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# Fiscal Policy and Lending Relationships

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**Fiscal Policy and Lending Relationships**

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**Abstract**



This paper studies how fiscal policy affects loan market conditions in the US. First, it conducts a Structural Vector-Autoregression analysis showing that the bank spread responds negatively to an expansionary government spending shock, while lending increases. Second, it illustrates that these results are mimicked by a Dynamic Stochastic General Equilibrium model where the bank spread is endogenized via the inclusion of a banking sector exploiting lending relationships. Third, it shows that lending relationships represent a friction that generates a financial accelerator effect in the transmission of the fiscal shock.

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# I. Introduction

During the Great Moderation the mainstream business cycle literature argued that any policy instrument other than the monetary policy rate played only a minor role in stabilizing the economy, this being the main reason why the focus on discretionary fiscal policy as a countercyclical tool was very limited (see e.g. Blanchard et al., 2010). As the recent crisis began, it was clear that fiscal policy was at least a dimension along which governments could do more, having soon realized that the crisis was taking a global and profound dimension, it was expected to be long-lasting, and the monetary policy interest rate, in many cases, had almost reached the zero lower bound.

Modern macroeconomics agrees on the fact that credit market conditions significantly affect business cycle dynamics (see e.g. Bean, 2010; Christiano et al., 2013). In the empirical literature there is evidence that credit spreads widen during downturns (see Gertler and Lown, 1999; Aliaga-Diaz and Olivero, 2010, 2011; Villa and Yang, 2011, among many others) and the Dynamic Stochastic General Equilibrium (DSGE) literature offers a variety of explanations (see Bernanke et al., 1999; Christiano et al., 2013; Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011, among others). As far as the bank spread is concerned, i.e. the difference between the loan rate and the deposit rate, an appealing but less studied determinant is offered by lending relationships. Aliaga-Diaz and Olivero (2010) provide empirical evidence of lending relationships. These imply 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 the bank spread more for bank-dependent borrowers than for those with access to public bond markets. According to Santos and Winton, the increase in the bank spread due to the informational hold up effect reaches 95 basis points in US data. Petersen and Rajan (1994) estimate that in the US loan market the average duration of lending relationships is 11 years. The hold-up problem in the loan market, however, is not a phenomenon involving only the US. The European Commission (2007) reports increasing switching costs also in the EU loan market, and there exists a substantial body of microeconometric evidence of lending relationships in a number of European countries, such as Italy, Belgium and Norway, where average lending relationship durations are in the order of 10 years (see Angelini et al., 1998; Degryse and Van Cayseele, 2000; Kim et al., 2003, among others).

Given the empirical relevance of lending relationships and the renewed interest in fiscal policy, natural questions are then: what are the typical effects of a government spending expansion on lending and the bank spread? And how is such a fiscal shock transmitted within an economy featuring lending relationships? Although in the literature there are papers investigating the stabilization properties of fiscal policy in DSGE models with credit frictions (see e.g. Fernández-Villaverde, 2010; Canzoneri et al., 2012; Carrillo and Poilly, 2013), these studies do not focus specifically on how a fiscal stimulus affects loan market conditions and do not take lending relationships into account. This paper fills in this gap on one hand by estimating the response of lending and the bank spread to a government spending expansion in a Structural Vector-Autoregressive (SVAR) model of the US economy. On the other hand, it develops a Real Business Cycle (RBC) model with lending relationships able (i) to match to a significant extent the empirical findings, and (ii) to provide a theoretical framework that allows one to study how the fiscal stimulus is transmitted via a banking sector characterized by the presence of long-lasting lending relationships.

The contribution of the paper is twofold. First, the estimated impulse responses from the SVAR provide evidence that the bank spread significantly falls in response to a government spending expansion, while lending increases. Second, the paper shows that, in the RBC model, a fiscal stimulus becomes more effective if increasingly stronger lending relationships are present in the loan market. In fact, the government spending expansion, by curbing the bank spread and boosting lending, fosters better credit market conditions, which in turn enact second-round expansionary effects on economic activity. In other words, there exists a financial accelerator effect in the transmission of the fiscal shock.

Lending relationships have already been explored in the DSGE arena. Aliaga-Diaz and Olivero (2010) introduce them into an otherwise standard RBC model where countercyclical bank spreads play a financial accelerator role in the propagation mechanism of technology shocks. In the New Keynesian (NK) literature, Aksoy et al. (2013) show that lending relationships are a feature of financial intermediation relevant for monetary policy making in a model with staggered prices and cost channels. The paper follows these studies in incorporating lending relationships via the modeling device that firms form deep habits in their borrowing decisions, following the strategy used by Ravn et al. (2006) to model consumption decisions. Deep habits in lending represents a very effective, though tractable, tool to incorporate the borrower's hold-up problem without having to explicitly formalize an asymmetric information problem. In fact, Aksoy et al. (2013, Appendix) formulate an adverse selection problem for the banking sector based on Akerlof (1970) and show that, in the symmetric equilibrium, the bank's profit margin is equivalent to the profit margin under deep habits in lending.

In this paper, the demand side of the model departs from more standard business cycle models in that households and the government feature external deep habit formation, and public goods enter households' utility with a certain degree of complementarity with private goods. While the former feature allows to match the sign of a number of impulse responses to government spending shocks with respect to SVAR results, the latter proves to be a powerful source of amplification in the transmission of such shocks.

The remainder of the paper is structured as follows. Section II presents the SVAR estimates. Section III illustrates the RBC model, describes functional forms and presents the choice of parameter values. Section IV discusses the results in the RBC model. Section V disentangles the effects of some model features. Section VI concludes and provides some suggestions for future research. An appendix complements the paper by providing (a) a series of robustness checks for the empirical results; (b) an analysis aiming at disentangling the effects of non-standard modeling features on the results of the DSGE model; (c) a NK extension of the model with price stickiness and monetary policy; (d) the full set of the DSGE model equilibrium conditions as well as the derivation of the deterministic steady state.

# II. Empirics

As anticipated, the empirical literature provides evidence of counter-cyclical credit spreads, but does not cover the more specific issue of how bank spreads and lending react to a government spending shock. This section fills in this gap by estimating a SVAR model of the US economy employing 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, 2008, for a discussion), while the end date falls before the start of the Great Recession.

The baseline specification is an adaptation of Monacelli et al. (2010) whereby the vector of endogenous variables contains the log of real per-capita government consumption expenditures, the log of real per-capita output, the average marginal tax rate computed by Barro and Redlick (2011),[1] the log of real per-capita private lending and the bank spread. The bank spread is computed as the difference between the three-month bank prime loan rate (BPLR) and the quarterly Treasury bill rate. To this five-variable specification further variables of interest are added one at a time. In particular, the following variables are analyzed: the log of real per-capita private consumption, the log real per-capita private domestic investment, the log of per-capita hours of work, the log of the real hourly wage, and the price mark-up.[2] Following Monacelli et al. (2010), the specification includes, as exogenous variables, a constant, a linear trend, and lags zero to four of the Ramey-Shapiro (RS) dummy variables, which take value one in those quarters in which large military build-ups took place in the US (1965q1, escalation of the Vietnam war; 1980q1, Carter-Regan military build-up upon the Soviet invasion of Afghanistan; 2001q3, 9/11 attack). The inclusion of the RS episodes addresses at least partially the issue of anticipation of government expenditure shocks. These in fact are identified by using the assumption firstly proposed

[1]This measure of taxes has been employed in recent studies such as Monacelli et al. (2010) and Ramey (2011b). In fact, being less dependent on the business cycle than the more traditional measure based on net taxes, it better captures policy choices. Nonetheless, the Appendix (Section A.1) shows that, in this specific case, the choice is completely harmless as the impulse responses are virtually coincident across the two alternative specifications.

[2]GDP, the GDP deflator, the interest rates used to compute the bank spread, private consumption, investment and lending were extracted from the ALFRED database of the Federal Reserve Bank of St. Louis. Government consumption expenditures were extracted from the NIPA tables of the Bureau of Economic Analysis. Per-capita hours of work is the series constructed by Francis and Ramey (2009) and available on Valerie Ramey's webpage. The real hourly wage is the average hourly wage of production workers in manufacturing produced by the US Bureau of Labor Statistics. As in Christiano et al. (2013), private 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. The price mark-up is computed as the log of the ratio between national income without capital consumption adjustment in manufacturing and wage and salary disbursements in manufacturing as in Monacelli and Perotti (2008) and the required variables were extracted from the NIPA tables. Where appropriate, the series were transformed in real per-capita terms by dividing their nominal values by the GDP deflator and the civilian population. All series are seasonally adjusted by the source.

by Blanchard and Perotti (2002) – and extensively adopted since then in the empirical literature – that government spending is unable to react to output and other unexpected shocks within a quarter due to implementation and decision lags typical of the budgeting process. If identification is achieved via a Choleski decomposition, this assumption simply translates into ordering government spending first (see e.g. Monacelli et al., 2010). 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 (2011b) criticizes the Blanchard-Perotti (BP) approach on the grounds that it 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. In particular, the point made is that VAR shocks alone miss the timing of the news as the narrative approach shocks Granger-cause the VAR shocks. Mertens and Ravn (2012) on one hand show that in theory anticipation effects may invalidate 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. The appendix shows that SVAR results are robust to a series of checks as far as both the specification of the empirical model – with the addition, for instance, of monetary policy variables – and anticipation effects are concerned. In particular, anticipation effects are tackled by using the method proposed by Auerbach and Gorodnichenko (2012) who use forecasts of the Greenbook and the Survey of Professional Forecasters to purify government spending shocks of any predictable component.

After estimating the reduced form of the SVAR, including four lags of the endogenous variables, its structural representation and correspondent identification of the structural shocks is obtained via a Choleski triangularization, as already discussed.[3] Figure 1 plots SVAR impulse responses to a positive shock to government consumption expenditure of size one percent of real output over a twenty-quarter horizon. All variables react in an hump-shaped fashion. Real output increases significantly reaching a peak multiplier of about 1.75 after two years and a half. Lending shows a statistically significant boost with a peak of almost 5 percent after three years, while the bank spread significantly declines by around 50 basis points on impact and reaches a negative peak of 70 basis points after two years. Private consumption is significantly crowded in by government consumption reaching its peak after two years, while private investment falls on impact and eventually experiences a significant crowding-in effect peaking after two years and a half. The responses of hours worked and the real wage are positive (apart from the insignificant negative response of hours worked in the second quarter), and gain statistical significance after a few quarters (more quickly in the case of the real wage). Finally, the price mark-up reacts negatively to the fiscal stimulus, the drop being significant at longer horizons.[4]

[3]To achieve this, the variables are ordered as follows: (i) government spending; (ii) output; (iii) the average marginal tax rate; (iv) private lending; the (v) bank spread. As a robustness check, many alternative variable orderings were used in the Choleski decomposition, obtaining only negligible differences with respect to the impulse responses reported as long as government spending was ordered first.

[4]Recent empirical contributions in the fiscal literature provide support for the fact that a government spending expansion causes a crowding-in effect on private consumption, an increase in hours worked, a boost in the real wage and a drop in the price mark-up (Blanchard and Perotti, 2002; Galí et al., 2007; Caldara and Kamps, 2008; Monacelli and Perotti, 2008; Pappa, 2009; Monacelli et al., 2010; Canova and Pappa, 2011; Fragetta and Melina, 2011). The US evidence on the effect

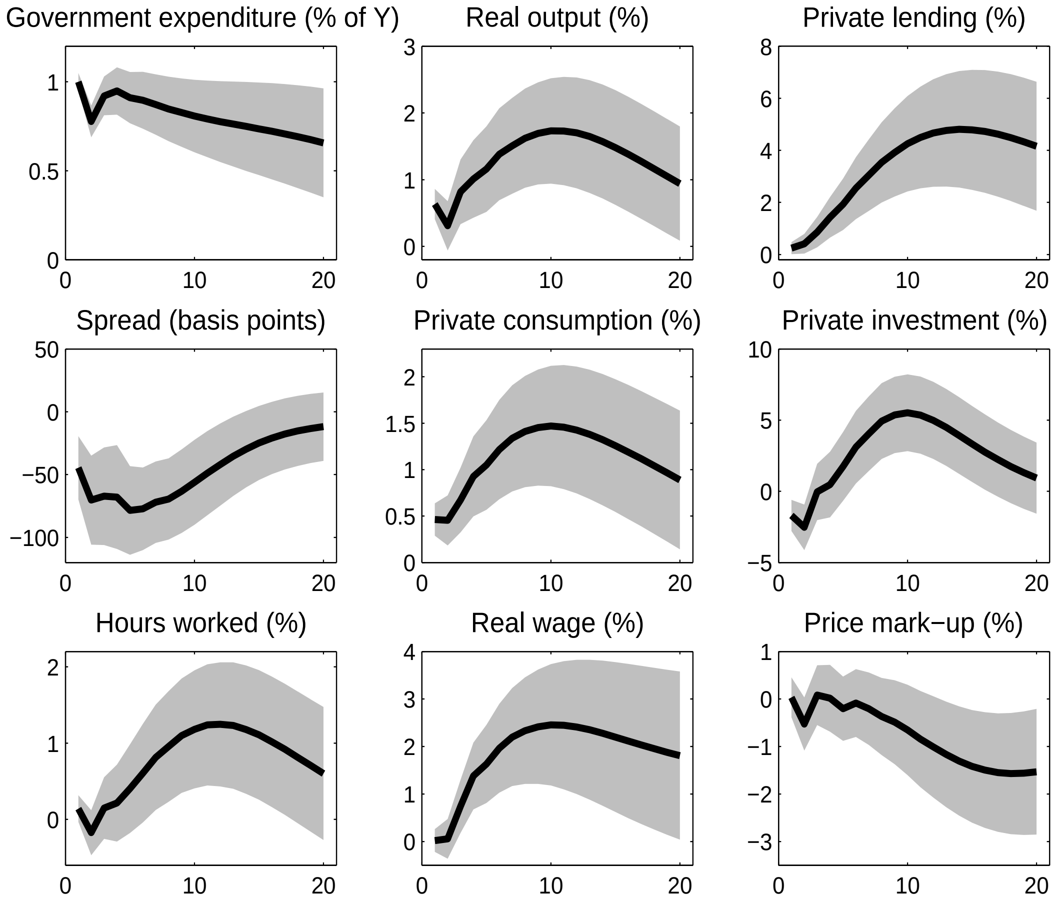



Figure 1: Estimated impulse responses from the SVAR over sample 1954q1–2007q4 to a shock to government consumption expenditure of size 1% of real output (shaded areas represent 90% confidence intervals).

# III. 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 supply labor. The government allocates government purchases over the varieties of consumption goods and raises lump sum taxes. Private and government consumption exhibit habits at the level of each variety of goods, i.e deep habits, as in Ravn et al. (2006). 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.[5] This feature is present both in the RBC model by Aliaga-Diaz and Olivero (2010) and in the NK model

of fiscal shocks, however, partially differs from the evidence in other countries (see Perotti, 2005). For a comprehensive survey see Hebous (2011).

[5]An important component of firm's debt in the US is non-banking finance. This paper focuses on bank-to-firm relationships, hence it abstracts from the issuance of corporate bonds. For a model featuring also corporate bonds see e.g. De Fiore and Uhlig (2011).

by Aksoy et al. (2013) and represents a reduced form way to incorporate the effects of informational asymmetries on borrowers' creditworthiness into a DSGE model. In fact, as explained by Aliaga-Diaz and Olivero (2010) 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 produces the same effects, as shown by Aksoy et al. (2013, Appendix). 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. The appendix provides a NK extension of the model with price stickiness and a central bank.

## A. 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:

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

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), preferences feature habit formation at the level of individual goods, or deep habits (see also Jacob, 2010; Di Pace and Faccini, 2012; Zubairy, 2012; Cantore et al., 2013). Similarly to the more common *superficial habits*, i.e. habits on the overall level of consumption, also deep habits may be internal or external. However, it is common practice to use the latter version as this is analytically more tractable. In fact, internal deep habits lead to a time inconsistency problem (see Ravn et al., 2006). In other words, what is commonly assumed is that agents *keep up with the Joneses good by good*. In the microeconometric literature there is recent evidence of deep habit formation. For instance Verhelst and Van den Poel (2012) estimate a spatial panel model using scanner data from a large European retailer and test for both internal and external deep habit formation. While they find some categories with internal habit formation, this effect is generally small. On the contrary, the external habit effect is always positive and significant. In the macroeconometric literature there are also estimates of deep habits for the US. For instance, Ravn et al. (2006) use a Generalized Method of Moments estimator applied to the consumption Euler equation and use the additional restrictions that deep habits imply for the supply side of the economy. Zubairy (2013) estimates the deep habit parameters within the broader setting of a Bayesian estimation of a medium-scale NK model. Cantore et al. (2012a) compare superficial and deep habit formation within an estimated NK model for the US and provide empirical support in favour of the deep form of habits.

Let $(X_t)^j = X\left[(X_t^c)^j, X_t^g\right]$ be a composite of habit-adjusted differentiated private and public consumption goods.[6] Let the private component of $(X_t^c)^j$ be in turn a composite of differentiated goods indexed by $i \in (0,1)$,

$$(X_t^c)^j = \left[\int_0^1 (C_{it}^j - \theta S_{it-1}^c)^{1-\frac{1}{\eta}} di\right]^{\frac{1}{1-\frac{1}{\eta}}}, \tag{2}$$

where $\eta$ is the elasticity of substitution across varieties, $\theta$ 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

$$S_{it}^c = \rho S_{it-1}^c + (1-\rho)C_{it}, \tag{3}$$

and $\rho$ measures the habit persistence.

Household $j$ solves a two-stage optimization problem. First, it minimizes total expenditure, $\int_0^1 P_{it} C_{it}^j di$, subject to equation (2). The optimal level of consumption for each variety for a given composite is then given by

$$C_{it}^j = \left(\frac{P_{it}}{P_t}\right)^{-\eta} (X_t^c)^j + \theta S_{it-1}^c, \tag{4}$$

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 (4) and the definition of nominal price index, the nominal value of the habit-adjusted consumption composite can be written as

$$P_t (X_t^c)^j = \int_0^1 P_{it}\left(C_{it}^j - \theta S_{it-1}^c\right) di. \tag{5}$$

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 (5)

$$C_t^j = (X_t^c)^j + \underbrace{\theta \int_0^1 \frac{P_{it}}{P_t} S_{it-1}^c di.}_{\equiv \Omega_t^j} \tag{6}$$

The representative household enters period $t$ with $D_t^j$ units of real deposits in the bank. During period $t$, the household chooses to consume $C_t^j$; supplies $H_t^j$ hours of work; and allocates savings in deposits at the bank, $D_{t+1}^j$, that pay the net interest rate $R_{t+1}^D$ between $t$ and $t+1$.

Each period the representative household gains an hourly wage, $W_t^j$; dividend payments, $\int_0^1 \Pi_{it} di$,

[6] This assumption implies that government consumption delivers some utility to private agents (see e.g. Pappa, 2009; Cantore et al., 2012b). Many studies assume that public consumption goods are not utility-enhancing, i.e. they are simply a waste of resources. The appendix shows the effects of this alternative assumption.

from final goods firms and $\int_0^1 \Pi_{bt} db$ from banks. In addition, the government imposes real lump-sum taxes, $T_t$. The household's intertemporal budget constraint can thus be expressed as

$$(X_t^c)^j + \Omega_t^j + D_{t+1}^j \leq W_t H_t^j + (1+R_t^D) D_t^j + \int_0^1 \Pi_{it} di + \int_0^1 \Pi_{bt} db - T_t, \tag{7}$$

where inequality (7) uses equation (6), 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 $(X_t^c)^j$, $D_{t+1}^j$ and $H_t^j$:

$$U_{X_t^c}^j = \lambda_t^j, \tag{8}$$

$$E_t[\Lambda_{t+1}^j (1 + R_{t+1}^D)] = 1, \tag{9}$$

$$-U_{Ht}^j = \lambda_t^j W_t, \tag{10}$$

where $\lambda_t^j$ 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.[7]

## B. 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. Alternatively, as in Leith et al. (2012) and Ravn et al. (2012), one can also argue that public goods are local in nature and households care about the provision of individual public goods in their constituency relative to other constituencies. For example, controversies over "post-code lotteries" in health care and other local services (Cummins et al., 2007) and comparisons of regional per capita government spending levels (MacKay, 2001) suggest that households care about their local government spending levels relative to those in other constituencies. Ravn et al. (2012) also propose the idea of procurement relationships that create a tendency for the government to favour transactions with sellers that supplied public goods in the past.

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

$$X_t^g = \left[\int_0^1 (G_{it} - \theta S_{it-1}^g)^{1-\frac{1}{\eta}} di\right]^{\frac{1}{1-\frac{1}{\eta}}}, \tag{11}$$

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

[7] Functional forms for equilibrium conditions (8)–(10) are reported in the appendix.

expenditures, which evolves as

$$S_{it}^{g} = \rho S_{it-1}^{g} + (1-\rho) G_{it}. \tag{12}$$

At the optimum,

$$G_{it} = \left( \frac{P_{it}}{P_t} \right)^{-\eta} X_t^g + \theta S_{it-1}^{g}. \tag{13}$$

Aggregate real government consumption $G_t$ evolves as an autoregressive process:

$$\log \left( \frac{G_t}{\bar{G}} \right) = \rho_G \log \left( \frac{G_{t-1}}{\bar{G}} \right) + \varepsilon_t^g, \tag{14}$$

where $\bar{G}$ is the steady-state level of government spending, $\rho_G$ is an autoregressive parameter, and $\varepsilon_t^g$ is a mean zero, i.i.d. random shock with standard deviation $\sigma^G$. The government runs a balanced budget, i.e. government spending is simply set equal to lump-sum taxes.

## C. 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. Lending relationships arise due to the presence of deep habits in lending. 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:

$$\min_{L_{bt}^e} \int_0^1 (1 + R_{bt}^L) L_{bt}^e db, \tag{15}$$

$$s.t. \left[ \int_0^1 \left( L_{bt}^e - \theta^L S_{bt-1}^L \right)^{1-\frac{1}{\eta^L}} db \right]^{1/(1-\frac{1}{\eta^L})} = \left( X_t^L \right)^e, \tag{16}$$

$$S_{bt}^L = \rho^L S_{bt-1}^L + (1-\rho^L) L_{bt}, \tag{17}$$

where $R_{bt}^L$ is the net lending rate, $L_{bt}^e$ is the demand by firm $e$ for loans issued by bank $b$, $\theta^L$ is the degree of habit in lending, $S_{bt}^L$ is the stock of (external) habit in lending, $\eta^L$ is the elasticity of substitution across varieties of loans, $\left(X_t^L\right)^e$ is the demand for loans by firm $e$ augmented by lending relationships and $\rho^L$ is the persistence of lending relationships. Equation (15) represents overall lending expenditure, equation (16) imposes deep habits in lending, and (17) imposes persistence in the stock of habit.

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

$$L_{bt}^{e} = \left(\frac{1+R_{bt}^{L}}{1+R_{t}^{L}}\right)^{-\eta^{L}} \left(X_{t}^{L}\right)^{e} + \theta^{L} S_{bt-1}^{L}, \tag{18}$$

where $(1+R_{t}^{L})$ is the price index for the loan composite and corresponds to the Lagrange multiplier attached to constraint (16) as standard with the Dixit-Stiglitz aggregator.

Entrepreneur $e$ faces also an intertemporal problem by solving which she chooses employment $H_{t}^{e}$, capital $K_{t+1}^{e}$ and investment $I_{t}^{e}$ 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:

$$\max_{H_{t}^{e},K_{t+1}^{e},I_{t}^{e}} E_{t} \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left\{ \begin{array}{c} \Phi_{t+s} F\left(K_{t+s}^{e}, H_{t+s}^{e}\right) - W_{t+s} H_{t+s}^{e} - I_{t+s}^{e} \\ + \left(X_{t+s}^{L}\right)^{e} - \int_{0}^{1} (1+R_{bt+s-1}^{L}) L_{bt+s-1}^{e} db + \Xi_{t+s}^{e} \end{array} \right\}, \tag{19}$$

$$s.t.\ K_{t+1}^{e} = I_{t}^{e} \left[1 - S\left(\frac{I_{t}^{e}}{I_{t-1}^{e}}\right)\right] + (1-\delta) K_{t}^{e}, \tag{20}$$

$$\int_{0}^{1} L_{bt}^{e} db \geq I_{t}^{e} + W_{t} H_{t}^{e}. \tag{21}$$

Equation (19) 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, $\Phi_{t}$ 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, $\Xi_{t}^{e} \equiv \theta^{L} \int_{0}^{1} \frac{1+R_{bt}^{L}}{1+R_{t}^{L}} S_{bt-1}^{L} db$ 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 (20) is a standard law of motion of capital, which depreciates at rate $\delta$, and investment is subject to adjustment costs as in Smets and Wouters (2007a), where $S(1) = S'(1) = 0$ and $S''(1) > 0$. Constraint (21) makes it necessary for firms to borrow from banks in order to finance investment expenditure and the wage bill, i.e. it 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 (21) holds with equality in equilibrium. Investment $I_{t}^{e}$ is also a composite of differentiated goods but it is not subject to deep habit formation: $I_{t}^{e} = \left[\int_{0}^{1} \left(I_{it}^{e}\right)^{1-\frac{1}{\eta}} di\right]^{\frac{1}{1-\frac{1}{\eta}}}$ . Expenditure minimisation leads to the optimal level of demand of investment goods for each variety $i$,

$$I_{it}^{e} = \left(\frac{P_{it}}{P_{t}}\right)^{-\eta} I_{t}^{e}. \tag{22}$$

Substituting for equations (20) and (21) into (19) and taking the first-order conditions with respect to

$H^e_t$, $K^e_{t+1}$ and $I^e_t$ lead to the following:

$$\Phi_t F_{H,t} = W_t E_t \left[\Lambda_{t,t+1}(1+R^L_t)\right], \tag{23}$$

$$Q_t = E_t \Lambda_{t,t+1} \left[ \ \Phi_{t+1} F_{K,t+1} + Q_{t+1}(1-\delta) \ \right], \tag{24}$$

$$\begin{aligned} E_t \left[\Lambda_{t,t+1}(1+R^L_t)\right] = Q_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - S'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}}\right] \\ + E_t \Lambda_{t,t+1} \left[ \ Q_{t+1} S'\left(\tfrac{I_{t+1}}{I_t}\right)\left(\tfrac{I_{t+1}}{I_t}\right)^2 \ \right]. \end{aligned} \tag{25}$$

Condition (23) 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 lending rate. Condition (24) equates the cost of one unit of capital, $Q_t$, 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 $\Phi_t$ represents the shadow value of output. Lastly, equation (25) equates the marginal borrowing cost for investment purposes to the marginal benefit, which is net of investment adjustment costs.

## D. Final good firms

A continuum of final good firms $i \in (0,1)$ buy the wholesale good from entrepreneurs at the real price $\Phi_t$, differentiate it and sell it in a monopolistically competitive market at price $P_{it}$. The real price $\Phi_t$ 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 $p_{it+s} \equiv P_{it+s}/P_{t+s}$ to maximize the following flow of discounted profits

$$E_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left\{ \left( \frac{P_{it+s}}{P_{t+s}} - MC_{t+s} \right) (C_{it+s} + I_{it+s} + G_{it+s}) \right\}, \tag{26}$$

subject to the demand for good $i$ in the form of private consumption $C_{it}$, (4), investment $I_{it}$, (22), and government consumption $G_{it}$, (13), and the laws of motion of the stocks of habits for households, (3), and the government, (12). This leads to the following first-order conditions:

$$\frac{P_{it}}{P_t} - MC_t + (1-\rho)\lambda^c_t = \nu^c_t, \tag{27}$$

$$E_t \Lambda_{t,t+1}(\theta \nu^c_{t+1} + \rho \lambda^c_{t+1}) = \lambda^c_t, \tag{28}$$

$$\frac{P_{it}}{P_t} - MC_t + (1-\rho)\lambda^g_t = \nu^g_t, \tag{29}$$

$$E_t \Lambda_{t,t+1}(\theta \nu^g_{t+1} + \rho \lambda^g_{t+1}) = \lambda^g_t, \tag{30}$$

$$\begin{aligned} &\frac{P_{it}}{P_t}(C_{it}+G_{it}) + (1-\eta)\left(\frac{P_{it}}{P_t}\right)^{1-\eta} I_t \\ +\eta MC_t \left(\frac{P_{it}}{P_t}\right)^{-\eta} I_t - \eta \nu^c_t \left(\frac{P_{it}}{P_t}\right)^{-\eta} X^c_t - \eta \nu^g_t \left(\frac{P_{it}}{P_t}\right)^{-\eta} X^g_t &= 0, \end{aligned} \tag{31}$$

where $\nu^c_t$, $\nu^g_t$, $\lambda^c_t$ and $\lambda^g_t$ are the Lagrange multipliers on constraints (6), (13), (3) and (12), respectively.

Let $MC^n_t$ denote the nominal marginal cost. The gross mark-up charged by final good firm $i$ can be defined as $\mu_{it} \equiv P_{it}/MC^n_t = \frac{P_{it}}{P_t}/\frac{MC^n_t}{P_t} = p_{it}/MC_t$. 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.

## E. Banking sector

Each bank $b$ chooses its demand for deposits, $D_{bt+1}$, and the loan rate, $R^L_{bt+1}$, 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:

$$\max_{D_{bt}, R^L_{bt}} E_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left\{ D_{bt+s+1} - L_{bt+s+1} + (1+R^L_{bt+s})L_{bt+s} - (1+R^D_{t+s})D_{bt+s} \right\}, \tag{32}$$

$$s.t.\ L_{bt} = D_{bt}, \tag{33}$$

$$L_{bt} = \left(\frac{1+R^L_{bt}}{1+R^L_t}\right)^{-\eta^L} X^L_t + \theta^L S^L_{bt-1}. \tag{34}$$

Equation (32) 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 (33) represents the bank's balance sheet, where loans on the asset side are equal to deposits on the liabilities side. Equation (34) represents the bank-specific demand for loans.

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

$$\nu_{bt} = E_t \Lambda_{t,t+s} \left[ \left(R^L_{bt+1} - R^D_{t+1}\right) + \nu_{bt+1} \theta^L (1-\rho^L) \right], \tag{35}$$

$$E_t \left[\Lambda_{t,t+s} L_{bt+1}\right] = \nu_{bt} \eta^L E_t \left[X^L_{t+1}\right], \tag{36}$$

respectively, where $\nu_{bt}$ is the Lagrange multiplier associated with this maximization problem. Equation

(35) states that the shadow value of lending an extra unit in period $t$ is equal to the benefit from the spread earned on this transaction plus the benefit of expected future profits arising from a share $\theta^L$ of lending being *held-up* at time $t+1$. According to equation (36), the marginal benefit of increasing the loan rate should be equal to its marginal cost given by the reduced demand for loans evaluated at $\nu_{bt}$.

## F. Equilibrium

In the symmetric equilibrium, goods markets, the labor market, and the loan market 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; and the stochastic processes.

The resource constraint completes the model:

$$Y_t = C_t + I_t + G_t. \tag{37}$$

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:

$$\hat{\mathbf{s}}_{t+1} = \Phi_1 \hat{s}_t + \Phi_2 \varepsilon_{t+1}, \tag{38}$$

$$\hat{\mathbf{d}}_t = \Phi_3 \hat{s}_t, \tag{39}$$

where vector $\hat{s}_t$ includes predetermined and exogenous variables; vector $\hat{d}_t$ contains the control variables; vector $\varepsilon_t$ includes all random disturbances; and matrices $\Phi_1$, $\Phi_2$ and $\Phi_3$ contain elements that depend on the structural parameters of the model. The appendix provides the full set of equilibrium conditions at the symmetric equilibrium and the computation of the deterministic steady state.

## G. Functional forms

To simulate the model the utility function specializes as $U(X_t, 1-H_t) = \frac{\left[X_t^{\omega}(1-H_t)^{1-\omega}\right]^{1-\sigma}}{1-\sigma}$, where $\sigma > 0$ is the coefficient of relative risk aversion, and $\omega$ is a preference parameter that determine the relative weight of leisure and the consumption composite in utility. The consumption composite is a CES aggregate of private and public deep-habit-adjusted consumption, $X_t = \left\{ \nu_x^{\frac{1}{\sigma_x}} \left(X_t^c\right)^{\frac{\sigma_x - 1}{\sigma_x}} + (1-\nu_x)^{\frac{1}{\sigma_x}} \left(X_t^g\right)^{\frac{\sigma_x - 1}{\sigma_x}} \right\}^{\frac{\sigma_x}{\sigma_x - 1}}$, with $\nu_x$ representing the share of the private component in the aggregator and $\sigma_x$ being the elasticity of substitution between the private and the public component. Investment adjustment costs are quadratic: $S\left(\frac{I_t}{I_{t-1}}\right)=\frac{\gamma}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2$, $\gamma>0$, while the production function is Cobb-Douglas: $F\left(H_t,K_t\right)=H_t^{\alpha}K_t^{1-\alpha}$, where $\alpha$ represents the labor share of income.

## H. Parameter choice

A number of parameter values are chosen to match some stylized facts for the US economy in the post-WWII era while others are set in accordance with available US empirical estimates. The time period in the model corresponds to one quarter in the data. Table 1 summarizes the parameter choice.

As standard in the business cycle literature, the subjective discount factor, $\beta$, is equal to 0.99 and the capital depreciation rate, $\delta$, to 0.025. The parameters in the utility functions are as follows: the coefficient of relative risk aversion, $\sigma$, is equal to 1.38 as in Smets and Wouters (2007a); and the preference parameter, $\omega$, is set to match steady-state hours of work equal to 0.44, as in Kydland and Prescott (1991); the elasticity of substitution between the private and the public component of the deep-habit-adjusted consumption composite, $\sigma_x$, is equal to 0.5, a value in the range proposed by Pappa (2009) that implies mild complementarity; while the share of the private component in the composite, $\nu_x$, is set to match a government share of output of 20%. While Section V. shows sensitivity of the results to different degrees of complementarity between private and public consumption, the appendix shows also the case in which public consumption does not deliver any utility to households. The production function parameter, $\alpha$, is equal to 0.6, as in Christiano et al. (2013).

The consumption deep habits parameters, $\theta$ and $\rho$, are equal to 0.86 and 0.85, respectively, following the estimates used by Ravn et al. (2006). The parameters representing deep habits in lending relationships, $\theta^L$ and $\rho^L$ are set equal to 0.72, and 0.85, respectively, relying on the estimates provided by Aliaga-Diaz and Olivero (2010). As the presence of deep habits in consumption and in borrowing decisions are key in enabling the DSGE model to reproduce empirical patterns, the appendix shows sensitivity analysis of the results to a wide range of values for the parameters $\theta$, $\rho$, $\theta^L$ and $\rho^L$.

The persistence parameter of government spending shocks $\rho_G$, set to 0.97, and the parameter in the adjustment cost function $\gamma$, equal to 5.74, follow the estimated values of Smets and Wouters (2007a).

Following Christensen and Dib (2008), the elasticity of substitution across different varieties, $\eta$, is set in order to target a steady state gross mark-up equal to 1.20, while the elasticity of substitution in the banking sector, $\eta^L$, is set in order to match a bank spread of 0.0075 (300 basis points per year).[8] In addition to the explicitly-targeted steady-state values, the above parameter choice implies a consumption-output ratio of around 60% and a private investment-output ratio of around 20%.

[8]The price mark-up and the bank spread are not only functions of the intra-temporal elasticity of substitutions in the goods sector and in the banking sector, but they are also a function of the degrees of deep habit formation in consumption, $\theta$, and borrowing decisions, $\theta^L$. Given the baseline choices of $\theta$ and $\theta^L$, the targeted levels of steady-state price mark-up and bank spread are reached by choosing $\eta\approx 8$ and $\eta^L\approx 425$, respectively.

| Parameter | | Value |
|---|---|---|
| Discount factor | $\beta$ | 0.99 |
| Capital depreciation rate | $\delta$ | 0.025 |
| Risk aversion | $\sigma$ | 1.38 |
| Elast. of subst. in consumption composite | $\sigma_x$ | 0.5 |
| Production function parameter | $\alpha$ | 0.6 |
| Deep habits in consumption | $\theta$ | 0.86 |
| Consumption habit persistence | $\rho$ | 0.85 |
| Deep habits in lending | $\theta^L$ | 0.72 |
| Pers. of lending relationships | $\rho^L$ | 0.85 |
| Persistence of government spending | $\rho_G$ | 0.97 |
| Elasticity of investment adjustment costs | $\gamma$ | 5.74 |
| Share of private component in consumption composite | $\nu_x$ | set to target $\frac{G}{Y} = 0.20$ |
| Preference parameter | $\omega$ | set to target $H = 0.44$ |
| Elasticity of substitution | $\eta$ | set to target $\mu = 1.20$ |
| Elast. of subst. in banking | $\eta^L$ | set to target $R^L - R^D = 0.0075$ |

Table 1: Parameter choice

# IV. Results

This section first analyzes the effects of an expansionary government spending shock in the model presented in Section III.. It then disentangles the role of financial frictions in the transmission mechanism of the fiscal shock.

Figure 2 shows that 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 and stimulates labor supply (see e.g. Baxter and King, 1993; Cogan et al., 2010). At the same time, however, the presence of deep habits in private and government consumption causes a fall in the price mark-up. Under deep habits the mark-up is counter-cyclical due to the coexistence of two effects: an *intra-temporal effect* (or *price-elasticity effect*) and an *inter-temporal effect*. The intra-temporal effect can easily be understood by looking at the demand faced by an individual firm $i$:

$$AD_{it} = C_{it} + G_{it} + I_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\eta} \left(X_t^c + X_t^g + I_t\right) + \theta \left(S_{it-1}^c + S_{it-1}^g\right). \tag{40}$$

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 $\left(X_t^c + X_t^g + I_t\right)$ rises, the "weight" of the price-elastic component of demand grows and the effective price elasticity of demand, $\tilde{\eta}_{it} \equiv -\frac{\partial AD_{it}}{\partial p_{it}} \frac{p_{it}}{AD_{it}} = \eta \left(1 - \theta \frac{\left(S_{it-1}^c + S_{it-1}^g\right)}{AD_{it}}\right)$, increases, as opposed to remaining constant and equal to $\eta$ as in the standard case ($\theta = 0$). The fact that the elasticity of demand is pro-cyclical is one determinant for the price

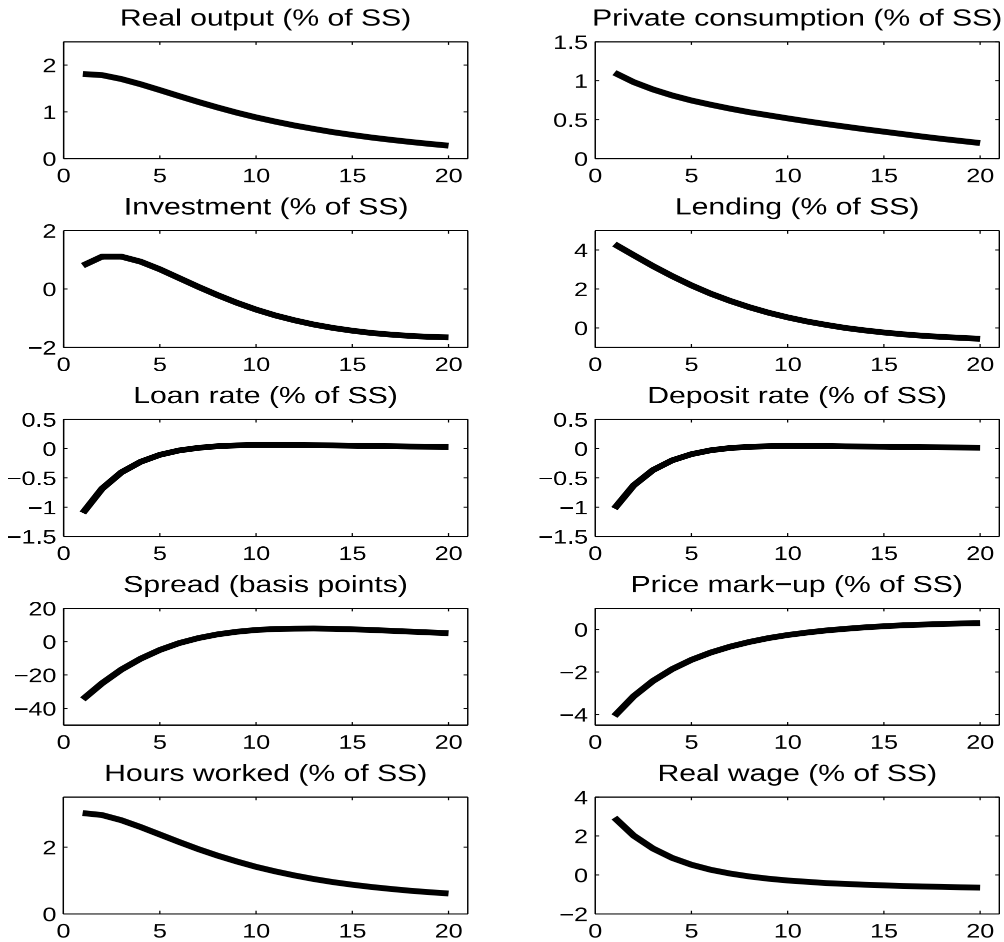



Figure 2: Impulse responses to a shock to government consumption expenditures of size 1% of real output.

mark-up being counter-cyclical. The other determinant comes from the inter-temporal 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 consumers into customer/firm relationships and charge them higher mark-ups in the future.

The fall in the mark-up translates into a rise in labor demand stronger than the rise in labor supply and into an increase in the demand for investment. The presence of investment adjustment costs makes it optimal to postpone the investment peak for few quarters. The resulting increase in the real wage triggers a strong substitution effect away from leisure and into consumption, hence the crowding-in of the latter. Both the increase in the real wage and the consumption crowding-in are consistent with the empirical evidence reported in Section II.. As the government spending shock is normalized to 1% of output, the response of output itself can be read as a fiscal multiplier, at impact equal to around 1.8, a value close to the empirical peak response reported in Figure 1. Given the presence of the financing constraint, the rise in the demands for labor and investment translates into an outward shift of the demand for loans made by firms, which is mirrored into a rise in the demand for deposits made by banks. The supply of deposits also experiences an outward shift, given the increased economic activity and the intertertemporal consumption/saving choice of forward-looking agents. The relative size of the shift of demand and supply in the markets for deposits and loans determines the sign of the responses of the deposit and the loan rates. In particular, the presence of investment adjustment costs – the effects of which are disentangled in Section V. – makes the supply effect prevail and both rates fall. The change in the bank spread is determined by how the two rates change with respect to each other. At this point lending relationships come into play. In fact, in the market for loans, banks incorporate the information of high future returns and hence their prospective ability of making high future profits due to the output expansion. Therefore, they are willing to give up some of the current profits in order to expand their customer base by locking in new customers into lending relationships. As a result, the loan rate falls in a more-than-proportional fashion compared to the fall in the deposit rate. Hence, the bank spread decreases and equilibrium lending rises.[9] In particular, the model predicts a fall in the bank spread of around 35 basis points – less than the peak observed in the data – and a surge in lending of around 4%, which instead is in line with VAR estimates. The model does not reproduce the pronounced hump shape of the VAR impulse responses, but overall depicts similar effects, at least as far as the sign, and, to a certain extent, the amplitude of the impulse responses to a government spending shock are concerned.

## A. Financial accelerator effect

Figure 3 disentangles the financial accelerator effect in the transmission of the government spending expansion. In particular, it shows the impact responses of the endogenous variables to different degrees of deep habits in lending, $\theta^L$. If $\theta^L = 0$ the model is not able to capture the borrower's hold up effect and the bank spread becomes constant by construction. In other words, financial frictions modeled in the form of lending relationships are removed. When $\theta^L > 0$ the model exhibits a financial accelerator effect. The higher the degree of deep habits in lending the more, in response to a fiscal stimulus, banks are willing to supply loans, exerting an increasingly downward pressure on the loan rate. This further stimulates lending and results into an increasingly stronger fall in the endogenous bank spread. For instance, an increase in $\theta^L$ from the baseline value of 0.72 to 0.82 brings the impact fall of the bank spread from 35 basis points to almost 70. As firms have more funds to finance their capital acquisition and the wage bill, investment and hours worked increase by more, which in turn allows for a greater expansion in output. These results suggest that, in the presence of lending relationships, fiscal policy becomes more effective because it leads to an improvement of loan market conditions and hence to a further boost in economic activity.

[9]Although with a different transmission mechanism, Carrillo and Poilly (2013) obtain the same sign of the impulse responses of lending and the corporate bond spread to a government spending expansion in a NK model featuring financial frictions as in Bernanke et al. (1999).

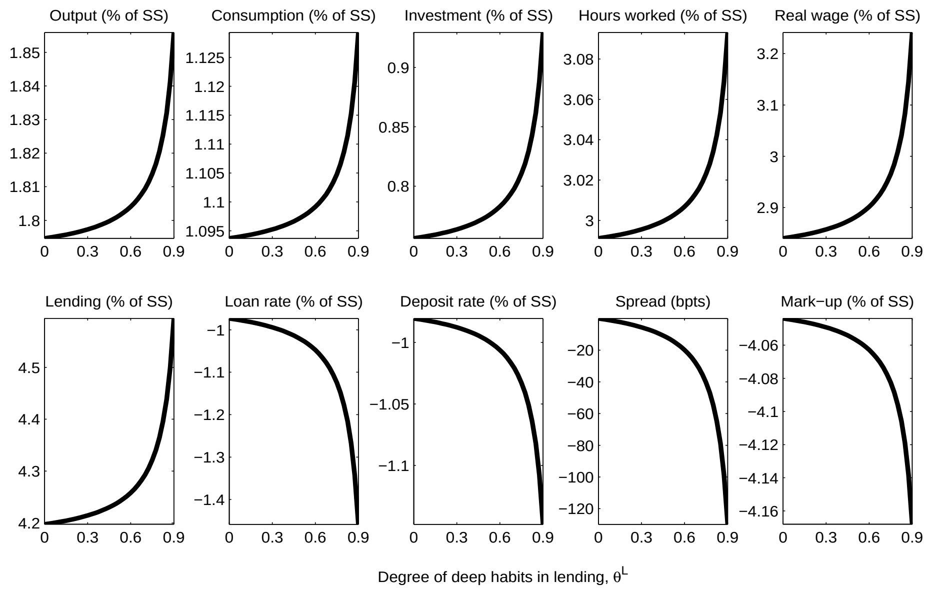
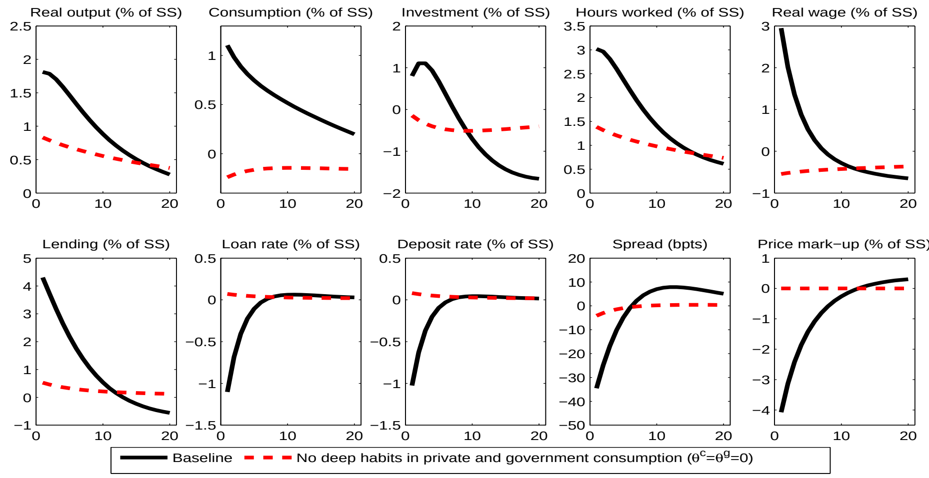



Figure 3: The financial accelerator effect (impact responses to a government spending expansion of 1% of output).

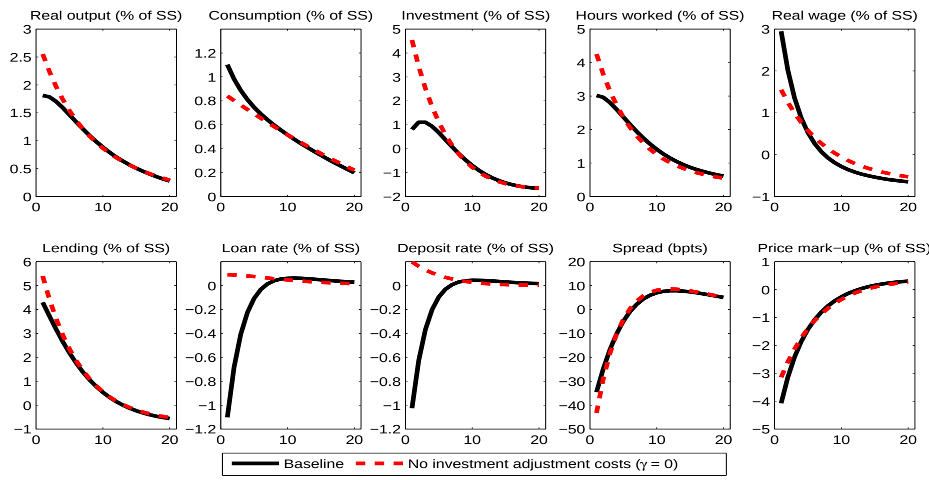
# V. Effects of some model features

This section disentangles the contribution of some key model features in determining the results presented in Section IV.

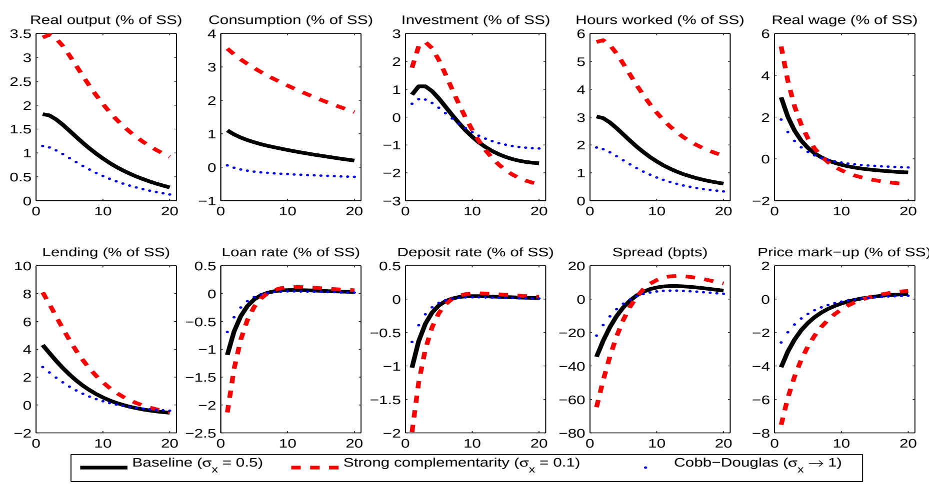
First, Figure 4a shows how the baseline model responds to a government expenditure shock vis-à-vis a restricted model in which deep habit formation in private and government consumption has been switched off. The latter model is straightforwardly obtained by setting $\theta = 0$. Without deep habits the price mark-up remains constant as in standard RBC models with imperfect competition. As a result, the transmission mechanism of a government spending expansion is dominated by the negative wealth effect that fosters a drop in consumption, investment and the real wage. Real output consequently rises in a less-than-proportional fashion with respect to government expenditures. These effects do not mirror the empirical impulse responses reported in Section II. In addition, in the absence of deep habits, because of the prevailing negative wealth effect, the shift in the supply of deposits and, as a consequence, of loans is weaker. At the same time, the demand for loans (which translates into the demand for deposits) increases as firms have to borrow in order to pay the increased wage bill and the fall in investment is gradual, given the presence of investment adjustment costs. Such dynamics foster an increase in the deposit and in the lending rate. The bank spread still falls as the presence of lending relationships makes it optimal for banks to raise the loan rate less than proportionally to the rise in the deposit rate. While the responses of lending and the bank spread are in line with empirics as far as their sign is concerned, they feature a much smaller amplification that, on the contrary, is at odds with the data.




(a) Deep habits in private and government consumption




(b) Investment adjustment costs




(c) Complementarity between private and government consumption

Figure 4: Effects of some model features (impulse responses to a government spending expansion of 1% of output)

Next, Figure 4b depicts a similar exercise consisting in removing investment adjustment costs, i.e. in setting $\gamma = 0$. As it is well known in the DSGE literature, such costs make it optimal for firms to change investment gradually. As a result, investment becomes hump-shaped and for most variables only the amplification is affected. Interestingly, in the absence of investment adjustment costs the loan rate and the deposit rate increase instead of falling. This is determined by fact that the outward shift of the loan demand, following a government spending expansion, dominates the outward shift of the loan supply.On the contrary, when investment adjustment costs are in place, the supply-side effect prevails on the demand-side because firms are better off delaying the change in investment. In either case, however, the lending relationship mechanism ensures that the relative movements of the two interest rates are such that the bank spread falls in line with the evidence provided in Section II.

Finally, Figure 4c highlights the implications of complementarity between public and private consumption in households' utility function. As it is well known in microeconomic theory, when $\sigma_x \to 0$ the aggregator function of the two components of consumption tends to Leontief, and private and public consumption become perfect complements. Instead, when $\sigma_x \to 1$ the aggregator function tends to Cobb-Douglas and the two goods are imperfect substitutes. It follows that the smaller is $\sigma_x$ the more private consumption is crowded in by a fiscal stimulus as public goods have to be consumed together with private goods. Such a mechanism affects the magnitude of changes in all macroeconomic variables, while preserving their signs, and turns out to be a powerful amplification mechanism.

The appendix discusses the sensitivity of the results to several model features in greater detail. In particular, a sufficiently large degree of deep habits in consumption is needed to match empirics as far as the sign of impulse responses to a government spending shock is concerned. As also shown in Subsection IV.1, results are qualitatively robust to any positive degree of lending relationships, which mainly affect the magnitude of financial variables. The choice of the persistence of deep habits in consumption and in lending affects the magnitude and timing of impulse responses, while their sign remain unaffected. A utility-enhancing government spending (as opposed to a "useless" government consumption) proves to be an important amplifier of the crowding-in effect on private consumption. The assumption of flexible prices proves harmless as main results hold in a NK extension of the model.

# VI. Conclusion

This paper analyzes the effects of a government spending expansion on loan market conditions and the implications of lending relationships for the effectiveness of a fiscal stimulus. A SVAR analysis conducted on US post-WWII data suggests that the bank spread responds negatively to a fiscal expansion, while lending increases. A RBC model where the bank spread is endogenized via the inclusion of a banking sector exploiting lending relationships mimics such findings. The model exhibits a financial accelerator effect in the fiscal policy transmission, as lending relationships determine an amplification mechanism of fiscal shocks. From a policy perspective such a feature is relevant in normal times but becomes even more relevant in a period of tight credit market conditions characterized by a shortage of lending and high borrowing costs. In fact, a fiscal stimulus makes lending more available to firms and this acts as a reinforcing mechanism in the expansion in real economic activity.

These results open interesting avenues for future research. For example, it would be useful to perform a Bayesian estimation of the DSGE model that allows, on one hand, to carry out a likelihood-race validation of key model features and, on the other hand, to provide a DSGE-based estimate of the lending relationships parameters that, in the literature, have so far been estimated using single equation methods. Moreover, the analysis could be extended to other advanced economies, such as the euro area, Japan, and the UK, in order to disentangle potential country-specific effects.

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# Appendix

## A Robustness of SVAR results

This section performs sensitivity checks on the SVAR results presented in the paper. The focus is on variations of the baseline specification of the empirical model. In fact, this includes private lending and the bank spread among the endogenous variables, and the novel results of the empirical part of the paper are on how these two variables react to a government spending expansion. Figure A.1 depicts the responses of the variables of interest to a government spending shock of size one percent of output using the baseline specification (bold lines and shaded areas representing mean responses and confidence bands, respectively) together with four alternative specifications (dashed lines and dotted lines representing mean responses and bounds of confidence bands, respectively), which are described below.

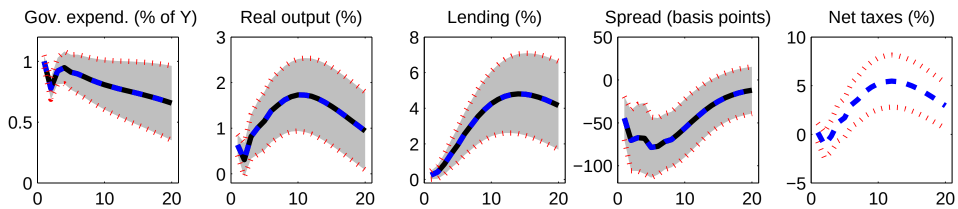
### 1. Substitution of the average marginal tax rate with net taxes

Many contributions (Blanchard and Perotti, 2002; Perotti, 2005; Caldara and Kamps, 2008; Fragetta and Melina, 2011) estimate the macroeconomic effects of fiscal shocks in the Blanchard and Perotti (2002) tradition using net taxes as a measure of taxes in the specification of the SVAR. Net taxes are computed as total government revenues net of transfers and interest payments.[10] This measure of taxes is constructed as such on the grounds that tax and transfers should have similar multiplicative effects on economic activity, as they affect disposable income in a similar way, while they plausibly have a rather different impact on activity than public consumption. In the paper we choose a specification close to Monacelli et al. (2010), who use the average marginal tax rate constructed by Barro and Redlick (2011) as the measure of taxes. In the literature, the choice of the tax variable is obviously very important when it comes to identifying the effects of tax shocks. In this paper, the focus is on government consumption shocks, hence this choice is somewhat less problematic. Nevertheless it is straightforward to verify whether results are robust to the substitution of the average marginal tax rate with the more traditional measure of net taxes. The impulse responses reported in Panel (a) of Figure A.1 show that results are indeed very robust to this choice. In fact the responses of the variables of interest to a shock to government consumption are virtually indistinguishable across the two alternative specifications, as far as both mean responses and confidence intervals are concerned.

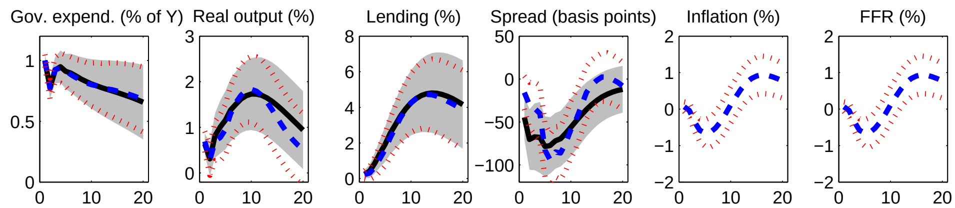
### 2. Introduction of the inflation rate and the Federal Funds rate

Although the paper focuses on the effects of a fiscal stimulus on lending and the bank spread, these two variables are likely to be influenced also by the monetary policy stance. A simple way to control

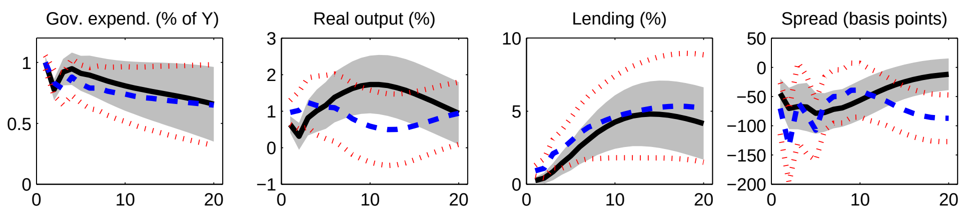
[10] These variables are available in the NIPA tables of the Bureau of Economic Analysis.



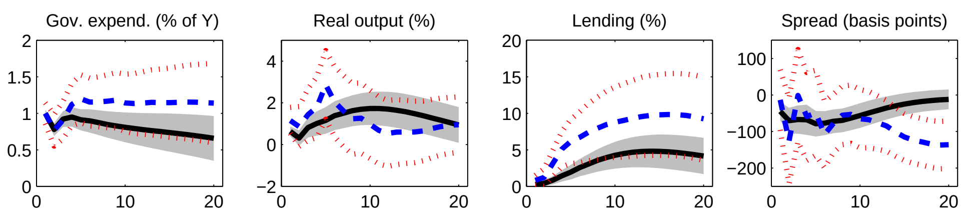

(a) Substitution of the average marginal tax rate with net taxes.




(b) Introduction of the inflation rate and the Federal Funds rate (FFR).




(c) Purified (unanticipated) innovations in government spending using SPF/Greenbook forecasts.




(d) SPF/Greenbook forecast errors for the growth rate of government spending as unanticipated shocks.

Note: Bold and dashed lines represents estimated impulse responses of the baseline and the alternative specifications, respectively. Shaded areas and areas within the two dotted lines represent 90% confidence intervals in the baseline and the alternative specifications, respectively.

Figure A.1: Various robustness checks for the SVAR results.

for monetary policy is to augment the vector of endogenous variables of the SVAR with monetary policy variables, such as the rate of inflation and Federal Funds rate (FFR).[11] Panel (b) of Figure A.1 shows that this change in the specification does not materially alter the responses of government spending, real output and lending to a fiscal stimulus, but changes to a certain extent the dynamic response of the bank spread. This still significantly falls (as in the baseline specification) but, while on impact it reacts less, at peak its reduction is more pronounced. The initial fall in the inflation rate and in the FFR followed by a significant increase mimics the results of other studies in the literature which employ slightly different specifications (see e.g. Caldara and Kamps, 2008). Section C of this Appendix provides a New Keynesian extension of the DSGE model presented in the main part of the paper where the role of the monetary response to a fiscal stimulus and its effects of lending and the

[11] The rate of inflation is computed as first difference of the log of the consumer price index (CPI). Both the CPI and the FFR are taken from the ALFRED database of the St. Louis Fed.

bank spread are explicitly taken into account.

## 3. Purified (unanticipated) innovations in government spending using SPF/ Greenbook forecasts

As already discussed in Section II of the paper, the literature has debated a great deal on the issue of anticipation of fiscal shocks (see e.g. Ramey, 2011a). To at least partially tackle the problem, in the baseline specification we follow Monacelli et al. (2010) and include, among the exogenous variables, lags zero to four of the Ramey-Shapiro (RS) dummy variables, which take value one in those quarters in which large military build-ups took place in the US. Auerbach and Gorodnichenko (2012) propose another appealing method that makes use of (i) the Survey of Professional Forecasters (SPF), an average of forecasts available since 1968 for GDP and since 1982 for government spending and its components; and (ii) government spending Greenbook forecasts prepared by the FRB staff for FOMC meetings. The Greenbook forecasts for government spending are instead available from 1966 to 2004. The authors splice the Greenbook and SPF government spending forecasts and construct a continuous forecast series running from 1966 to present.[12] One way to account for the forecastable components of VAR residuals is to expand the model to include professional forecasts, namely the forecast growth rate of real government purchases for time $t$. In this specification an innovation in government consumption orthogonal to the forecast is interpreted as a purified (unanticipated) government spending shock. As the SPF/ Greenbook forecasts are available starting from 1966, by including this variable we lose the first 12 years of observations. As evident from Panel (c) of Figure A.1, results are pretty robust both to the inclusion of this key variable and to the change of the sample. In particular, taking anticipation effects into account in such a way slightly shifts up the confidence band of the response of lending; it alters the dynamic response of real output, making the impact multiplier somewhat higher and the peak multiplier somewhat lower; it alters the dynamics of the bank spread, which falls more at peak, but it also makes the confidence interval wider. Nonetheless, the sign of the impulse responses of the macroeconomic variables of interest to a government spending shock is the same as in the baseline model and their magnitude is on average quite similar.

## 4. SPF/Greenbook forecast errors for the growth rate of government spending as unanticipated shocks

A variant to the approach used in Subsection 3. – proposed by Auerbach and Gorodnichenko (2012) as well – is to introduce in the SVAR the forecast error of government spending. This is computed as the difference between the spliced Greenbook/SPF forecast series and the actual, first-release, series of the government spending growth rate. In this case an innovation in the forecast error about government spending is interpreted as an unanticipated shock.[13] Panel (d) of Figure A.1 shows that, by identifying

[12]The series is available at http://www.aeaweb.org/aej/pol/data/2010-0164_data.zip.

[13]It has to be noted that the fiscal shock in this case is rather different. In fact, in the previous approach the shock is a purified government consumption shock, in that the variable of the SVAR that is shocked is still government consumption,

unanticipated government spending shocks, the signs of the impulse responses are preserved. However, there are some noticeable differences with respect to the baseline model. In particular, the response of government spending becomes more persistent, the peak output multiplier becomes bigger and also the responses of lending and the bank spread are considerably amplified, although the confidence band of the bank spread becomes very wide and statistical significance is obtained only at longer horizons.

# B Sensitivity exercises for the DSGE model

This section illustrates a series of modifications in the baseline DSGE 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 1. shows the sensitivity of the results to a wide range of values of the parameters capturing the degree of deep habits in consumption and of lending relationships while Subsection 2. carries out a similar analysis by looking at the parameters measuring the persistence of deep habits in consumption and of lending relationships. Subsection 3. explores the robustness of the results when public consumption does not provide utility to households.

## 1. Degree of deep habits in consumption and of lending relationships

This subsection shows the sensitivity of the results reported in Section IV to the values of the parameters measuring the degree of deep habits in consumption, $\theta$, and the degree of lending relationships, $\theta^L$. The remaining parameters are set as in the baseline model specification – Table 1.

Figure B.1 shows the impact responses to a government spending expansion (i) at different degrees of deep habits in consumption and (ii) at different degrees of lending relationships.

When there are no lending relationships, i.e. $\theta^L = 0$, the impact response of the bank spread is zero at any value of deep habits in consumption, since the removal of lending relationships eliminates the effects of financial frictions and implies a constant spread by construction, as shown in Subfigure B.1d. As long as $\theta = 0$, if $\theta^L > 0$, the bank spread falls after an expansionary government spending shock as explained in Section IV. At any given positive $\theta^L$, the impact response of the bank spread declines as the degree of deep habits in consumption, $\theta$, increases. As both $\theta$ and $\theta^L$ 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 the demand for labor and investment, and hence lending, 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 bank spread.

The behavior of the price mark-up explains also why the responses of real wage and consumption are

but the shock itself is purified from the forecastable component. Instead in this case the shock is to the forecast error of government spending; and government consumption, as well as the other endogenous variables, react to it.

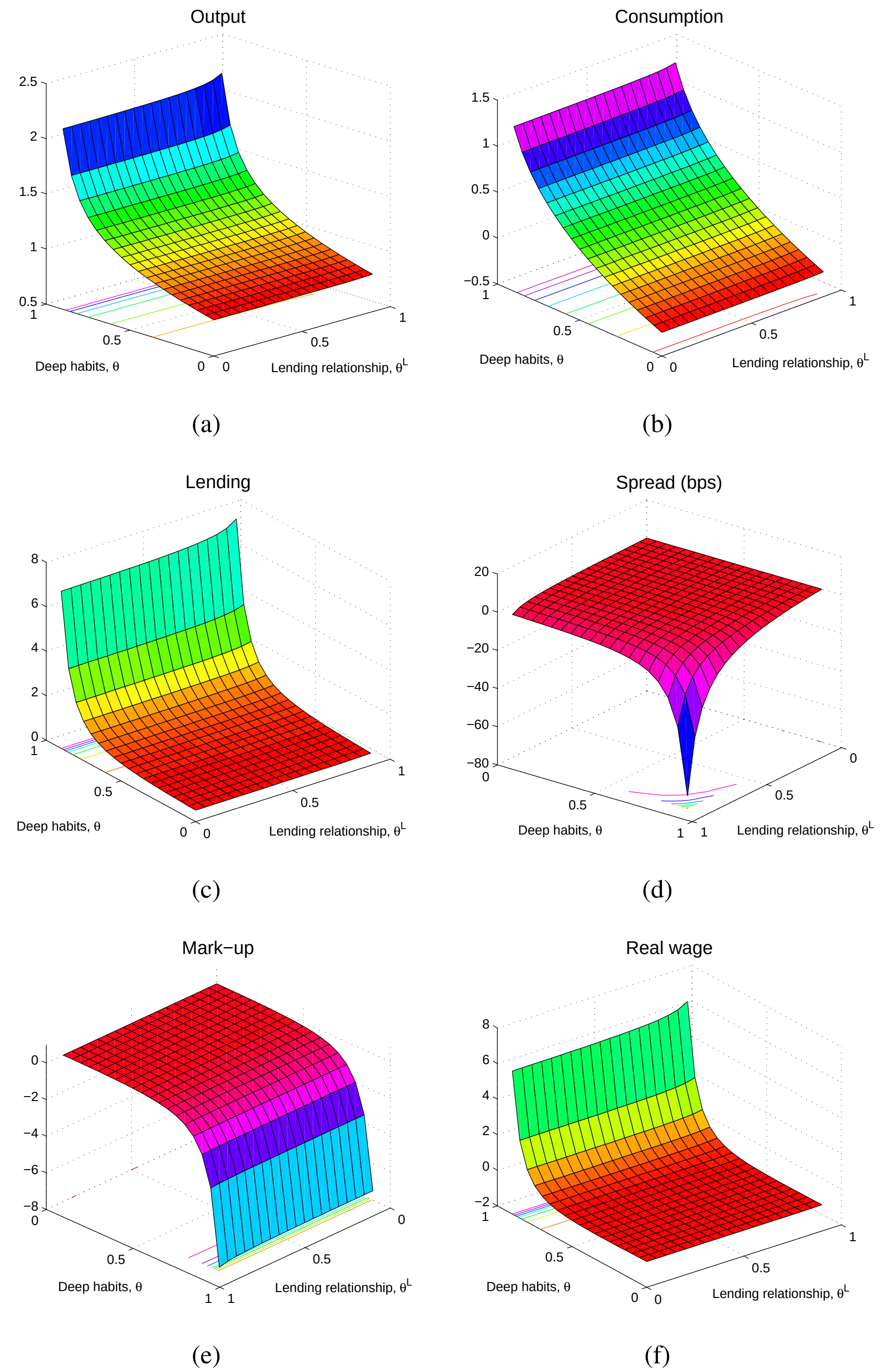



Figure B.1: Sensitivity of impact responses to the parameter of deep habits in consumption, $\theta^c$, and of lending relationships, $\theta^L$.

negative for low degrees of deep habits in consumption, but they turn positive for higher values of deep habits when, following a fiscal stimulus, the increase in labor demand becomes stronger than the rise in labor supply. Subfigure B.1a shows that when deep habits in consumption and in lending are both off, the value of the impact output multiplier is about 0.8. 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, due to the increasing fall in the price mark-up. Analogously, stronger lending relationships are associated with a rise in the output multiplier, driven by the negative effect on the bank spread that causes a larger expansion in lending. The amplification of the government spending shock when lending relationships are "on" is justified by the presence of an endogenous spread, which leads to a financial accelerator effect, as explained in Section IV.A. The degree of deep habits in consumption overall dominates the magnitude of the impact output multiplier.

## 2. Persistence of deep habits in consumption and of lending relationships

Sensitivity of the results to the choice of the parameters measuring consumption habit persistence, $\rho$, and the persistence of lending relationships, $\rho^L$, is shown in Figures B.2 and B.3. Figure B.2 shows the impulse responses for the first 20 quarters at different values of $\rho$. When deep habits in consumption last for only one quarter, i.e. $\rho = 0$, the negative impact responses of the mark-up are substantially magnified. In this case, final good firms reduce the price mark-up to a greater extent in order to lock in as many of their customers as possible. Habits at the variety level, in fact, can be exploited for only one quarter, during which their customers are charged larger mark-ups. After that, the mark-up quickly returns to its steady state. The response of the real wage is obviously similar to that of the price mark-up since the stimulus on labor demand is strongest in the first quarter and quickly dies out when $\rho = 0$. The same rationale applies to the demand for investment, hence lending and the bank spread. An increasingly higher persistence leads to a lower amplification of consumption and, at the same time, to a greater duration of the propagation mechanism of a government spending expansion.

Figure B.3 shows impulse responses for the first 20 quarters at different values of $\rho^L$. Subfigure B.3d shows that banks seek to exploit lending relationships to a large extent when these last only one quarter, i.e. $\rho^L = 0$. This is the case of short-term lending relationships as opposed to the long-term ones analyzed in the paper. In this case, in fact, the fall in the bank spread is substantially magnified because the effect of locking-in new customers into bank-to-firm relationships takes place only in the first quarter. Subfigure B.3c shows that the lower the persistence parameter, the higher the response of lending due to stronger reduction in the bank spread. The price mark-up is barely affected by a different degree of persistence in lending relationships. Hence the change that real variables experience when $\rho^L$ increases is lower than the corresponding change taking place when $\rho$ increases.

Overall, sensitivity analysis to the values of $\rho$ and $\rho^L$ reveals that the sign of the impact responses of the variables to a government spending shock is robust to any choice of the persistence parameters, while the magnitude is indeed affected.

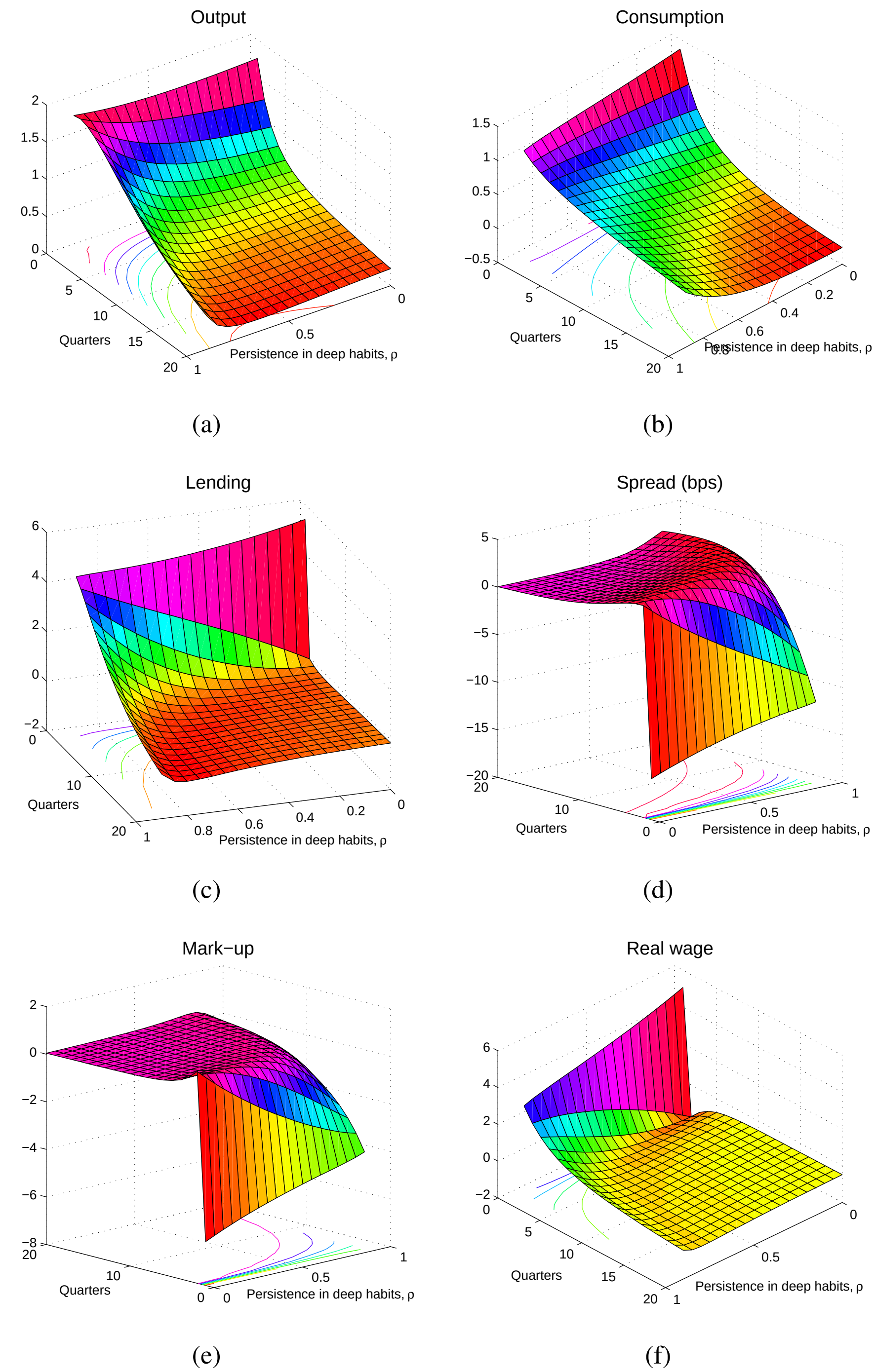



Figure B.2: Sensitivity of impulse responses to the persistence in deep habits in consumption, $\rho$.

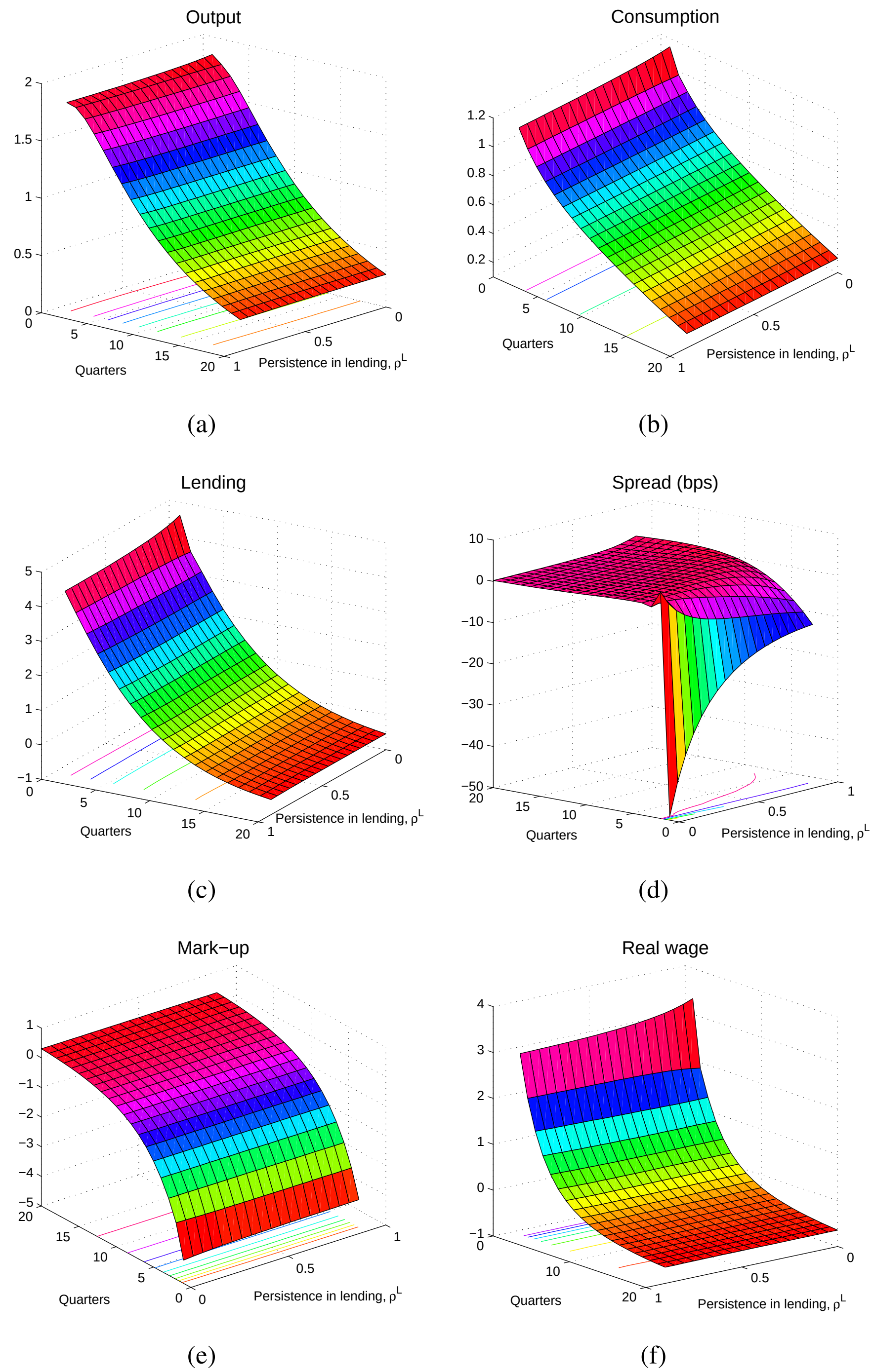



Figure B.3: Sensitivity of impulse responses to the persistence in lending relationships, $\rho^L$.

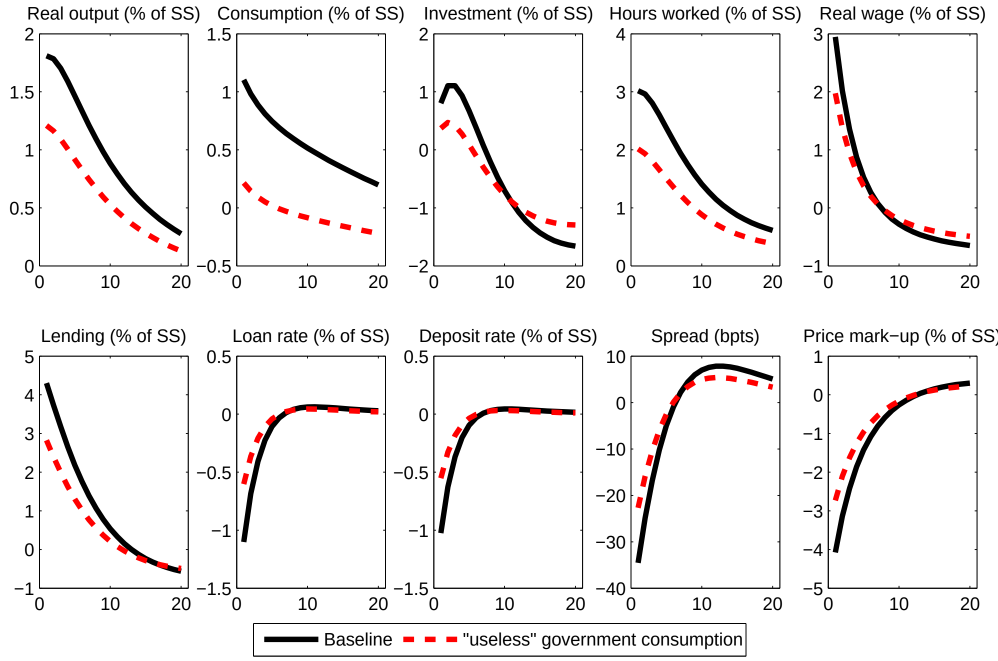



Figure B.4: Sensitivity to government consumption in the utility function (impulse responses to a government spending expansion of 1% of output).

## 3. Quantitative implications of a "useless" government consumption

Figure B.4 shows how macroeconomic variables in the baseline model (solid lines) respond to a government expenditure shock *versus* the responses obtained in a restricted model in which public consumption does not deliver any utility to households (dashed lines). This implies that public goods are simply a waste of resources as in other models in the literature. This corresponds to a model where $\nu_x$ is set equal to 1 and the remaining parameters are set as in Table 1. While the sign of the impact responses of the variables to a government spending shock is not affected by the presence of public consumption in the utility function, their size changes in particular as far as private consumption is concerned. When public consumption is useless from the point of view of the households, its increase does not affect directly the first order conditions of households. Hence the effect of deep habits in both private and public consumption is reduced and the price mark-up falls by less. As a consequence, a government spending expansion exerts a lower impact on labor demand and the crowding-in effect on consumption, although still present, is weaker. As far as private lending and the bank spread are concerned, although some quantitative differences are present, their behavior is very similar in the two alternative specifications.

# C A NK Extension of the Model

This section offers a new-Keynesian (NK) extension of the model that includes sticky prices and monetary policy. Price stickiness is introduced as in Rotemberg (1982), i.e. by assuming that changing prices costs resources.[14]

## 1. Introducing sticky prices

The introduction of sticky prices changes the problem of final good firms $i \in (0,1)$ in that they now choose the price level, $P_{it}$, instead of the relative price, $p_{it}$, and they face quadratic price adjustment costs proportional to overall production $\frac{\xi}{2}\left(\frac{P_{it}}{P_{it-1}}-1\right)^2 Y_t$, where parameter $\xi$ measures the degree of price stickiness. Thus, the profit function now reads as

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

The first-order conditions with respect to $C_{it+s}$, $S^c_{it+s}$, $G_{it+s}$, $S^g_{it+s}$ remain unaltered relative to the flexible-price case, while taking the first-order condition with respect to the price level $P_{it+s}$ leads to the following:

$$\left\{\begin{array}{c} \frac{P_{it}}{P_t}(C_{it}+G_{it})-\xi\left(\frac{P_{it}}{P_{it+s}}-1\right)\frac{P_{it}}{P_{it-1}}Y_t+(1-\eta)\left(\frac{P_{it}}{P_t}\right)^{1-\eta}I_t \\ +\eta MC_t\left(\frac{P_{it}}{P_t}\right)^{-\eta}I_t-\eta\nu^c_t\left(\frac{P_{it}}{P_t}\right)^{-\eta}X^c_t-\eta\nu^g_t\left(\frac{P_{it}}{P_t}\right)^{-\eta}X^g_t \\ +\xi E_t\Lambda_{t,t+1}\left[\left(\frac{P_{it+1}}{P_{it}}-1\right)\frac{P_{it+1}}{P_{it}}\right]Y_{t+1} \end{array}\right\}=0, \tag{C.2}$$

which, in the symmetric equilibrium, reads as

$$\left\{\begin{array}{c} C_t+G_t+(1-\eta)I_t+\eta MC_tI_t-\eta\left(\nu^c_tX^c_t+\nu^g_tX^g_t\right) \\ +\xi E_t\Lambda_{t,t+1}\left[(\Pi_{t+1}-1)\Pi_{t+1}\right]Y_{t+1}-\xi\left[(\Pi_t-1)\Pi_t\right]Y_t \end{array}\right\}=0, \tag{C.3}$$

where $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ is the gross inflation rate. Note that the pricing equation (C.3) collapses to the analogous flexible-price equation (31) in the paper when $\xi = 0$. Furthermore, when $\xi > 0$, real cost $\frac{\xi}{2}\left(\frac{P_t}{P_{t-1}}-1\right)^2 Y_t$ enters the economy's resource constraint.

[14]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. By contrast using Calvo-type contracts introduces firm-specific habit effects which are more difficult to handle.

The NK model is closed by monetary policy, which is set by imposing Taylor rule

$$\log\left(\frac{R_t^n}{\bar{R}^n}\right) = \rho_r \log\left(\frac{R_{t-1}^n}{\bar{R}^n}\right) + (1-\rho_r)\left[\rho_\pi \log\left(\frac{\Pi_t}{\bar{\Pi}}\right) + \rho_y \log\left(\frac{Y_t}{\bar{Y}}\right)\right], \tag{C.4}$$

where $R_t^n$ is the gross nominal interest rate, and $\rho_r$, $\rho_\pi$ and $\rho_y$ are policy parameters referring to interest-rate smoothing, and the responsiveness of the nominal interest rate to inflation deviations and to the output gap, respectively. A Fisher equation links the real deposit rate $R_{t+1}^D$ to the nominal interest rate:

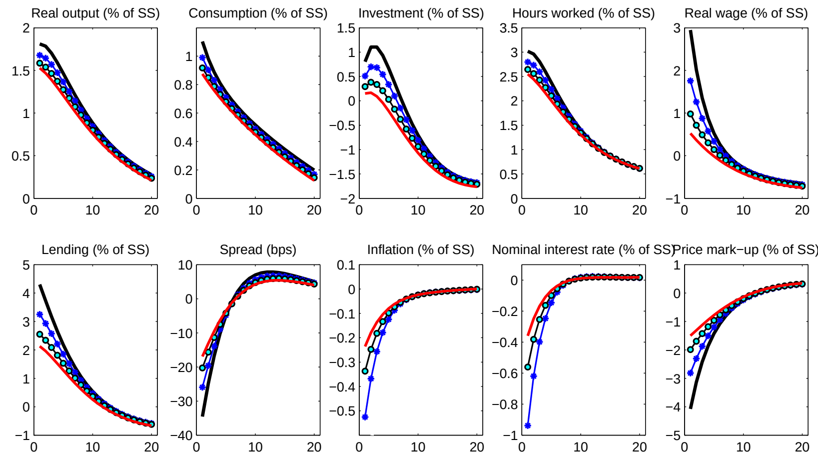
$$1 + R_{t+1}^D = E_t\left[\frac{R_t^n}{\Pi_{t+1}}\right]. \tag{C.5}$$

## 2. Results

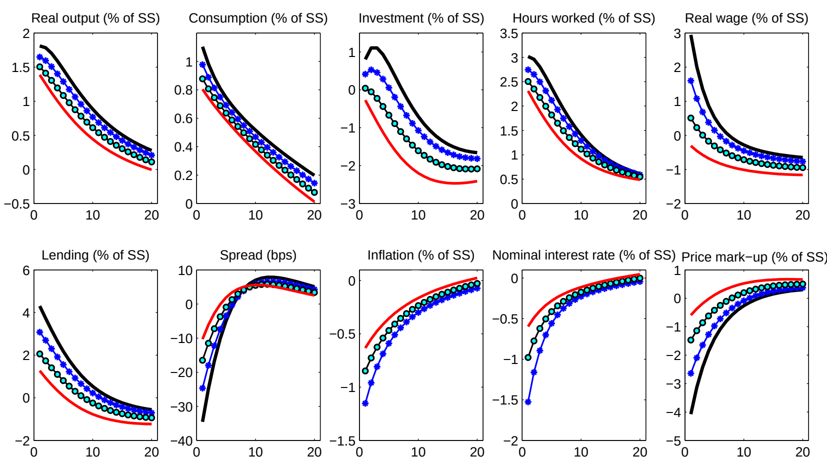
Woodford (2011) shows that adding sticky prices into an otherwise standard DSGE model enhances the effects of a government spending expansion. Jacob (2010) shows that, if price stickiness is added into a model with deep habit formation, the countercyclical movement that the government spending shock induces in the mark-up is milder, that private consumption may still be crowded out as in traditional RBC and NK models and, consequently, the output multiplier becomes small. As in Cantore et al. (2012b, 2013), results show that, with deep habit formation, the addition of price stickiness indeed softens the effects of a government spending expansion. However, here for an empirically plausible degree of deep habit formation and price stickiness the effects of a government spending expansion in terms of consumption and investment crowding-ins, the decline in the mark-up, the increase in the real wage, the size of the output multiplier, as well as the responses of private lending and the bank spread, are quite robust to the introduction of price stickiness. In other words, price stickiness *per se* does not subvert the effects of a government spending expansion. These issues are explored in greater detail in the context of a simpler NK model with optimal monetary policy with no financial frictions in Cantore et al. (2012b).

Figure C.1 shows the effects of an expansion of government expenditures at different degrees of price stickiness in three alternative scenarios. First, in the top panel of Figure C.1, we assume a "standard" Taylor rule, that borrows the posterior estimates of Smets and Wouters (2007b), i.e. the nominal interest rate exhibits persistence in line with the data, ($\rho_r = 0.81$), the monetary authority reacts to inflation ($\rho_\pi = 2.04$) and to the output gap ($\rho_y = 0.08$).We explore different degrees of price stickiness, $\xi$. In particular, a level of $\xi = 41.18$ corresponds to a Calvo contract average duration of around 3 quarters for our calibration, which approximately corresponds to the duration implied by the posterior estimate of the Calvo parameter in Smets and Wouters (2007b).[15] When price stickiness is introduced, the effects of the fiscal expansion become softened by the decrease in the rate of inflation. This occurs if the shift in aggregate supply, due to the presence of a sufficiently high level of deep habits, is rather strong relative to the shift in the aggregate demand created by the government spending expansion. As far as loan market variables are concerned, the rise in the demand for loans is less pronounced and hence

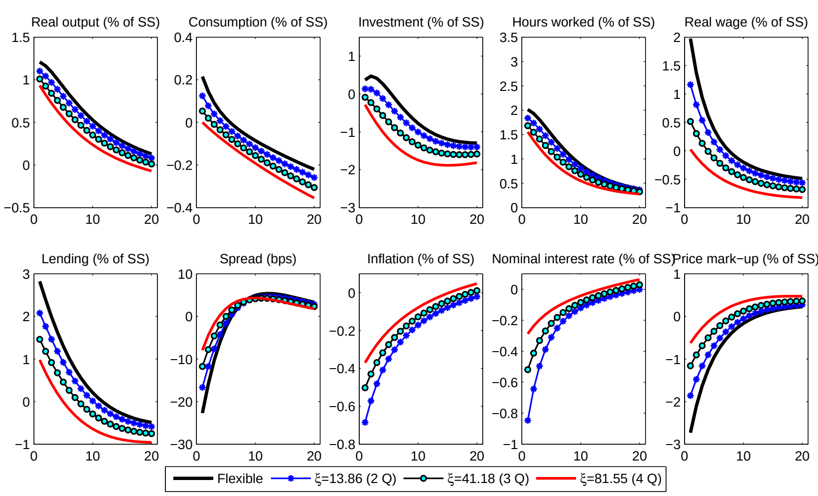
[15]For the algebraic relationship between the Rotemberg and the Calvo parameter see Jacob (2010) and Cantore et al. (2013).




(a) "Standard" Taylor rule ($\rho_y = 0.08$).




(b) Taylor rule with strong reaction to the output gap ($\rho_y = 0.5$).




(c) Strong reaction to the output gap ($\rho_y = 0.5$) and "useless" government consumption.

Figure C.1: A government spending expansion (1% of output): flexible *versus* sticky price version.

the fall in the bank spread is softened for increasing degrees of price stickiness. Overall, however, the effects of a government spending expansion are similar to those obtained in the flexible-price case.

In the middle panel of Figure C.1, the Taylor rule features a strong response to the output gap ($\rho_y = 0.5$). In this case, Cantore et al. (2012b, 2013) show that the strong reaction of monetary policy to the output gap offsets the effects of the fiscal expansion to a greater extent because the nominal interest rate falls less relative to the fall in the inflation rate. This leads to a smaller fall in the real interest rate or, for particularly high levels of price stickiness and monetary reactions to the output gap, even to an increase in the real interest rate. For high degrees of price stickiness, investment is crowded-out and the real wage falls, contrary to empirics and baseline results. The rise in lending and the fall in the bank spread are less pronounced, but the sign of the responses of loan market variables is preserved. Unlike in Cantore et al. (2013) the private consumption response and the output multiplier are still quite robust to the choice of $\rho_y$ as the presence of government spending in the utility function prevails on the strong monetary response to the output gap.

The bottom panel of Figure C.1 shows the responses to a government spending expansion in a model with different degrees of price stickiness, a strong reaction to the output gap ($\rho_y = 0.5$) and a "useless" government consumption ($\nu_x = 1$) *versus* a flexible price version. As explained in Subsection B.3 when government consumption does not deliver utility to households, the expansionary effect of the fiscal shock is reduced. This effect, combined with high degrees of price stickiness and a strong reaction of monetary policy to the output gap, leads also to a crowding-out of consumption driven by the positive reaction of the real interest rate. Under this scenario the fall in the bank spread and the rise in lending and output are still present but smaller from a quantitative point of view. Nevertheless, it has to be acknowledged that, first, in the empirical DSGE literature, estimates of the value of $\rho_y$ are typically very low, around the value showed in the top panel of Figure C.1. Second, in the optimal policy literature, optimised interest rate rules using a welfare criterion find a weak long-run response of the interest rate to the output gap; for example, Schmitt-Grohe and Uribe (2007) find $\rho_y = 0.1$ and Cantore et al. (2012b) find a value close to zero in a NK model with deep habits in consumption.

# D Symmetric equilibrium

**Production function and marginal products:**

$$F(H_t, K_t) = H_t^{\alpha} K_t^{1-\alpha} \tag{D.1}$$

$$F_{K,t} = (1-\alpha)\frac{Y_t}{K_t} \tag{D.2}$$

$$F_{H,t} = \alpha\frac{Y_t}{H_t} \tag{D.3}$$

**Utility function, marginal utilities and deep habits in consumption:**

$$U(X_t, 1-H_t) = \frac{\left[X_t^{\omega}(1-H_t)^{1-\omega}\right]^{1-\sigma}}{1-\sigma} \tag{D.4}$$

$$X_t = \left[\nu_x^{\frac{1}{\sigma_x}}\left(X_t^c\right)^{\frac{\sigma_{x-1}}{\sigma_x}} + (1-\nu_x)^{\frac{1}{\sigma_x}}\left(X_t^g\right)^{\frac{\sigma_{x-1}}{\sigma_x}}\right]^{\frac{\sigma_x}{\sigma_{x-1}}} \tag{D.5}$$

$$U_{X_t^c} = \omega\,(1-H_t)^{1-\omega}\,\nu_x^{\frac{1}{\sigma_x}}\left[X_t^{\omega}\,(1-H_t)^{1-\omega}\right]^{-\sigma} X_t^{\omega-1}\left(\frac{X_t}{X_t^c}\right)^{\frac{1}{\sigma_x}} \tag{D.6}$$

$$U_{H_t} = -(1-\omega)(1-H_t)^{-\omega} X_t^{\omega}\left[X_t^{\omega}\,(1-H_t)^{1-\omega}\right]^{-\sigma} \tag{D.7}$$

$$S_t^c = \rho S_{t-1}^c + (1-\rho^c)C_t \tag{D.8}$$

$$C_t = X_t^c + \theta S_{t-1}^c \tag{D.9}$$

$$-U_{H_t} = U_{X_t^c} W_t \tag{D.10}$$

**Intertemporal investment/consumption decisions:**

$$K_{t+1} = (1-\delta)K_t + I_t\left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] \tag{D.11}$$

$$S\left(\frac{I_t}{I_{t-1}}\right) = \frac{\gamma}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 \tag{D.12}$$

$$Q_t = E_t \Lambda_{t,t+1}\left[\ \Phi_{t+1} F_{K,t+1} + Q_{t+1}(1-\delta)\ \right] \tag{D.13}$$

$$E_t\left[\Lambda_{t,t+1}(1+R_t^L)\right] = Q_t\left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - S'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}}\right] + E_t\Lambda_{t,t+1}\left[\;Q_{t+1}S'\left(\tfrac{I_{t+1}}{I_t}\right)\left(\tfrac{I_{t+1}}{I_t}\right)^2\;\right] \tag{D.14}$$

$$\Lambda_{t,t+1} = \beta\frac{U_{X_t^C+1}}{U_{X_t^C}} \tag{D.15}$$

$$E_t[\Lambda_{t+1}(1+R_{t+1}^D)] = 1 \tag{D.16}$$

$$\Phi_t F_{H,t} = W_t E_t\left[\Lambda_{t,t+1}(1+R_t^L)\right] \tag{D.17}$$

**Further entrepreneurs' and banks' decisions:**

$$L_t = I_t + W_t H_t \tag{D.18}$$

$$L_t = X_t^L + \theta^L S_{t-1}^L \tag{D.19}$$

$$S_t^L = \rho^L S_{t-1}^L + (1-\rho^L)L_t \tag{D.20}$$

$$L_t = D_t \tag{D.21}$$

$$\nu_t = E_t\Lambda_{t,t+1}\left[\left(R_{t+1}^L - R_{t+1}^D\right) + \nu_{t+1}\theta^L(1-\rho^L)\right] \tag{D.22}$$

$$E_t\left[\Lambda_{t,t+1}L_{t+1}\right] = \nu_t\eta^L E_t\left[X_{t+1}^L\right] \tag{D.23}$$

$$\text{spread} = R_t^L - R_t^D \tag{D.24}$$

**Final good firms' decisions:**

$$1 - MC_t + (1-\rho)\lambda_t^c = \nu_t^c \tag{D.25}$$

$$E_t \Lambda_{t,t+1}(\theta \nu_{t+1}^c + \rho \lambda_{t+1}^c) = \lambda_t^c \tag{D.26}$$

$$1 - MC_t + (1-\rho)\lambda_t^g = \nu_t^g \tag{D.27}$$

$$E_t \Lambda_{t,t+1}(\theta \nu_{t+1}^g + \rho \lambda_{t+1}^g) = \lambda_t^g \tag{D.28}$$

$$\left\{ \begin{array}{c} C_t + G_t + (1-\eta) I_t + \eta MC_t I_t - \eta \left( \nu_t^c X_t^c + \nu_t^g X_t^g \right) \\ + \xi E_t \Lambda_{t,t+1} \left[ (\Pi_{t+1} - 1) \Pi_{t+1} \right] Y_{t+1} - \xi \left[ (\Pi_t - 1) \Pi_t \right] Y_t \end{array} \right\} = 0 \tag{D.29}$$

**Government:**

$$S_t^g = \rho S_{t-1}^g + (1-\rho) G_t \tag{D.30}$$

$$G_t = X_t^g + \theta S_{t-1}^g \tag{D.31}$$

$$\log\left(\frac{G_t}{\bar{G}}\right) = \rho_G \log\left(\frac{G_{t-1}}{\bar{G}}\right) + \varepsilon_t^g \tag{D.32}$$

**Resource constraint:**

$$Y_t = C_t + I_t + G_t + \frac{\xi}{2} (\Pi_t - 1)^2 Y_t \tag{D.33}$$

**Taylor rule and Fisher equation (sticky-price model):**

$$\log\left(\frac{R_t^n}{\bar{R}^n}\right) = \rho_r \log\left(\frac{R_{t-1}^n}{\bar{R}^n}\right) + (1-\rho_r) \left[ \rho_\pi \log\left(\frac{\Pi_t}{\bar{\Pi}}\right) + \rho_y \log\left(\frac{Y_t}{\bar{Y}}\right) \right] \tag{D.34}$$

$$1 + R_{t+1}^D = E_t \left[ \frac{R_t^n}{\Pi_{t+1}} \right] \tag{D.35}$$

# E Steady state

Steady-state values of hours worked, $H$, capital, $K$, and the marginal cost, $MC$, solve simultaneously the definition of the marginal product of labor, (D.3), the banks' demand for deposits, (D.22), and the pricing equation, (D.29), while the value of the remaining unknowns in the system of equations reported in Appendix D can be found recursively by using the following relationships:

$$\overline{\Lambda} = \beta \tag{E.1}$$

$$\overline{R^D} = \frac{1}{\beta} - 1 \tag{E.2}$$

$$\overline{I} = \delta \overline{K} \tag{E.3}$$

$$\overline{Y} = \overline{K}^{1-\alpha} \overline{H}^{\alpha} \tag{E.4}$$

$$\overline{G} = \overline{\left(\frac{G}{Y}\right)} \overline{Y} \tag{E.5}$$

$$\overline{S^g} = \overline{G} \tag{E.6}$$

$$\overline{X^g} = (1-\theta)\overline{G} \tag{E.7}$$

$$\overline{C} = \overline{Y} - \overline{I} - \overline{G} \tag{E.8}$$

$$\overline{S^c} = \overline{C} \tag{E.9}$$

$$\overline{X^C} = (1-\theta)\overline{C} \tag{E.10}$$

$$\overline{X} = \left[ \nu_x^{\frac{1}{\sigma_x}} \left( \overline{X^c} \right)^{\frac{\sigma_{x-1}}{\sigma_x}} + (1-\nu_x)^{\frac{1}{\sigma_x}} \left( \overline{X^g} \right)^{\frac{\sigma_{x-1}}{\sigma_x}} \right]^{\frac{\sigma_x}{\sigma_{x-1}}} \tag{E.11}$$

$$\overline{U_{X^c}} = \omega \left(1-\overline{H}\right)^{1-\omega} \nu_x^{\frac{1}{\sigma_x}} \left[ \overline{X}^{\omega} \left(1-\overline{H}\right)^{1-\omega} \right]^{-\sigma} \overline{X}^{\omega-1} \left( \frac{\overline{X}}{\overline{X^c}} \right)^{\frac{1}{\sigma_x}} \tag{E.12}$$

$$\overline{U_H} = -(1-\omega)\left(1-\overline{H}\right)^{-\omega} \overline{X}^{\omega} \left[ \overline{X}^{\omega} \left(1-\overline{H}\right)^{1-\omega} \right]^{-\sigma} \tag{E.13}$$

$$\overline{W} = -\frac{\overline{U_H}}{\overline{U_{X^c}}} \tag{E.14}$$

$$\overline{L} = \overline{I} + \overline{WH} \tag{E.15}$$

$$\overline{S^L} = \overline{L} \tag{E.16}$$

$$\overline{X^L} = (1-\theta^L)\overline{L} \tag{E.17}$$

$$\overline{D} = \overline{L} \tag{E.18}$$

$$\overline{F_K} = (1-\alpha)\frac{\overline{Y}}{\overline{K}} \tag{E.19}$$

$$\overline{R^L} = \frac{\beta \left( \overline{MCF_K} \right)}{\beta - \beta^2(1-\delta)} - 1 \tag{E.20}$$

$$\overline{\nu} = \frac{\beta \overline{L}}{\eta^L \overline{X^L}} \tag{E.21}$$

$$\overline{\mathrm{spread}} = \overline{R^L} - \overline{R^D} \tag{E.22}$$

$$\overline{F_H} = \beta \overline{w} \frac{\left(1 + \overline{R^L}\right)}{\overline{MC}} \tag{E.23}$$

$$\overline{\lambda^c} = \frac{\beta \theta \left(1 - \overline{MC}\right)}{1 - \beta \theta (1 - \rho) - \beta \rho} \tag{E.24}$$

$$\overline{\nu^c} = 1 - \overline{MC} + (1 - \rho) \overline{\lambda^c} \tag{E.25}$$

$$\overline{\lambda^g} = \overline{\lambda^c} \tag{E.26}$$

$$\overline{\nu^g} = \overline{\nu^c} \tag{E.27}$$

$$\overline{\Pi} = 1 \tag{E.28}$$