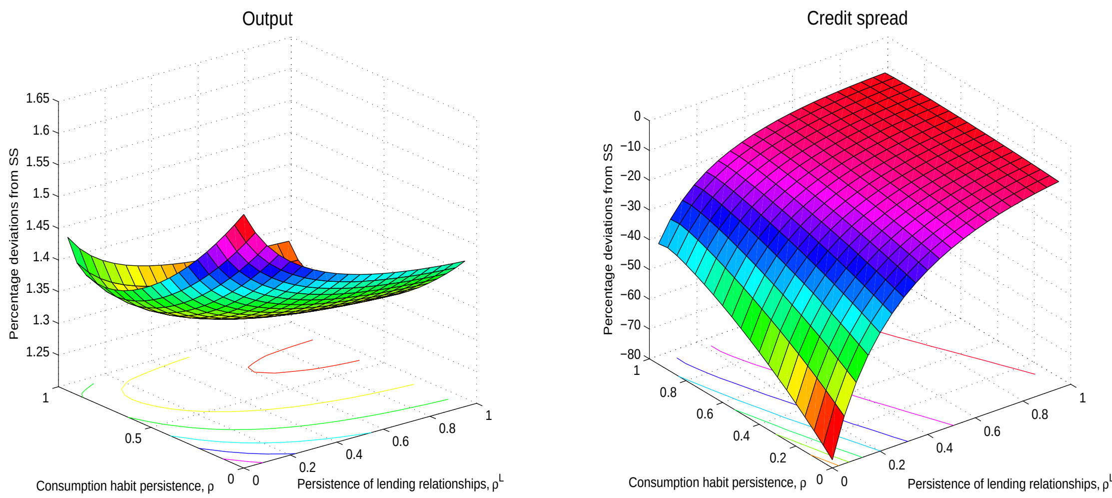

Figure 10: Sensitivity of output and credit spread to consumption habit persistence and the persistence of lending relationships. Impact responses to a government spending expansion of 1% of output.

After that, mark-ups quickly return to their respective steady state. An increasingly higher persistence leads to a lower amplification and, at the same time, to a greater duration of the propagation mechanism of a government spending expansion.

Figure 10 shows the impact responses of output and the credit spread to a government spending expansion (i) at different degrees of consumption habit persistence and (ii) at different degrees of the persistence of lending relationships. The chart on the right-hand side shows that when $\varrho = \varrho^L = 0$, the negative effect on the credit spread is substantially magnified as the mechanisms discussed above and reported in Figure 9 take place at the same time. Therefore, sensitivity analysis to the values of ϱ and ϱ^L reveals that the sign of the impact response of the credit spread to a government spending shock is robust to any choice of the persistence parameters. The magnitude is even amplified if lower degrees of persistence are assumed. The left-hand side of Figure 10 shows that the lower the persistence parameters, the higher the impact output multiplier due to stronger reductions both in the price mark-up and in the credit spread. The reduction that the impact output multiplier experiences when ϱ^L increases, at a given ρ, is lower than the reduction that takes place when ϱ increases for any given ρ^L. This can be explained by the fact that a decrease in the persistence of lending relationships causes a greater fall in the impact response of the credit spread, relative to the fall in the impact response of the price mark-up when the consumption habit persistence is decreased by the same amount.

6.3 Sticky prices and financial accelerator

This subsection explores (i) the issue of whether the introduction of sticky prices changes the results of the model presented in Section 5 and (ii) the financial accelerator effect in the sticky-price version of the model.

Figure 11 shows the impact responses of the main macro variables to a government spending expansion of 1% of output (i) at different degrees of deep habits in consumption, θ, and (ii) at different degrees of price stickiness, ξ. Even in absence of deep habits in consumption, the presence of price stickiness generates a countercyclical response of the price mark-up and an increase in the real wage after an expansionary government spending shock, as standard in the NK models (e.g. Pappa, 2009). However, the moderate decline in the price mark-up is not able to generate the crowding-in effects on consumption and investment. As a consequence, price stickiness alone is not able to reproduce the empirical finding presented in Section 2 that the credit spread declines in response to a government spending expansion.

A government spending expansion, being a demand shock, in general yields an increase in the rate of inflation. However, for high values of θ, an increase in the degree of price stickiness give rise to non-monotonic changes in the rate of inflation. In fact, high degrees of deep habits induce a strong decline in the price markup that makes the aggregate supply shift outward to a larger extent, thus reducing the inflationary pressure exerted by the government expenditure expansion.[10] From a quantitative point of view, higher degrees of price stickiness lead to higher output multipliers. If coupled with higher degrees of deep habits in consumption the model in general yields analogous, though amplified, results to those obtained in the flexible-price benchmark of Section 5.[11]

[10] Cantore et al. (2011) show that, at sufficiently high levels of deep habits, inflation may also fall in response to a government spending expansion.

[11] Jacob (2010) argues that the introduction of price stickiness reduces the downward pressure of the government spending expansion on the mark-up in the presence of deep habits, nullifying the desirable effects on macro variables such as the real wage or private consumption, which provide a bridge between empirical findings and theoretical DSGE models. However, Cantore et al. (2011) show that Jacob's result is driven by the assumption that the monetary policy rate reacts to the output gap, not merely by the introduction of sticky prices. In this paper, due to the presence of the cost channel, dealing with Taylor rule specifications that imply a reaction to the output gap is more problematic. In fact, here, the marginal cost also depends on the nominal interest rate and this affects the impact and the transmission of monetary policy as movements in the interest rate influence both the demand side and the supply side of the model. For instance, Surico (2008) shows that in a NK model augmented with the cost channel, if the Taylor rule includes a reaction coefficient to the output gap, the region of indeterminacy increases. Aksoy et al. (2009) provide an analysis of how the region of determinacy changes in a sticky price model augmented with a cost channel and lending relationships.

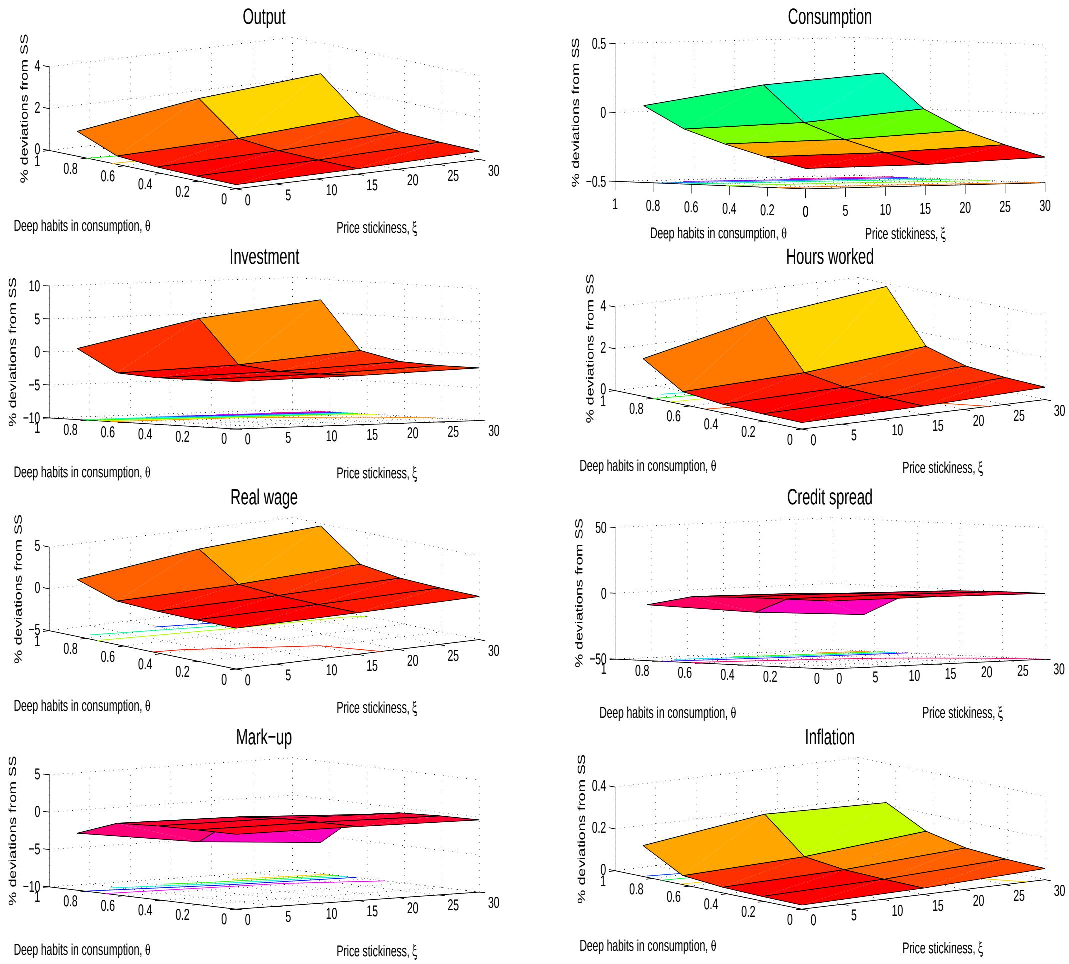

Figure 11: Sensitivity to deep habits in consumption and the degree of price stickiness. Impact responses to a government spending expansion of 1% of output.

Figure 12 explores the financial accelerator effect in the transmission of the government spending expansion in the sticky-price version of the model. In particular, it shows the impact responses of output, investment, hours worked and the spread to different degrees of deep habits in lending, θ^L, when $\xi = 30$ – which corresponds to Calvo contracts that last almost 3 quarters, as explained in Section 4 – and deep habits in consumption are activated (so that the the negative response of the credit spread is matched). If $\theta^L = 0$, the model is not able to capture the borrower's *hold-up* effect and the credit spread becomes constant by construction. In other words, financial frictions modeled

The interaction of fiscal policy with alternative monetary policies and the issue of indeterminacy goes beyond the scope of this paper and is left for future research.

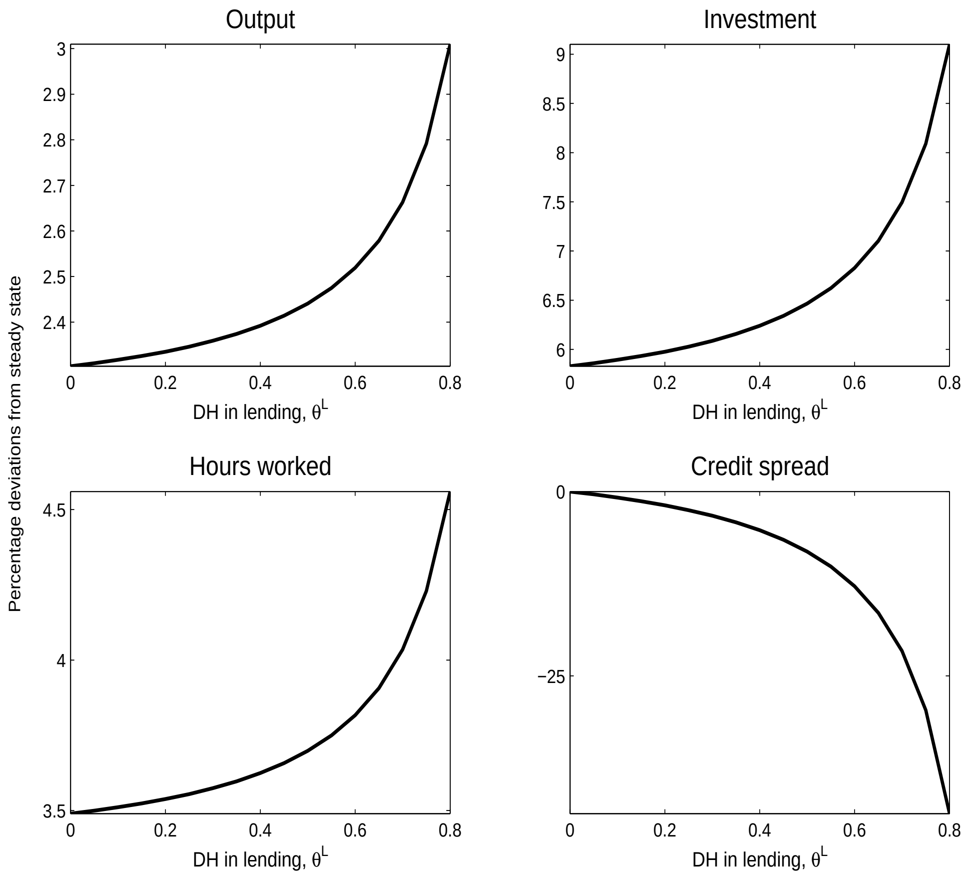

Figure 12: Impact responses to a government spending expansion of 1% of output for different degrees of deep habit in lending.

in the form of lending relationships are removed. When $\theta^L > 0$, the model exhibits a financial accelerator effect. The amplification of the shock when lending relationships are "on" is driven by the presence of an endogenous spread. The current demand for credit is now a function of past borrowing levels. The higher the degree of deep habits in lending, the higher is the willingness of the banks to give up some of their current profits in order to expand their customer base by locking in more customers into lending relationships that will be exploited in the following periods. Thus, the increasing reduction of the spread allows a greater expansion in lending and, therefore, investment and labor. This mechanism reinforces the increase in output, amplifying the expansionary effects of the government spending shock. The financial accelerator effect is present in similar fashion to other models embedding financial frictions, such as Bernanke et al. (1999) (BGG) and its application to fiscal policy done by Fernández-Villaverde (2010). However, the model setup and the amplification mechanism here are different. In the BGG class of models, the introduction of the credit market contributes to amplifying the shocks hitting the economy because of the link between "the external finance premium" (EFP) and the net worth of potential borrowers, which is the source of financial frictions.[12] As explained above, in lending relationships model financial frictions arise because of the borrower's *hold-up* effect.

7 Conclusion

The empirical evidence provided in this paper suggests that the credit spread responds negatively to an expansionary government spending shock, while consumption, investment, and lending increase. A DSGE model where the credit spread is endogenized via the inclusion of a banking sector exploiting lending relationships does not mimic such findings. However, the introduction of deep habits in private and government consumption considerably improves the performance of the model in replicating empirics. In fact, with this addition, the model is able to match not only the empirically verified relationship between the credit spread and government spending shocks, but also the crowding-in effect on consumption and investment as well as the decline in the price mark-up.

Sensitivity checks and extensions show that core results hold for a number of model calibrations and specifications. The model also exhibits a financial accelerator effect, since the presence of banks exploiting lending relationships amplifies the effect of expansionary government spending shocks. New-Keynesian features coupled with the cost channel of monetary policy and distortionary taxation give rise to determinacy issues, which are left for future research.

[12] The EFP is the difference between the cost of funds raised externally and the opportunity cost of funds internal to the entrepreneur. When borrowers have little wealth to contribute to the project financing, the potential divergence of interests between borrowers and lenders (the suppliers of external funds) is greater and, therefore, agency costs increase. In equilibrium, lenders must be compensated for higher agency costs by a larger EFP. As a result, the EFP depends inversely on borrowers' net worth. The pro-cyclicality of borrowers' net worth implies a counter-cyclical EFP; therefore, this mechanism enhances the swings in borrowing. This, in turn, affects investment and output.

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